Serious Play Approaches for Creating, Sharing, and Mobilizing Tacit Knowledge in Cross-disciplinary Settings

by

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ABSTRACT

Serious play—the notion of bringing the benefits of play to bear on work-related tasks—is receiving more attention as a remedy to many challenges of the modern knowledge economy. Exploring and defining the role of serious play approaches to facilitate collaborative problem-solving and value creation, this dissertation consists of four related research papers.

The first research paper (RP1) reconciles three different conceptualizations of knowledge into a new theory of knowledge. This pluralistic definition allows knowledge to change character across the span of the value creation process. The paper further introduces a model called the Wheel of Knowledge (WoK) for mobilizing knowledge throughout the different knowledge conversions of the value creation process. The second research paper (RP2) advocates that serious play can scaffold and accelerate these knowledge conversion processes, it disaggregates existing serious play approaches, and starts to operationalize the WoK by using it to match different types of serious play approaches to different types of knowledge conversion challenges. The third research paper (RP3) validates the WoK by sorting the serious play literature according to how it applies to the different knowledge conversion processes. The paper provides a framework for ascertaining the applicability of serious play methods to specific knowledge conversion challenges and identifies under-explored research areas of the serious play field. The fourth research paper (RP4) tests the recommendations of RP3 by applying the LEGO® Serious Play® (LSP) method to a knowledge conversion challenge focused on tacit knowledge sharing. It reports on a mixed-methods, multi-session case study in which LSP was used to facilitate cross-disciplinary dialogue and deliberation about a wicked problem. Results show that LSP is particularly useful in the beginning of a value creation process and that it facilitates socialization and tacit knowledge sharing. Taken together the papers demonstrate the necessity, potential, and application of serious play as a catalyst for the knowledge conversion processes presented in the WoK. It is now clear that different serious play approaches are suitable as respectively: an accelerator for trust-building and collective creativity, as a conduit for iterative innovation, and as a way of making rote tasks more engaging.

DEDICATION

To my friends, family, and felines: your love, support, and presence made this effort possible.

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CHAPTER 1

BACKGROUND, MOTIVATION, AND SUMMARY OF APPROACH

Applying design methods to real-world societal, environmental, and organizational problems has gained traction recent years (Kolko, 2012; Mau & Leonard, 2004). But how do we translate designerly ways of doing and thinking to be adoptable by non-designers? Serious play – and expanded forms of communication as advocated by Rittel (1972) and Roberts (2000) – have been heralded as a promising way of engaging multi-disciplinary teams, end-users, and other stakeholders in the design process and integrating knowledge towards a resolution of wicked problems (Rittel & Webber, 1973). When bringing design's fortes to organizations that do not view themselves as designers or creatives, it is suitable to frame design in terms of what they are already familiar with: Knowledge work. This dissertation makes designerly ways of doing more readily adoptable to organizations outside of the creative disciplines by connecting design to knowledge management and by building on definitions of knowledge that are already widely accepted in organizational science, knowledge creation, innovation management, and engineering. To make this connection in RP1 I bring seminal work of leading scholars in these fields (Nonaka, Drucker, and Ayres) into dialogue and reconciles their understandings of knowledge into a pluralistic theory of knowledge that — like the three understandings of design outlined below — spans the entire value creation process. While these scholars views on knowledge are complementary, they have not before been brought together.

The term 'design' can be conceive of in at least three different ways. The mainstream association is to think of design as a *noun*—'a design'—for example in the physical form of a consumer product, the blueprints for a house, or the construction drawings for a machine to be executed. However, design can also be conceived of as a verb—in two ways: First, the *process* of 'designing' which entails the integration of the human-, technology-, and business-parameters of a problem space toward an effective solution. Second, design can be 'to form or conceive in the mind'—to contrive or plan. In the latter design is about ideas and concepts. These three understandings correspond with how products appear in the world. Hence, the value creation

process of design includes all three descriptions: It starts with an idea, which is matured into an effective solution, which can then be executed and brought to scale (see RP1).

Similarly, it is widely acknowledged that all value in the modern knowledge economy can be traced back to tacit knowledge (Nonaka, 2007; Polanyi, 1966). However, value cannot be extracted from tacit knowledge—it must first be externalized and made explicit (Teece & Nonaka, 2001). Therefore the value creation process entails knowledge conversion processes, that make tacit knowledge shared and ultimately explicit. For these knowledge conversion processes design-inspired ways of thinking and doing can add a competitive advantage. They can support the processes of exploring the possibilities with an open mind, make the uncertain concrete and testable through physical models, as well as offer ways to sustain engagement with the task at hand.

Due to the breadth and complexity of the challenges that 'design as a verb' can take on, engineers and designers are not the only ones who design. "Everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (Simon, 1996, p. 111). In his inclusive definition of design, "the intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state." (Simon, 1996, p.111). Thus, the increasing complex challenges that design processes are applied to require that designers and non-designers alike increase their capacity for design thinking and cross-disciplinary collaboration. Serious play has been heralded as a way of sharing these strategies broadly, as they create a 'low floor' (=accessible entry level, Resnick, 2005) for engaging non-designers in design-inspired approaches to challenges ranging from organizational, societal, or product oriented in nature.

Whether engaged in an integrative design process for the purpose of creating a complex, new product or resolving a wicked problem, shared requirements remain: to create, share, and mobilize tacit knowledge in cross-disciplinary settings. To make progress towards suitable (re)solutions to problems that go beyond disciplinary silos, it is essential to leverage experience, knowledge, and skill-sets from a diverse range of backgrounds (Amabile, 1996; 1998; Rittel,1972;

Roberts, 2000; Boradkar, 2010). However, in the diversity among team members and stakeholders lies both the seed of synergy and the seed of conflict. Reasons can be conflicting interests and priorities, as well as differing perspectives on what constitute valid knowledge and appropriate problem-solving approaches.

For these collaborations to be generative, collaborators must be able to take the perspectives of others, think creatively, be solution-oriented, and self-reflective. Another key to success is their ability to communicate constructively and share knowledge across disciplines. Barriers to the cultivation of cross-disciplinary knowledge and communication however still exist at all levels—from student to faculty and practitioner. These include: 1) a lack of knowledge about collaborators' information needs (O'Brien et al., 2003), 2) a variation of cultural expectations between individuals and disciplines (O'Brien et al., 2003), and 3) an absence of shared vocabularies for communicating about complex societal problems within and across disciplines (Borego et al., 2007).

At the core of methodologies seeking to address wicked problems are *expanded forms of communication* (Roberts, 2000). Each of the ten principles presented in Rittel's (1972) second-generation approach to systems analysis, highlight the "barriers to communication" present in the first generation approaches, stemming from the nineteenth century rational view of science and evident in the industrial era's reductionist approach to problem-solving (Churchman, 1967; Taylor, 1911). Taken collectively Rittel's communicative strategies call for: participatory design, experts to be cautious of their limitations, appreciation of the importance and role of all personal perspectives and how these effect the relationship between scientific and political processes, transparent design rational approaches, the individuals in the unique position of a designer/ planner to exhibit a Socratic voice, i.e., presenting problems as a teacher rather than a doctor, and the need to foster and maintain optimistic attitudes (in the face of daunting wicked problems, which can never be solved, only re-solved), and argumentative process and deliberation. Serious play approaches constitute a promising mode of such expanded forms of communication.

This dissertation focuses on serious play approaches as a means for lowering the barriers to successful innovation and bringing the power of designerly ways of doing to non-

design contexts. Serious play methods are an array of playful/ gameful (McGonigal, 2011; 2015) ways of activating knowledge and accelerating the process from thought to action in organizations. While an array of methods are amassed under the umbrella term serious play, the motivation for application spans from nurturing creativity and bringing diverse stakeholders together to solve tough problems, to accelerating complicated cross-disciplinary innovation processes, and to support an increased engagement even in rote tasks. Hence, all serious play methods are *not* alike, and applying an unsuitable method may lead to adverse results. However, the literature on serious play remains fragmented, and there is neither a comprehensive overview of the serious play methods, nor guidance for matching their characteristics to corresponding knowledge conversion challenges.

The overall raison d'être for this research effort is to provide new insights about serious play approaches as catalysts for the constructive collaboration and knowledge conversion processes required for value creation and learning in organizations.

Overview of Research Papers in Dissertation

This dissertation consists of four related research papers each focused on knowledge conversion and serious play approaches, but exploring the topic at different levels of abstraction and through different research methods. They emphasize respectively theory building, conceptualization, validation & operationalization, and practical application in the pursuit of creating new insights for advancing the emergent field of serious play.

The first research paper (RP1) is the broadest and most theoretical. It reconciles three different conceptualizations of what knowledge is into a new theory of knowledge. This flexible definition of what knowledge is allows for it to change character across the span of the value creation process. It further introduces a model called the Wheel of Knowledge (WoK) that mobilizes knowledge through knowledge conversion processes. The second research paper (RP2) makes the case that serious play methods can scaffold and accelerate these knowledge conversion processes, it disaggregates existing serious play approaches, and starts to operationalize the WoK by using it as a lens for matching different types of serious play

approaches to different types of knowledge conversion challenges. The third research paper (RP3) seeks to validate the WoK by sorting the serious play literature according to how it applies to the different knowledge conversion processes. The paper offers a framework for ascertaining the applicability of serious play methods and identifies under-explored areas of the emergent serious play field. The fourth research paper (RP4) is the most applied. It describes how a serious play method can be useful for facilitating cross-disciplinary dialogue and deliberation about wicked problems by reporting on a mixed-methods, multi-session case study in which LEGO® Serious Play® was used in the context of discussing societal and environmental implications related to nanotechnology.

Taken together the research papers that constitute this dissertation demonstrate the necessity, potential, and application of serious play as a catalyst for knowledge sharing when grabbling with complex problems, as a conduit for innovation in creative collaborations, and as a way of making rote tasks more engaging. Allowing the reader to establish a quick overview of the body of WoK each research paper is described in greater detail below, listing the research questions, the main contributions, the abstract, and the most essential figures.

Summary of Chapter 2 (RP1)

Table 1. Research questions and main contributions for chapter 2 (RP1).

A Knowledge-based Theory of Creativity, Innovation, & Entrepreneurship	
Research questions	RQ1: What might a theory of knowledge suitable for entrepreneurial value creation look like?
	RQ2: With all value ultimately deriving from tacit knowledge, how can it be brought to an explicit state suitable for value extraction?
Main contributions	The paper advances a new theory of knowledge that integrates the three conceptions of knowledge as belief, technique, and artifact into an flexible understanding of the character of knowledge as evolving across the span of the value creation process.
	The paper introduces the Wheel of Knowledge model for knowledge conversion.

Abstract

There is now consensus among business scholars that economic value in the post-industrial age ultimately derives from *knowledge*. One popular theory describes this knowledge as the justified true belief that emerges from shared experiences among the members of a firm. Another popular theory views knowledge as manifest in the techniques that improve yield on resources. Neither theory offers a complete view of the evolving character of knowledge throughout the processes of creation, innovation, and application that are required for entrepreneurship. This paper describes a third way of understanding knowledge as embodied in the symbolic, digital, and physical artefacts of the firm (including software, design drawings, manuals, standards, specifications, and material products) and advances a new theory of entrepreneurship as mobilization of knowledge through these three conceptions: belief, technique, and artefact. To encompass each of these, I apply design thinking to reconceptualize Nonaka's socialization, externalization, combination, and internalization (SECI) model to include the entire knowledge management life cycle from idea to product. I call the result the Wheel of Knowledge to emphasize the iterative nature of innovation. In contrast to Nonaka's SECI spiral, the Wheel places externalization and internalization adjacent in a cyclic tacit-explicit-tacit loop of knowledge conversion that eventually produces explicit

artefacts for subsequent combination. Thus, the Wheel replaces the metaphor of a never-ending spiral with one more suitable to making progress towards production of explicit knowledge embodied in explicit products.

Chapter 2 (RP1) Key Figures

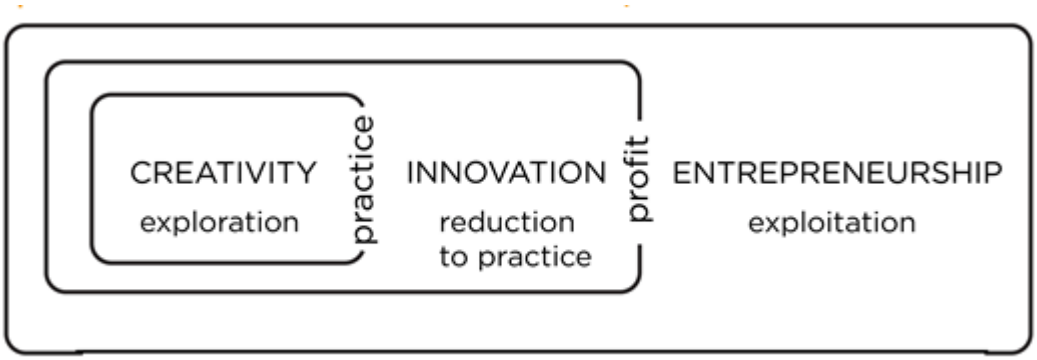

Figure 1. The Value Creation Life Cycle (VCLC).

Figure 2. The Wheel of Knowledge (WoK) depicts the tacit and explicit knowledge conversion processes taking place in the value creation life cycle.

Summary of Chapter 3 (RP2)

Table 2. Research questions and main contributions for chapter 3 (RP2)

The Wheel of Knowledge: Catalyzing Knowledge Creation, Innovation, & Value Extraction Through Serious Play.	
Research questions	RQ1: How might we match the character of knowledge with strategies for knowledge management?
	RQ2: What might suitable knowledge management approaches be?
	RQ3: What is serious play approaches and how do they connection particular knowledge management challenges?
Main contributions	Suggests serious play as an equally pluralistic management approach.
	Disaggregates the fuzzy vocabulary in the literature of serious play.
	Describes the essential role of serious play for each phase of the value creation process and matches serious play approaches with the character of knowledge work.

Abstract

While the character of work in developed countries has changed from manual labor to knowledge work, management approaches often fail to reflect this shift. Many modern organizations still apply the same motivational tools of punishment, control, and extrinsic reward that were instrumental to productivity of manual work in the industrial era but are detrimental to creative work in the post-industrial era. Even organizations that recognize that all modern business-value ultimately derive from knowledge, may fail to realize that the character of knowledge and the type of knowledge work change over the course of the value creation process. This misconception leads to little recognition of the critical connection between the character of knowledge and strategies for knowledge management. In fact, as the type of knowledge work changes, so do the types of activities and incentives that enable knowledge workers to be creative and productive. Based on a pluralistic understanding of the character of knowledge and the related types of work as evolving over the course of the value creation process, this chapter suggests serious play as an equally pluralistic management approach. First, it is necessary to disaggregate the fuzzy vocabulary in the literature of serious play. Next, guided by the Wheel of Knowledge (WoK)—a

model for knowledge creation, innovation, and entrepreneurship—the chapter describes the essential role of serious play for each phase of the value creation process and matches serious play approaches with the character of knowledge work. Starting with knowledge creation, playful approaches facilitate and accelerate the socialization processes that allow ideas to be shared and creativity to flourish. Proceeding to innovation, ideas are matured and reduced to practice through iterative, experimental processes of externalization/internalization with physical and digital manifestations. Lastly, with a focus on value extraction, the hard work of manufacturing and production become essential. Here, gameful approaches that include pay incentives and social recognition are essential to optimize performance. By matching forms of play to the right knowledge processes, business leaders will increasingly recognize the value of serious play at work.

Chapter 3 (RP2) Key Figures

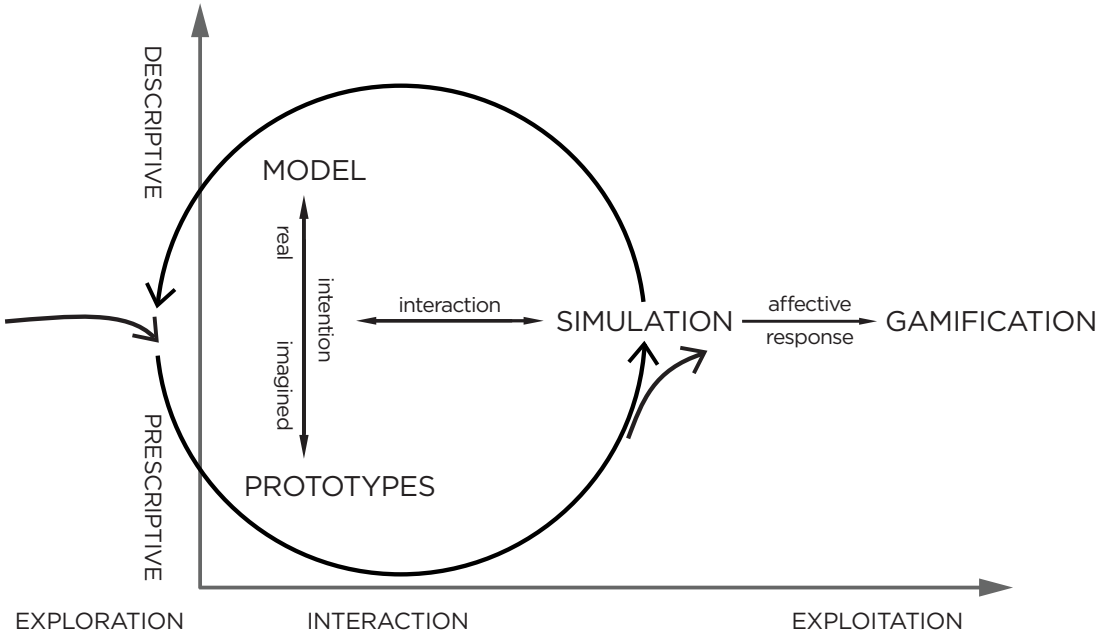

Figure 3. The relationship between models, prototypes, simulations, and games/gamification arranged according to their suitability for representing descriptive versus prescriptive purposes and whether the motivation for doing the work is mainly intrinsic or extrinsic. The Wheel of Knowledge graphic is superimposed to indicate in which phase each approach is most applicable.

Table 3. Conceptual guidance table that illustrates the relationship between the main concepts: types of knowledge (Martin, 2009; Polanyi, 1969; Grant, 1996, Pink, 2011), organization goals (March, 1991; McCarthy & Gordon, 2011), knowledge conversion processes (Nonaka et al., 2000), process purpose (Jensen et al., 2017a; Caniëls et al., 2014), motivation, role of rewards (Caniëls et al., 2014; McGonigal, 2015), approach (Suorsa, 2015; McGonigal, 2015), what must be facilitated, and interactional characteristics/dimensions of play (Soursa, 2015).

Types of Knowledge	Mystery	Heuristic	Algorithmic
	Tacit		Explicit
Org. Goal	Exploration		Exploitation
Knowledge Conversion Processes			
Process Purpose	**Creativity** Idea generation	**Innovation** Idea promotion	**Value Extraction** Idea implementation
Motivation	Intrinsic		Extrinsic
Role of rewards	Hinders creativity	No or demotivating effect	Motivating effect
Approach	Playful	Purposeful experimentation	Gameful
Facilitating	Building group tacit knowledge through shared experiences Mutual trust Sense of security and safety for speaking up Become familiar with collaborators (their personality, expertise, and skills)	Test concepts (E & I) Concept maturation (E & I) Convey ideas, thoughts, and values (E) Understand and empathize (I) Active listening (I) Asking clarifying questions (I) Asking what-if?-questions (E)	Perfecting capacity and skills Getting better / more effective Practice future challenges in a safe context Meeting a quota

	Explore opportunities Goal alignment	Building on others' ideas (E)	Optimizing Standardizing Measuring Benchmarking
Interactional characteristics/ **Dimensions of being in play**	Openness Familiarity Interpersonal trust Equality Commitment Being present	Criticality Reflectivity Interpersonal trust Commitment Being present	Seriousness Being present Commitment Interpersonal trust Criticality

Summary of Chapter 4 (RP3)

Table 4. Research questions and main contributions for chapter 4 (RP3).

Play At Work: Mapping The Serious Play Literature According To The Wheel Of Knowledge	
Research questions	RQ1: Is the WoK useful lens for organizing the serious play literature knowledge conversion challenges?
	RQ2: How can we compare and distinguish between the functionality and worth of serious play approaches?
	RQ3: Are serious play methods that facilitate the different knowledge conversion processes equally covered in the literature?
Main contributions	Sorts serious play papers according to types of knowledge conversion processes.
	Provides guidance on how to ascertain which phase(s) of the WoK that an approach applies to.
	Validates of the Wheel of Knowledge as a lens through which to match serious play approaches with suitable knowledge conversion challenges.
	Offers a framework for understanding the applicability of serious play approaches.
	Highlights under-explored areas in the literature.

Abstract

Serious play methods are receiving more attention as a remedy to many of the challenges of the modern knowledge economy. While the methods are often referred to under the umbrella term serious play, the motivation for application spans from nurturing creativity and bringing diverse stakeholders together to solve tough problems, to accelerating complicated cross-disciplinary innovation processes, and to support an increased engagement even in rote tasks. Hence, all serious play methods are not alike. The literature remains fragmented, and there is neither a comprehensive overview of the serious play methods, nor guidance for matching their characteristics to corresponding knowledge conversion challenges. However, the Wheel of Knowledge (WoK) offers a theoretical model for understanding knowledge conversion processes and may also provide a useful lens for organizing the serious play literature. This paper seeks to test the WoK by organizing methods found in the serious play literature according to the knowledge conversion processes referred to as socialization, externalization, internalization, and

combination. This is done through an iterative, heuristic examination of the literature, followed by an overview of how the existing literature pertains to the different knowledge conversion processes. Having distilled parameters that reveal the characteristics and affordances of the dominant serious play methods suitable for different knowledge challenges, the paper offers a comparative framework for classification of serious play methods and identifies under-explored areas of the field.

Chapter 4 (RP3) Key Figures

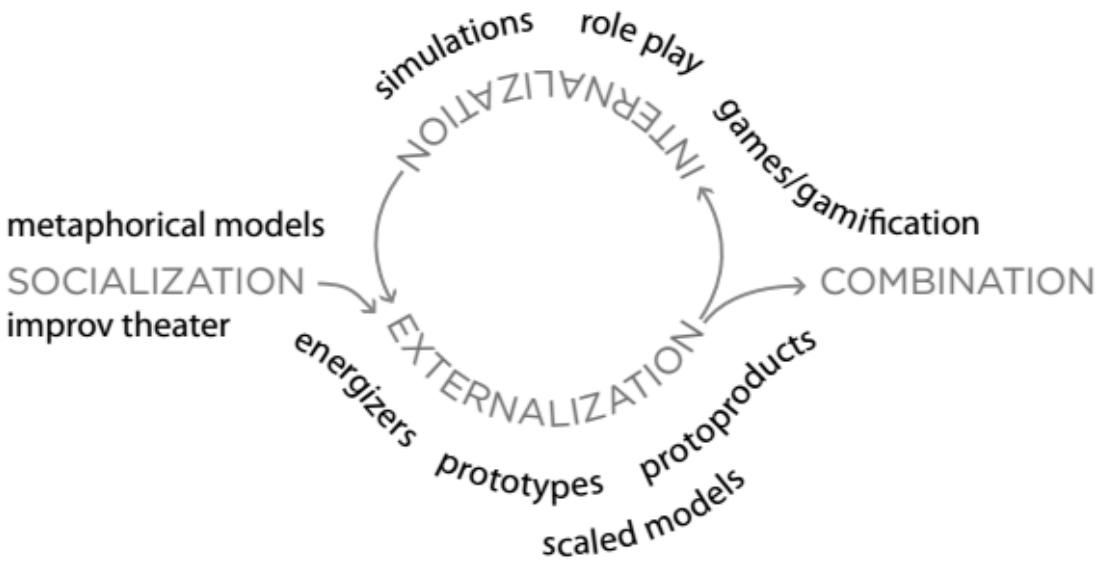

Figure 4. Illustration of how different types of serious play methods may align with the WoK phases.

Table 5. Examples of serious play methods/approaches that pertain respectively to socialization, externalization, internalization, and combination plotted into the framework.

	Examples of serious play methods/approaches			
Parameters	**LEGO® Serious Play®** An example of Socialization	**Prototyping** An example of Externalization	**Simulations** An example of Internalization	**Gamification** An example of Combination
Purpose	Build trust Incite creativity Generate ideas Explore possibilities Allow for tacit knowledge to emerge.	Make ideas real and testable Propose solutions Integrate feedback	Learn by doing Challenge assumptions Practicing Embody know-how	Optimal performance Increase job-satisfaction Ensure quality Achieve flow Persuasive feedback Behavior change
Degree of structure	Open-ended. Allows for meaning to emerge.	Emergent, yet deliberate. Iteratively working towards an adaptive vision informed by feedback.		Constrained. Clear, measurable goals. One right way.
Materiality	Self-created physical, *metaphorical* boundary objects that support storytelling.	Entail creating material (or digital) representations that make assumptions explicit and proposed solutions concrete and testable.	May include physical or *virtual* props or environments. Offer sensory feedback.	Typically include real, explicit, literal, physical products. May include literal, explicit, digital representations. May offer sensory and affective feedback.
Role of the participant	Share insights and generate ideas.	Propose and mature solutions.	Engage with intervention. Learn by doing.	Perform and adapt based on feedback.

Knowledge	Exploring a *mystery*. Mainly tacit.	*Heuristic* experimentation. Shifting between tacit and explicit.		Executing *algorithmic* tasks. Mainly explicit.
Underlying questions	What could be? What if..? Why?	How might we…? What if we…? Would it work if…?	How would I… act, do, feel, know? But what if…?	What is the best way to…? How many/ much? What is in it for me/ the team?
Temporality	Event (workshop).	Iterative, project-specific practice		On-going.
Facilitation	Skilled facilitator.	Self-driven team.	Automated environment.	Typically automated/ computerized or part of organization's incentive structure.

Summary of Chapter 5 (RP4)

Table 6. Research questions and main contributions for chapter 5 (RP4)

Serious Play in Multidisciplinary Student Teams	
Research questions	RQ1: To what extent are collaborative inquiry activities adapted from the LEGO® Serious Play® (LSP) method a useful approach for advancing the processes of socialization, externalization, and internalization?
	RQ2: Does the NEAP curriculum expand students' knowledge about nanotechnology and its implications?
	RQ3: What empirical recommendations can be derived from the NEAP class to guide others looking to apply LSP in higher education and beyond?
Main contributions	Shares findings on the curriculum effectiveness and student experience based on pre- and post surveys and a summative focus group.
	Shares practical recommendations for professors and facilitators seeking to apply the LEGO® Serious Play® facilitation method.

Abstract

The complex social and environmental challenges of the 21st century, referred to as wicked problems, require synthesis of different types of knowledge from multiple disciplines and communities. Nanotechnology is an example of a wicked problem and may create as many new problems as it resolves, thus warranting thorough examination and deliberation involving multiple stakeholders to ensure responsible innovation and governance. However, many conventional approaches to wicked problems have two persistent shortcomings: 1) a failure to address the difficulty of cross-disciplinary communication in the absence of interactional expertise, and 2) a failure to integrate proven creative problem solving methods. Despite nearly five decades of maturation in practices since the term 'wicked problems' first appeared in the literature in 1967, a need remains for exploring new approaches. This paper reports on a series of novel undergraduate workshops that tested the LEGO® Serious Play® (LSP) method for facilitating deliberation in multidisciplinary teams of students considering the social, ethical, and environmental implications of nanotechnology. LSP is a content neutral, hands-on facilitation method using boundary objects as a metaphorical vehicle for lowering the barriers to communication, thereby building empathetic perspective taking and increasing the "collision" of

ideas to boost the collective creativity. The paper shares findings on the curriculum effectiveness and student experience based on pre- and post surveys and a summative focus group. The LSP method proved useful in three respects: 1) it accelerated the socialization process essential for generating and sharing creative ideas by structuring interactions with material boundary objects, 2) it enabled students to externalize their ideas and perspectives in more explicit forms through the use of material metaphors, and 3), it facilitated the internalization of new knowledge. Given the role of LSP in the socialization, externalization, and internalization processes of knowledge conversion known to be essential to creativity in organizations, this experience justifies further exploration of the use of serious play methods for fostering understanding of wicked problems. The paper includes recommendations for professors and facilitators seeking to apply the LEGO® Serious Play® facilitation method.

Chapter 5 (RP4) Key Figures

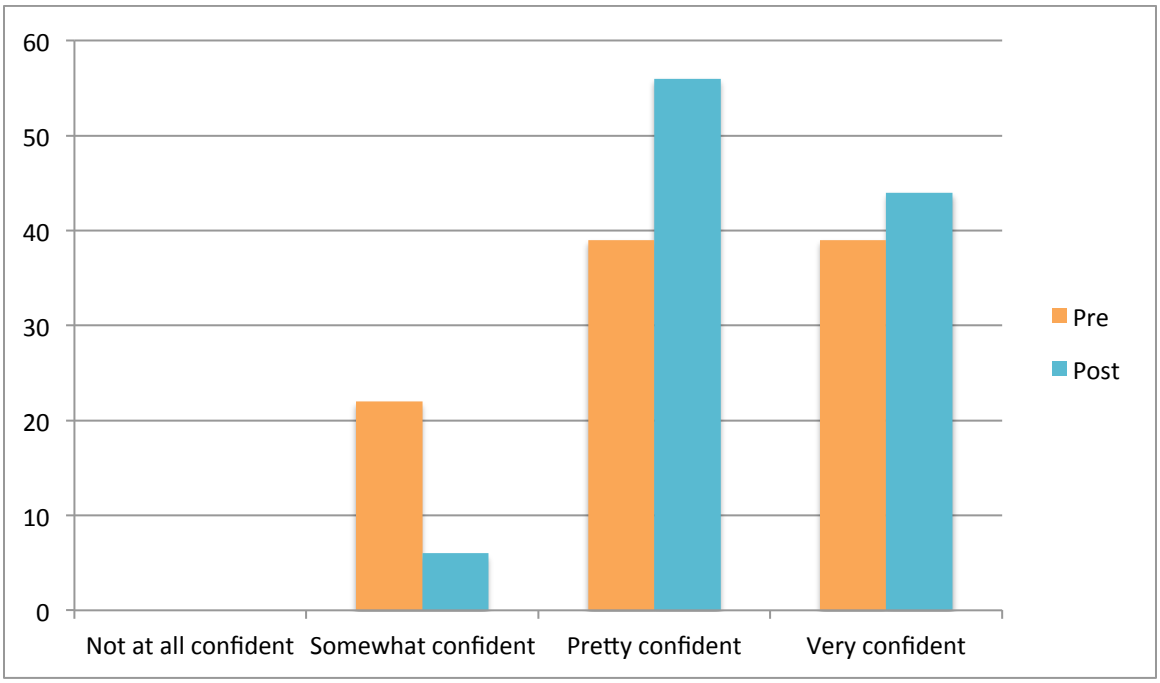

Figure 5. Students indicated an increased confidence in being able to "form new ways of thinking about complex issues" in the pre and post survey.

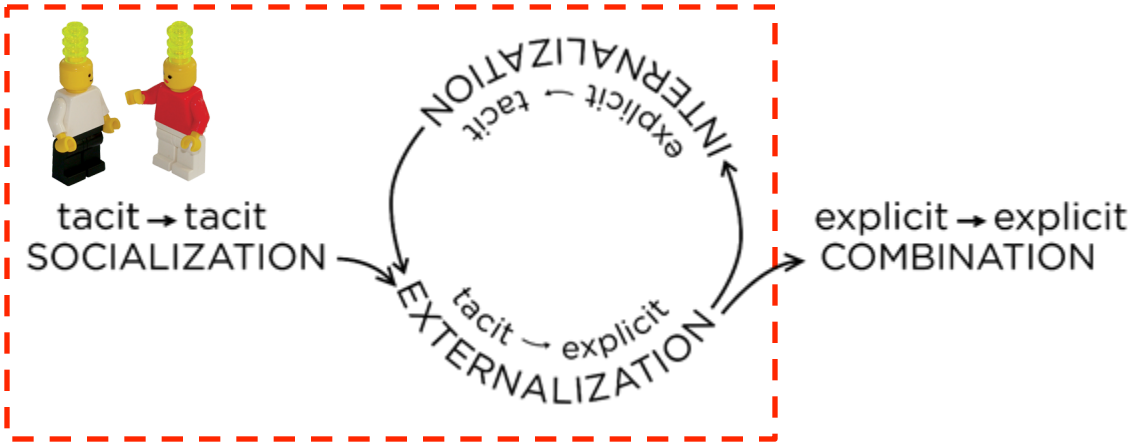

Figure 6. Material deliberation methods, such as LSP, are useful interventions in the first three phases of the Wheel of Knowledge: Socialization, Externalization, and Internalization.

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CHAPTER 2:

A KNOWLEDGE-BASED THEORY OF CREATIVITY, INNOVATION, & ENTREPRENEURSHIP

Introduction

Whereas the industrial age was characterized by business ventures that captured monopoly returns by cornering resources, supply chains, or geographic niches, the post-industrial economy has destroyed these protections through a combination of deregulation, technological innovation, and globalization (Friedman, 2005). In the knowledge age, above-market returns only accrue to ventures capable of creating, producing, and selling entirely new products (Thiel & Masters, 2014). Thus, there is now widespread agreement that all modern business value creation must ultimately be traced back to new *knowledge* (Nonaka, 2008; Martin, 2009; Drucker, 2014). In particular, Grant (1996) and others emphasize the importance of *tacit* knowledge (c.f. Polyani, 1966) that is difficult for competitors to replicate or imitate. However, development of new tacit knowledge is insufficient for successful value creation, as value can only be extracted at scale after the tacit knowledge has been made explicit (Nonaka, 2007; Nonaka & Teece, 2001).

Sharing and exploiting tacit knowledge is one of the most difficult, time consuming, and expensive challenges modern firms face (Grant, 1996; Kogut & Zander, 1992). This makes it important to explore and understand the approaches through which organizations can support knowledge creation, reduction of that knowledge to practice (i.e., innovation), and application of these practices to create business value – a process, when considered overall, is called *entrepreneurship*.

The earliest stages of entrepreneurship require discovery, whereas latter stages require replication (e.g., manufacturing, franchising, or publishing). These two stages have been broadly categorized as *exploration* and *exploitation*, and balancing them is essential for sustained business success (March, 1991, Cheng and Van de Ven, 1996, He & Wong, 2004, McCarthy & Gordon, 2011). In other words, the dynamic environment of a constantly shifting market place requires leaders to both run and reinvent their businesses at the same time (Reeves & Harnoss, 2015). As evident in table 1, the main focus of knowledge creation is on exploration and thereby

on creativity and innovation, whereas the main focus of business is typically on exploitation and thereby on innovation and entrepreneurship (application of knowledge to extract value).

Table 7. Characteristics of the activities and structures associated with exploration and exploitation.

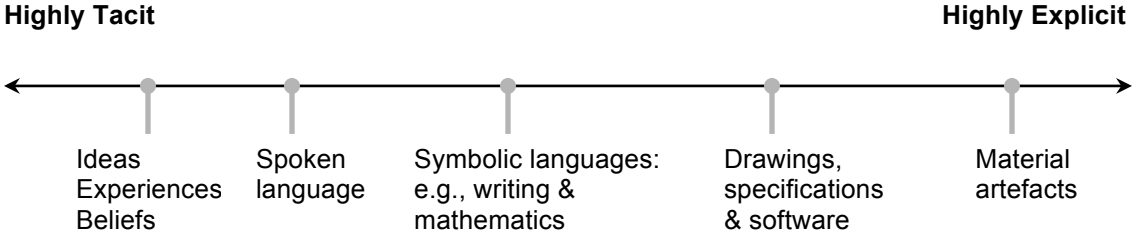
Exploration		**Exploitation**
Search, variation, risk taking, experimentation, play, flexibility, discovery, innovation		Refinement, choice, production, efficiency, selection, implementation, execution
(Cheng and Van de Ven, 1996; March,1991; He & Wong, 2004)		
Organic structures, loosely coupled systems, path breaking, improvisation, autonomy and chaos, and emerging markets and technologies		Mechanistic structures, tightly coupled systems, path dependence, routines, control and bureaucracy, and stable markets and technologies
(Ancona et al. 2001; Brown and Eisenhardt 1998; Lewin et al. 1999)		
Knowledge creation focus		**Business focus**
Creativity (Belief)	Innovation (Technique)	Entrepreneurship (Application)
(Nonaka et al., 2008; Drucker 2014)		

Despite the emphasis that popular scholars place on knowledge, there is little consensus on a unified theory of *what knowledge is* (Ayres 2016; Grant 1996). For example, some knowledge creation scholars (Nonaka et al., 2000; Grant, 1996; Erden et al., 2008; von Krogh et al., 2012) define knowledge as "justified true belief" continuously created within the firm. By contrast for other scholars, knowledge only becomes interesting when it manifests as *innovation* that improves the productive yield on resources (e.g., Drucker, 2014). In this view, there may be little managers can do to accelerate creation of new knowledge. Rather, they must monitor conditions carefully to notice when it emerges and then extract value from it through the hard work of innovation and entrepreneurship. This contrast highlights the different interests of these two lines of thought. Whereas knowledge creation scholars express little interest in commercialization (Teece in Nonaka et al., 2008), to business scholars "belief" is irrelevant until it is applied to production of valuable goods and services.

To unify these two perspectives requires a shared conceptualization of knowledge. However, no one has put forth an understanding of the evolving nature of knowledge that is applicable to the whole value creation process from exploration to exploitation. Likely, because

there is no clear consensus on what knowledge is -- particularly in terms of what qualifies as explicit, unambiguous knowledge. Grant offers the tautology: “that which is known” and acknowledges that many types of knowledge are needed within a firm to create value, but refrains from suggesting a definition of knowledge. This leaves scholars and entrepreneurs without a unifying understanding that encompasses the entire knowledge-based value creation life cycle.

To achieve such a description, this paper adds to the knowledge creation scholars’ view of knowledge as belief and the business scholars’ view of knowledge as technique, by incorporating the realization shared by engineers like Ayres (1994; 2016) and creatives like Tillander (2008) that physical artefacts, tools, and materials also constitute a *material embodiment* of knowledge[1] (see figure 7). Thus, knowledge is more than design ideas, and more than the know-how required to manufacture, it is also embodied in the devices, products and assemblies that result from the manufacturing processes. This becomes clear in the example of reverse engineering, in which a competitor seeks to acquire knowledge of how to design and manufacture a new product by examining an existing product already on the market. It is the knowledge embodied in the specific arrangement of materials, components, subassemblies, and the internal functioning of the product as a whole, that reverse engineering is seeking to acquire.



[1] Given the definition outlined above, that knowledge can be embodied in an artefact, it is important to make the

Figure 7. Spectrum rating manifestations of knowledge from highly tacit to highly explicit.

Taking these three views of knowledge together, this paper can now construct a more comprehensive understanding of value creation in which the nature of knowledge evolves from idea, to process, to product. Understanding the evolving character of knowledge along this process, and how to facilitate its conversion to new forms, is critical to business success. Therefore, this paper reconceptualizes the knowledge conversion processes originally formulated by Nonaka as socialization, externalization, combination, and internalization (SECI) in a new form called the Wheel of Knowledge (WoK). In contrast to the SECI model, which spirals in an interminable expansion of new knowledge within the firm, the Wheel of Knowledge is organized as socialization followed by an iterative externalization-internalization loop, ending in combination of explicit knowledge embodied in materials, parts, and components that become valuable products beyond the firm. This makes the new model better suited for entrepreneurship.

A Multi-dimensional Understanding of Knowledge

There is a common perception of knowledge as something intangible (Ayres, 1994; 2016; Teece, 1998). This is indeed the case at the fuzzy front end of an exploration process, where knowledge in the form of skills, know how, and ideas are tacit in the minds of individuals (Nonaka, 1994). However, as Nonaka & Teece (2001, p. 127) assert: “Knowhow does not usually command significant value until it is embedded in products. Only then can its value be fully extracted.” For both of these notions to be true require a flexible understanding of knowledge as changing across the span of a value creation process -- i.e. knowledge as a temporal, evolving phenomenon. For this I draw on Ayres (1994; 2016) and Tillander (2008) who do not limit their definitions of knowledge to human mental processes and conscious learning, but instead argue that the products of design and production (i.e., materials, tools, software, machines) are explicit embodiments of knowledge—e.g. a chair can be seen as a material representation of all the knowledge that went into designing and producing it. This notion might seem equally far from knowledge creation scholars’ “justified true belief” or business scholars’ ambiguous description of

knowledge as something that can lead to innovation, as measured by improvement on the yield of resources. Ayres however adds his unique conceptualization without contradicting either view. In fact, he acknowledges both understandings by also casting knowledge as being both “intangible” and “part of technology” thereby making its contribution to the economy (Ayres,1994, p. 154), which is consistent with e.g. Drucker’s priorities. Additionally, without using the terms tacit or explicit, Ayres is consistent with e.g. Nonaka’s conceptualizations, when explaining that some intangible knowledge can be learned only by direct experience and practice, whereas other knowledge can be accumulated and passed on in “reduced form”—e.g. in science books.

Where Ayres helps unite the two perspectives, is by conceptualizing the “extra-somatic” accumulation of knowledge as “simply an extension of learning” (Ayres, 1994, p.207).
In other words, the end product, which is key to business scholars’ focus on the yield or resources, is a natural continuation of Nonaka’s and other’s focus on knowledge creation and building capacity within the learning organization to act. This ties the two scholars’ views on knowledge together by offering a conceptualization of knowledge as being pluralistic and plastic in nature—changing over time from being intangible, tacit knowledge to becoming highly explicit knowledge in its final form, where it is embodied in a product (entrepreneurial asset). In this unified view, the nature of the essential knowledge evolves from knowledge creation scholars’ tacit, “justified true belief”, to business scholars’ idea that knowledge is embodied as efficiency of technique or production practices, to Ayres’ and Tillander’s recognition of knowledge as an explicit material embodiment in products and software (including design drawings, written specifications, and mathematical equations).

The Value Creation Life Cycle

Entrepreneurship requires connecting all three views of knowledge from ideas (belief), to processes and practices (technique), to explicit symbolic and material embodiments (artefacts), in what is call the Value Creation Life Cycle (Figure 2). Each stage is explained in further detail below.

- *Creativity* is conceiving of an original and useful idea. Creation of new knowledge begins as ideas that originate from exploring new connections between seemingly separate entities. In this stage of the process ideas are explored, challenged, formed, and matured as they collide with others. As a result, new and stronger ideas emerge (Johnson, 2011).
- *Innovation* requires reduction of creative ideas to practice. This conceptualization follows the model of United States patent law which requires explanation of an invention in explicit plans, drawings, or specifications which must be "reduced to practice" in the sense that they have been matured, proven to work, and described ("codified") in sufficient detail to allow others to reproduce the invention. (Hunter, 2013)
- *Entrepreneurship* is the pursuit of generating value (economic, social, or environmental) by identifying, developing, and exploiting new services, products, or markets (Thiel & Masters, 2014). In this view, entrepreneurship scales and exploits innovation to benefit customers, society, or the environment (Stokes et al., 2010; Drucker, 2014).

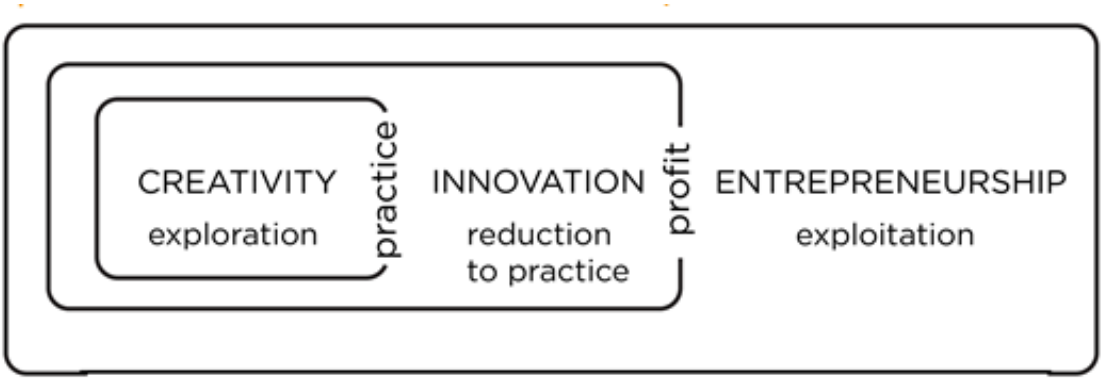


Figure 8 The Value Creation Life Cycle (VCLC).

The value creation life cycle makes clear that creativity and innovation are the essential antecedents of entrepreneurship. However, entrepreneurship is also more than just the sum of these two parts. For a novel product, service, or idea to be *entrepreneurial*, it must become usable, useful, and used. This requires the maturation, communication, and translation of a

creative idea into a practice, which can then be exploited by and for the marketplace. Thus, knowledge creation alone is insufficient for entrepreneurship (Teece, 2007). That knowledge must be translated into practice and replicated for its value to be realized outside of the organization. Moreover, only *explicit* knowledge scales (Thiel & Masters, 2014). Thus, it is possible for e.g. a surgeon, or a chef, to be extraordinarily successful such that they may earn hundreds of dollars an hour for their labor. Nonetheless, service work that depends on a high degree of tacit knowledge cannot reach mass production without being made explicit and replicable – the recipes scale, but the meals do not.

The SECI Model: Overview and Limitations

As a model that focus on the conversions between tacit and explicit knowledge the SECI model (Nonaka, 1994) provides a good starting point for understanding how knowledge can progress through the phases of the knowledge-based value creation life cycle above. It is the most cited model for knowledge creation, but is not suitable for entrepreneurship in its current form. An overview of the SECI model, followed by a reconceptualization of the knowledge modes—informed by the pluralistic understanding of knowledge, current design practices, and the ambiguous nature of language—serves as a step towards a re-interpretation that opens the SECI spiral to cover all three phases of the knowledge-based value creation life cycle.

SECI is typically used in business administration, information systems, and organizational learning, but has also been appreciated by design scholars (Dubberly & Evenson, 2011) for coinciding with certain design processes, e.g. the analysis-synthesis bridge model. The four modes of knowledge conversion occur in a "spiral of knowledge" in the following order:

- *Socialization* refers to the process of sharing tacit knowledge through direct experience. Here the conversion is tacit to tacit. Since tacit knowledge is that which cannot be reduced to explicit, it is especially difficult to share and assess (Grant, 1996). Because it is challenging to articulate, experiential, and often context depended, tacit knowledge is acquired through shared experiences and can take place without language, e.g. through

observations, apprenticeships, or informal social meetings. The socialization phase is where tacit knowledge such as shared world-views, mental models, and mutual trust can be established (Nonaka et al, 2000) – sometimes even a shared vocabulary (von Krogh et al, 2001). In this way the socialization process is a critical step to building a solid foundation for collaboration, as it serves to create high quality group tacit knowledge (GTK), which enables teams to be adaptive and improvise (Erden, von Krogh, & Nonaka, 2008). The key action in socialization is *empathizing*.

- E*xternalization* serves to convert knowledge from tacit to explicit. This process allows for tacit knowledge to be shared with others and serve as the foundation for new knowledge (Nonaka et al, 2000). An example of this conversion is concept creation in new product development. While Nonaka (1994) admits that externalization is the least developed and understood of the four constructs, he claims that tacit knowledge can be shared through dialogue, writing, sketches, and other representations aided by analogies and metaphors. The key action in externalization is *articulating*.

- *Combination* is the process of combining, systematizing, and connecting existing sources of explicit knowledge, i.e. synthesizing knowledge from many different sources in one context (Nonaka & Takeuchi, 1995). Hence, the combination mode of knowledge conversion is explicit to explicit. In this process “explicit knowledge is collected from inside or outside the organization and then combined, edited, or processed to form more complex and systematic explicit knowledge.” (Nonaka et al., 2008, p. 23) When the combination phase occurs knowledge that has surfaced and been made explicit through the externalization phase can now be captured, edited, and be made available to others in a formal manner (Martin & Root, 2009). The key action in combination is *connecting*.

- *Internalization*, which Nonaka (1994) refers to as a form of learning, is the process of converting explicit knowledge (back) into tacit knowledge, e.g. explicit protocols into tacit

company culture. Hence, in the SECI model after internalization the knowledge conversion process starts over again with socialization. “In internalization, individuals reflect upon themselves by putting themselves in the context of newly acquired knowledge and the environment where the knowledge should be utilized.” (Nonaka & Toyama, 2003, p. 6). Internalization is about embodying explicit knowledge though action and practice (Dubberly & Evenson, 2011), which can be fostered by learning-by-doing approaches, simulations, and experiments. The key action in internalization is *embodying*.

Although, the SECI model provides a structural perspective on knowledge (Newell et al., 2009) and offers a process for knowledge creation and conversion of tacit and explicit knowledge, it has limitations when it comes to entrepreneurship and the pluralistic understanding of knowledge that I have derived from Ayres (1994; 2016). The four knowledge modes outlined above occur on individual, group, and organizational levels, which Nonaka conveys through the spiral of knowledge creation and conversion *within* an organization. “Within” is key, because the model does not indicate an output to the external world as a result of the process. David J Teece (in Nonaka et al, 2008) even suggests: "Perhaps we should take Nonaka literally when he frames his theory around knowledge creating, and not knowledge commercialization." This is one of the model’s key limitations when it comes to entrepreneurship and the importance of replication compared to the WoK. Teece further asserts that Nonaka's “theory of knowledge creation needs to be married to a theory of knowledge utilization and value capture if it is to become a robust theory to guide management decisions." (Nonaka et. al, 2008, p. xv).

While the SECI model and the sub-processes provide a useful vocabulary for discussing knowledge, as inherently abstract and intangible, the fact that it does not cover knowledge exploitation prevents its full translation to an entrepreneurial perspective. Only knowledge that is explicit, and thereby easily shared and communicated, can be brought to scale and exploited through entrepreneurship. Because tacit knowledge, such as knowhow, does not yield scalable value until it is embedded in products (Nonaka & Teece, 2001), part of what makes the SECI less

suitable for entrepreneurship is the fact that the spiral ends on tacit knowledge in the internalization quadrant. This works for a knowledge creation focus where the goal is to increase learning and the capacity to act within the organization, but for entrepreneurship where the goal includes knowledge exploitation, the model must end in a mode of explicit knowledge–i.e. combination or externalization.

I hold that combination is the natural end-mode for entrepreneurship, because connecting explicit and explicit knowledge lead to scalable and replicable outcomes that can be brought to market. This fits with Ayres' (1994; 2016) conceptualization of material products as being extra somatic embodiments of knowledge. Though the assembly of explicit knowledge, e.g. in the form of chapters, code, or components, the combination process results in products that have a higher degree of accumulated knowledge and are thereby more desirable and valuable.

Nonaka (1994) acknowledges that the concept of externalization is not well developed or fully studied. Counter to Grant (1996), who defines tacit knowledge as that which cannot be uttered in formal language, Nonaka claims that tacit knowledge can be externalized into explicit knowledge through dialogue – especially metaphor and analogy. What he fails to acknowledge is that language can be ambiguous. Therefore, words are often inadequate for creating a shared understanding of an idea or concept—particularly if the project team has not had enough prior shared experiences and linguistic socialization to understand the tacit dimensions of language (Collins, 2002). Within a team that has already developed a high level of interactional expertise (Collins, 2002) and group tacit knowledge, dialogue may be a sufficient means of externalization. The more explicit and unambiguous the externalization, the less shared tacit knowledge is required on the receiving end to understand (internalize) the concept or idea conveyed.

In my view, the tacit requirements of language mean that most dialog is just socialization (i.e., tacit-to-tacit knowledge exchange), with the exception of rarified groups using specialized jargon such scientists working within a sub-specialty, or design teams that have invented their own new terms or words understood only within their highly socialized circles. Therefore, my view of externalization applies a more strict expectation than Nonaka. Inspired by Ayres (1994; 2016), design prototyping practices, and the use of boundary objects to aid knowledge exchange

in cross-disciplinary settings (Gorman, 2010), I recast successful externalization as requiring more explicit formalisms such as models, prototypes, storyboards, drawings, equations, software, or simulations. In this view, externalization can take place in synchrony with internalization (such as during demonstration of a prototype), or long after the explicit artefact is externalized.

Collaborative design and engineering practices make use of iterative and continuous externalization-internalization loops that provide feedback and allow for reconceptualization of ideas and prototypes prior to production. This is consistent with Nonaka & von Krogh (2009) who suggest that barriers to creativity and innovation can be overcome by intensifying interactions between collaborators and thereby expand the boundaries of their knowledge. It furthermore ensures an intense knowledge synthesis, an accumulative knowledge capture (e.g. externalized and materialized in models and prototypes), as well as a mutual learning process between collaborators (internalization).

The Wheel of Knowledge: Expanding SECI to Entrepreneurship

Our reconceptualization of the SECI model (see figure 3 below) bridges the full process from knowledge creation, over innovation, to entrepreneurship, thereby offering a more comprehensive understanding of the process and encouraging a sustainable innovation approach that balances exploration and exploitation. Critical to my reconceptualization is re-ordering the SECI processes such that they end with combination of explicit embodiments of knowledge in the form of materials, parts, assemblies, and software. Thus, this model could also be referred to as $S(E/I)^nC$, in that the externalization/internalization exchanges may take place many times before the solution space has been fully explored and the implications integrated into a viable product. Nonetheless, I refer to this interpretation as the Wheel of Knowledge (WoK), a cycle which has four phases. However, I argue that the two middle phases, externalization and internalization, occur iteratively and may take place simultaneously. That is, these two phenomena do not occur in a strictly linear fashion. The act of externalizing knowledge informs internalization, and vice versa. The loop corresponds approximately to the phase of "innovation" in Figure 2, whereas, socialization and combination correspond to the creativity and entrepreneurship stages,

respectively.

Figure 9 The Wheel of Knowledge (WoK) depicts the tacit and explicit knowledge conversion processes taking place in the value creation life cycle.

Design Rationale for the WOK

Many entrepreneurs adopt practical, design thinking inspired methods consistent with the iterative externalization-internalization cycle that is at the core of the Wheel of Knowledge. For example, the business model generation canvas and subsequent work on value proposition design (Osterwalder et al., 2010; 2014) advocate for a number of quick test cycles to adapt and justify ideas in explicit forms. This adaptive cycle is one of the core principles of design thinking: prototype, share, elicit feedback, reiterate. From this perspective, the conversion of knowledge through externalization and internalization should occur in a loop, much like the principle of iterative prototyping.

Nonetheless, to create value, products must eventually emerge from the externalization-internalization cycle and proceed to combination. Because the conversion processes in combination are explicit to explicit, the input to combination must be explicit knowledge from externalization, e.g. in the form of computer code, parts, blueprints or design specifications, which specifies the combination of disorganized raw materials into a new, higher value embodiment of knowledge. The Wheel of Knowledge reconfigures the SECI process to emphasize both this iterative loop of externalization & internalization (E/I) as well as the eventual emergence of explicit knowledge such as innovative products, services, or business models from the E/I cycle to the

combination stage where these explicit instantiations of the new knowledge can be scaled.

Differences Between the SECI & the WoK

To illustrate the differences between the SECI and the WoK I show how Nonaka's & Takeuchi's (1995) famous example of the bread-making machine looks through the lens of first the SECI then the WoK.

In the original bread-making machine example an R&D team struggles to design an appliance that gets the bread crust just right. A breakthrough happens, after the team's software developer does an apprenticeship with the master baker and thereby acquires tacit knowledge about the kneading process. This happens through shared experience, or what Nonaka & Takeuchi (1995, p. 105) refer to as *socialization*. Once the software developer gets back to her team she *externalizes* (transfers her tacit knowledge of) the desired features the machine must exhibit through phrases such as "twisting stretch" or "make the propeller move stronger". The engineer in the team would then try to translate those tacit descriptions into explicit machine specifications. However, for engineers that had never touched dough before, understanding (internalizing) the kneading process based on a verbal description proved inadequate. Thus, they too went to the master baker to learn the kneading procedure through shared experience. According to Nonaka & Takeuchi (1995) combination took place when the team was then able to produce a prototype by combining the "twisting stretch " concept and their technological knowhow. This example reaffirms my assertion that language is often insufficient for externalizing tacit knowledge.

The Wheel of Knowledge offers a different interpretation. From the broader perspective of the WoK, the apprenticeships and introduction of new jargon, such as "twist and stretch" are all contained within the tacit-tacit exchange of socialization that provides the team shared experiences, a shared frame of reference, and a shared mental model (alignment) of what they are trying to achieve. The socialization process also develops social bonds and builds trust within the team. Like the first step in a design thinking process this step is about empathizing with reality (what is). In this phase the team members share their perspectives of the experience and discuss

what observations (needs and insights) matter to the project. This is a way of exploring and defining the problem and solution space.

According to the Wheel of Knowledge, it is only in the construction of a prototype (or boundary object) that the shared tacit knowledge belonging to the design team is externalized. The prototype and the bread produced by it are explicit material embodiments of that tacit knowledge. Testing the machine and eating the bread is an, in this case both metaphorical and literal, internalization of that explicit embodiment in the experience of crunch, chewing and tasting that justifies the knowledge. When entering the externalization/ internalization phase the team benefits from the shared vocabulary established during socialization. As team members share their experience of eating the bread, the internalization process happens again and new ideas may emerge for modifying the prototype, resulting in a new externalization. This externalization-internalization loop takes place multiple times as prototyping is a means of learning and making the tacit knowledge explicit.

Only when the knowledge is justified as tasty bread is the prototype concept reduced to the drawings and specifications necessary for manufacturing. Here, another externalization-internalization loop is required that transfers knowledge from the design team to the manufacturing team, who must internalize understanding of the design and figure out how to obtain and combine the necessary materials, parts, and software to reliably reproduce bread machines at scale. Finally, when the manufacturing knowledge is justified in the production of new machines that meet the design specifications, the combination process can be run in earnest.

As evident from the examples above, a key difference between the SECI and the WoK is in how much of the value creation process the model includes. For Nonaka the job is done when an R&D team arrives at a prototype and the organization has learned from the experience. For Drucker that is just the beginning of the hard work of entrepreneurship: Value must be extracted from the innovation by putting it into production and bringing it to market. Hence, the WoK includes those steps in the combination phase. Table 2 below summarizes the essence and differences between the four different knowledge modes in in the SECI and the WoK.

Table 8. The table below summarizes how the SECI and the Wheel of Knowledge differ in their interpretation of the four knowledge modes.

	Definitions of the concepts		
Concept	**SECI**	**WoK**	**Main differentiator**
Socialization (Empathize)	Sharing and creating tacit knowledge through direct experience, e.g. observations or apprenticeship. Can happen without language.	← That and… Sharing, reflecting discussing through dialogue. Building mutual trust as well as shared vocabulary and mental models.	The entire SECI fits within the WoK's conceptualization of socialization.
Externalization (Articulate/ Conceptualize)	Vaguely defined. Emphasis on articulating tacit knowledge into concepts through dialogue, reflections, metaphors, and analogies.	Articulating, conceptualizing, and materializing tacit knowledge into explicit concepts through models and prototypes supported by dialogue, reflections, metaphors, and analogies. Part of the E/I loop.	SECI says dialogue is sufficient for externalization. WoK says that is often not the case, and argues for more explicit, less ambiguous representations, e.g. prototypes.
Internalization (Embodying)	Learning by doing, making explicit knowledge tacit through experience and reflections. Develop best practices and culture in the firm. Provides the foundation for the next knowledge spiral starting on socialization. Learning: personal and organizational.	Learning by doing, making explicit knowledge tacit through experience and reflections. Understanding what has been shared in externalization, fitting it into own mental models. Part of the E/I loop. Learning: project-based, personal and organizational.	SECI says internalization feeds into socialization. WoK says it feeds into an iterative externalization/ internalization loop and leads to both topic matter, personal, and organizational learning.
Combination (Connecting)	Connecting, applying, gathering, integrating, editing, transferring, diffusing, relating, and systematizing different sources of explicit knowledge. New knowledge is formed as a result of these collisions, can range	Producing, replicating, optimizing, assembling, building, bringing to scale, and connecting different sources of explicit knowledge e.g. components or code into a more valuable/useful product.	SECI says the result of combination can still be abstract or concrete (e.g. prototypes). WoK says the outcome is concrete, working products that can be taken to market.

	from a new justified true belief to a prototype.		

Conclusion

Knowledge is the most important source of value creation and it plays a key role in different ways throughout the value creation process. Having pointed out the parallels between knowledge creation scholars' and business scholars' work to respectively exploration and exploitation, I argue that the key to sustainable value creation is not found in one or the other. On the contrary, just like exploration and exploitation, knowledge creation and knowledge utilization must happen in tandem. By drawing on Ayres (1994; 2016) I have arrived at a new conceptualization of knowledge as pluralistic and plastic—evolving from intangible to extra somatic—over the course of the value creation process. This new understanding of knowledge enables me to unify the view focused on knowledge creation (creativity and innovation) within the company with the view focused on innovation and entrepreneurship. Thereby providing scholars, entrepreneurs, and managers an applied model to actualize knowledge-driven entrepreneurship.

I hold that the Wheel of Knowledge fits better with an entrepreneurial context (value creation) than the SECI, because it covers the full range of the value creation life cycle. Consequently, it ensures both continued innovation through consistent knowledge creation and exploration, but also focuses on generating a tangible, scalable outcome that can satisfy customer needs and thereby keep the company in business. A key difference that makes the WoK more suitable for entrepreneurship is that is *ends on explicit* knowledge, which is necessary for extracting value.

As any model the Wheel of Knowledge is a generalization of reality. While it is theoretically more suitable for entrepreneurship, any model is only as good as the level of skillfulness with which it is applied—macro recommendations are not always reflected in the micro implementation. To help operationalize the WoK the next chapter will offer guidance for how to implement it in an organization by distinguishing which methods drive value creation in respectively socialization, externalization/internalization, and combination.

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CHAPTER 3

THE WHEEL OF KNOWLEDGE:
CATALYZING KNOWLEDGE CREATION, INNOVATION, & VALUE EXTRACTION
THROUGH SERIOUS PLAY

Introduction

Global competition, changing technologies and market needs accelerate the product development life cycle and make creativity, innovation, and value extraction essential to the survival of the modern firm (McDonough, 1993). In recent years, the emphasis on achieving and maintaining a competitive advantage in a constantly shifting marketplace of products and ideas has only intensified (Drucker, 2014; Reeves & Harnoss, 2015; Simons, 2013). This dynamic environment requires leaders of both established companies and start-ups to run and reinvent their businesses at the same time, simultaneously re-balancing "exploration" (creation of new products and services) and "exploitation" (production of revenue to support growth) (March, 1991; McCarthy & Gordon, 2011). This balancing act calls for, novel approaches to strategy and execution in multiple parts of the value creation process (Reeves & Harnoss, 2015). For instance, Martin (2009) suggests Design thinking (Brown, 2008) as an approach for balancing exploration of new knowledge with exploitations of current knowledge, thereby accelerating the pace through the value creation process.

During the industrial age, managerial scientists such as Frederick Winslow Taylor, optimized the exploitation phase of production—deriving business value from specialization, optimization, standardization, and economies of scale to increase the productivity of manual workers (Taylor, 1911). In the pursuit of economic efficiency, and based on the principle that workers are motivated by carrots and sticks, Taylor would measure, analyze, specify, and optimize the workflow down into the smallest detail—and then reward workers that performed it as prescribed and punish workers that did not adhere to these standards. This type of management requires a hierarchical, top-down structure, which cast managers as authoritative, monitoring, and controlling, and workers as lazy, selfish, and in need of being managed—

consistent with what McGregor describes as Theory X (McGregor, 1960). Although not an ennobling environment for the workers, Taylor's achievement of increasing manual worker productivity did provide a foundation for economic and social gains of the 20th century (Drucker, 1999). However, to successfully manage and motivate knowledge workers (Drucker, 2002; Mladkova, 2012; Water & Beruvides, 2012) requires a different environment more consistent with Theory Y (McGregor, 1960). This view casts managers as collaborative and trustful of their subordinates, and the workers as being responsible, deserving autonomy, and striving for self-development and mastery.

The fact that scientific management approaches were so instrumental in improving production and creating wealth in the industrial era makes it very tempting to apply the same Tayloristic approaches of measurement, optimization, and top-down control to the whole process of knowledge management (Deming, 1986; Simons, 2013). However, these approaches are only meaningful when dealing with explicit knowledge, which is codified, formal, and systematic (Nonaka & Takeuchi, 1995). During exploration, knowledge workers play a critical role in identifying opportunities and generating ideas, as well as maturing concepts into innovations, which can then be scaled through knowledge exploitation. Relying on management approaches suitable for exploitation can actually be detrimental in the exploration phase, because they tend to narrow the focus and stifle creativity (Amabile, 1998; Pink, 2011). Acknowledging the need for more ambidextrous approaches, leading experts on business strategy lament that the essential tools and techniques employed by modern management have changed little over the last two generations (Hamel & Breen, 2007). As such, understanding how to enhance the knowledge worker's creativity and productivity across the entire span of the value creation process remains one of the most relevant challenges of the 21st century (Drucker, 2014; Frick, 2011; Mladkova, 2012).

True to the Tayloristic spirit of optimization, Drucker used to think that there was "one right way" to manage people—or at least there should be." (Drucker, 1954; 2007, p. 14). He however abandoned this view after reading Maslow's book *Eupsychian Management*, now "Maslow on Management" (Maslow, 1998). Eupsycian means moving toward psychological

health or self-actualization, which is consistent with the top of Maslow's famous pyramid of needs. This convinced Drucker that different people have to be managed differently.

While there might be as many "best ways" of managing, as there are knowledge workers, there are still some generalizations that can be made not about the individual knowledge workers, but *about the type of knowledge work* they engage in. While there is currently little recognition of the connection between the character of knowledge and strategies for knowledge management (Pink, 2011), this chapter asserts that as the character of knowledge changes throughout the value creation life cycle—so must the knowledge management strategies.

A Pluralistic Understanding of Knowledge

Jensen et al. (2017a) corrects the misconception that knowledge exists only as justified true *belief* (Grant, 1996; Nonaka, 1994) and that it becomes useful only in the *techniques* through which it is applied (Drucker, 2014). In fact, knowledge can also be *embodied* in human artifacts, such as equations, software code, blueprints, specifications, materials, and products (Ayres, 1994; 2016). Synthesizing these narrow foci of what knowledge is allows for a *pluralistic understanding* of knowledge, which spans the entire value creation life-cycle from idea to production. It stands to reason that those scholars that view knowledge in a single way would consistently prescribe management techniques that have been proven effective for the type of knowledge they understand. However, the realization of knowledge as a pluralistic concept that evolves from abstract (e.g., beliefs), to technique (e.g., technology), to material embodiment (e.g. products) requires a greater breadth of knowledge management options (Jensen et al., 2017a; Ayres, 1994; Ayres, 2016). Success in knowledge management depends on matching the right management techniques to the character of the knowledge.

Counter to the prevailing view in most companies of knowledge management as a branch of information technology (Helgesen, 2008), here knowledge management techniques are viewed as enablers of the in-depth learning and the value creating interactions and activities that must take place in each of the phases of the value creation process (socialization, externalization/ internalization, and combination) (Jensen et al. 2017a). In other words, the appropriate

knowledge management techniques are those that enable the knowledge worker to be in the right frame of mind for doing the type of work called for in the relevant phase.

The Evolving Character of Knowledge

Both the nature of knowledge and knowledge work evolve throughout the value creation process. While Pink (2011) frames the concepts *heuristic* and *algorithmic* as types of knowledge work, Martin (2009) adds *mystery* as the precursory knowledge work and integrates the three concepts as consecutive stages of a model, known as the Knowledge Funnel (Martin, 2009, p.8). Upon introducing these three types of knowledge work—which are dominant at each their stage of the value creation process—this section critiques the Knowledge Funnel model and proposes an alternative model informed by knowledge management literature and iterative design practices.

Mystery (Creation)

Moldoveanu (Martin, 2009) describes the knowledge work at the fuzzy front-end of exploration as dealing with a *mystery*. Many discoveries are made because something in our environment triggers our curiosity, but elude our understanding. Moldoveanu argues that the route out of this mystery state begins with a hunch, a pre-linguistic intuition. Hence, knowledge, in the early stages of the value creation process, starts out as personal, abstract, tacit hunches, beliefs, and ideas (Grant, 1996; Polanyi, 1966) and the pursuit hereof can be motivated by intrinsic drives like curiosity. Sharing, developing, and exploiting tacit knowledge is one of the most difficult, time consuming, and expensive challenges modern firms face (Grant, 1996; Kogut & Zander, 1992), partly because it can only be made shared through direct, collective experiences, also referred to as *socialization* (Nonaka, 1994; Jensen et al., 2017a).

Heuristic (Experimentation)

Next comes the challenging task of making the tacit knowledge explicit, which is a necessity in order to conceptualize, explain, test, and fully understand and improve upon the idea

(Rodgers & Clarkson, 1998). This process ultimately turns what was once tacit knowledge into an innovation, an explicit representation of knowledge that has been reduced to practice (Hunter, 2013). This type of knowledge work, characteristic for the exploration phase, is *heuristic* and requires creativity, as there is no predefined route for the process, which would guarantee a successful outcome (Pink, 2011). In R&D teams and other design-minded contexts this way-finding process happens in an iterative loop of *externalization and internalization* (Jensen et al., 2017a*)*—i.e. through the development of a prototype (solution proposal), which is then tested and receives feedback on how it can be improved. Here knowledge comes into play both as technique and as something that is embodied in a physical structure. Once the idea has been reduced to practice and matured into an explicit form that is useful and usable, it is ready to be brought to scale and exploited.

Algorithmic (Execution)

The final stage of the value creation process deals with value extraction. Here the *combination* of explicit knowledge with other explicit knowledge – e.g. in the form of assembling components or compiling computer code. Pink (2011) categorizes the type of knowledge work associated with exploitation as *algorithmic*—in the sense that there is a clearly defined goal and the (knowledge) worker can follow a set of established instructions to complete the task, much like the manual workers in Taylor's factories. For algorithmic knowledge work—which might be complicated, but has a low level of complexity, and require little to no creativity—incentives and rewards have a positive correlation with productivity (Caniëls et al., 2009; Amabile, 1996). This type of knowledge work, which is routing and follows a logical script, is often automated or outsourced. Examples are robotic assembly lines and customer service call centers that are moved to India. A way to motivate knowledge workers to improve their performance in algorithmic, rote tasks is to make it into a game (Pink, 2011).

Knowledge Process Models

Martin (2009) depicts the process of going from mystery, to heuristic, to algorithmic as a "knowledge funnel", which narrows down the solution space in a sequential, non-iterative fashion. However, like the waterfall model for software development (Laplante & Neill, 2004), this type of model only accommodates straightforward design challenges. They are too linear and deductive to accommodate complex problems, which are not amenable to reductionist approaches (Rittel & Webber, 1973). Instead, this chapter builds upon the Wheel of Knowledge (WoK) model (see fig. 1) introduced in the "A Knowledge-based Theory of Creativity, Innovation, & Entrepreneurship" chapter (Jensen et al., 2017a), which offers an iterative approach to innovation.

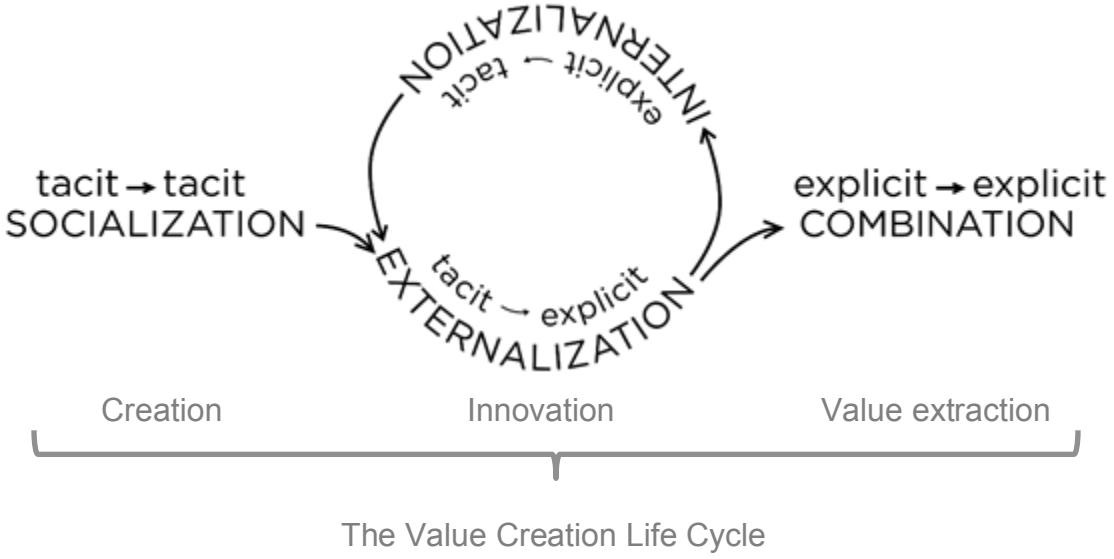


Figure 10. The Wheel of Knowledge (WoK) depicts the tacit and explicit knowledge conversion processes taking place in the value creation life cycle (Jensen et al., 2017a). Because this model is particularly geared towards entrepreneurship/intrapreneurship, creation is a prerequisite for innovation, and innovation is necessary for value extraction to occur.

The Wheel of Knowledge is an expansion and reconceptualization of the SECI knowledge creation model (Nonaka & Takeuchi, 1995), which is known for embracing the ambiguity, fluctuation, chaos, and uncertainty characteristic of real world conditions (Kawamura, 2016). Whereas, the SECI model is a recursive spiral suitable for knowledge creation *within* an

organization, the Wheel of Knowledge is organized as an iterative loop with a forward progression that enables it to encompass the full value creation process of knowledge creation, innovation, and entrepreneurship (production). For this reason, and because the WoK ends on explicit knowledge, it is suitable for knowledge processes geared towards entrepreneurial and intrapreneurial ventures. In business contexts there is a need for explicit outcomes, as value can only be extracted at scale after the tacit knowledge has been made explicit (Nonaka, 2007; Nonaka & Teece, 2001).

This chapter aims to help organizations match the right type of serious play knowledge management technique to the type of knowledge challenge they face. First, the paper introduces the concept of serious play and argues why playful approaches are uniquely positioned to benefit the knowledge worker's creativity and productivity in different types of knowledge work. Next, examples of these approaches are disaggregated and mapped onto the phases of the Wheel of Knowledge to clarify which types of serious play approaches have affordances that support: 1) *socialization* by creating environments for knowledge workers to share tacit knowledge, 2) *externalization/internalization* by offering an iterative process of prototyping and feedback that makes tacit knowledge explicit and explicit knowledge tacit, 3) *combination* of explicit knowledge with other explicit knowledge by making rote, algorithmic tasks more game-like. Lastly, a discussion of the importance of matching the right serious play intervention with the knowledge challenge at hand as well as the criticality of a skilled facilitation of serious play methods.

Play As The Way

Based on the pluralistic understanding of the character of knowledge and the related types of work as evolving over the course of the value creation process, this chapter suggests serious play as an equally pluralistic management approach for eliciting persistent engagement (the action) and intrinsic motivation (the drive).

Making The Case for Play

The separation of work and play became particularly distinct during industrialization, when the assembly line replaced craftsmanship and workers lost autonomy. Henry Ford and Taylor were big proponents of this division. Ford famously stated: “When we are at work we ought to be at work. When we are at play we ought to be at play. There is no use trying to mix the two. The sole object ought to be to get the work done and to get paid for it. When the work is done, then play can come, but not before.” (Ford, 1922/2006, p. 106). In the industrial era, simply gaining compliance from the workers was sufficient, which made extrinsic, contingent rewards, such as payment and bonuses, suitable management techniques. However, compliance is less relevant in today’s economy, where the challenge is to create and extract value from new knowledge, rather than from specialization and optimization of algorithmic, manual work (Nickols, 2000). For modern knowledge workers to make meaningful and novel contributions requires creativity, persistence and genuine engagement—not just compliance. This has naturally led organizations, researchers, and practitioners in the knowledge economy to search for alternative management strategies that better serve their purposes.

Some thought leaders have heralded play as the way. For example, Richardson (2011) forecasts that countries that take play seriously, by nurturing it in education and the workforce as well as formalizing play as a national effort, will reap the financial and societal benefits and gain a competitive edge. Similarly, Pat Kane predicted, “Play will be to the 21st century what work was to the industrial age—our dominant way of *knowing, doing & creating value*.” (Kane, 2011, emphasis added). Even earlier, Abraham Maslow asserted “Almost all creativity involves purposeful play”. A rising interest in playful approaches (Suorsa, 2015) may prove these thought leaders right.

Getting Serious About Play

Play typically creates associations to hedonic leisure – or is dismissed as something children do for fun and enjoyment. For this reason, the concept "serious play" (Schrage 2000) may sound like an oxymoron, but it is in fact the synergistic relationship between these two

seemingly contradictory concepts that makes it powerful. While the lighthearted side of play emphasizes and encourages imagination, creativity, experimentation, taking risks, suspending judgment (Gauntlett and Holzwarth, 2006), challenging assumptions and boundaries, and moving beyond win-lose scenarios (Rumore, 2016), juxtaposing seriousness and playfulness fosters a deeper engagement with challenge (McGonigal, 2015).

While play can be fun, it also offers an innate element of earnestness. Now, serious play is applied to serious challenges in serious work-related contexts. Serious play is purposeful – with an intentionality that goes beyond simply having fun (Rieber et al., 1998; Roos, 1999; Statler et al., 2011). This side of play is what gives participants a sense of urgency, being in the present moment, on a mission where they are fully engaged, aptly challenged and dedicated with a complete focus on the task at hand (Csikszentmihalyi, 1975). According to Brian Sutton-Smith, Dean of Play Studies at the University of Pennsylvania, “To play is to act out and be willful, as if one is assured of one's prospects” (Sutton-Smith, 2009, p. 198).

The benefits of serious play approaches are often framed in terms of the cognitive, social, and emotional (Mabogunje et al, 2008) benefits to the participants, which are interrelated and construe a foundation for constructive collaborations and motivation. Cognitively, play approaches can enable participants to draw on their creativity and imagination (Piaget, 1951; Papert, 1996) and pave the way for breaking out of established patterns and taking on new perspectives (de Bono, 2010). Socially, situations enhanced by play develop new frames for interaction (Vygotsky, 1978), breaking conformity and increasing the crosspollination of ideas and knowledge sharing in organizations. Emotionally, play approaches can provide participants positive affective associations with the activity and interactions, “as well as a safe context in which to take risks, to try on new roles, and to explore new potential forms of practice” (Holliday et al., 2007, p. 128). Both laboratory studies and longitudinal studies in organizations have established that our emotional state affects our creativity and productivity, showing that positive affect makes us more creative and productive (Barsade & Gibson, 2007; Amabile et al., 2005). Csikszentmihalyi (1975) finds that, contrary to popular belief, the best moments are not when we are relaxed and passive or simply “having fun” (though that can be enjoyable) – rather it is when

we feel full of purpose, deeply engrossed, and when the challenge at hand match our abilities. He refers to this zone of optimal experience as flow. When we are in flow time seems to pass quickly and self-consciousness dissolves. This can occur in both work and play, in fact Csikszentmihalyi (2000, p.190) explicitly stated that “the boundaries between work and play are artificial”.

What Serious Play Is

While play in some communities is celebrated as rebellion against Taylorism and as a way of making work more fun—for example by infusing frivolous, autotelic play (e.g. DeKoven, 2002)—the concept of *serious play* (SP) refers to applying playful methods to a serious, typically work-related challenge (Statler et al., 2011). Serious play is an umbrella term for an array of innovation and facilitation methods typically used to foster intrinsic motivation, collaboration, experiential leaning, deep engagement, and creative problem solving. According to Schrage (2000, p. 2), who helped popularize the term, serious play approaches include “any tools, technologies, techniques, or toys that let people improve how they play seriously with uncertainties.” Therefore, serious play is not about the physical or digital output of these processes, but rather about fostering behaviors and interactions (i.e. *doing*) that lead to the by-products: creativity, innovation, and entrepreneurship.

The Need for Guidance

While there exists an array of serious play methods—from "energizers" to prototyping methods and from open-ended, emergence-oriented interventions (e.g. material deliberation methods) to goal-achievement-oriented interventions (e.g. simulations and gamification). Distinguishing between the different types, understanding their affordances, and knowing which to choose when can be confusing, especially because authoritative sources on serious play (e.g. Schrage, 2000; Brewer & Shubik, 1979) present the different approaches as a more or less monolithic entity with fuzzy distinctions between, for example, models and prototypes, or games and simulations.

Nonetheless, not all serious play methods are alike. The failure of scholars to differentiate makes it difficult for organizations to recognize which methods are suitable for their goal/process. It is problematic when organizations attempt to embrace and apply unconventional methods without knowing how to prescribe the right type of intervention for the right type of knowledge processes and they are unlikely to achieve the desired outcomes. In fact, applying unsuitable methods might make things worse—both on a solution and process level—exacerbating the situation by generating solutions with undesirable consequences (Camillus, 2008) and leading to diminished stakeholder buy-in, engagement, and creativity levels (Deci, 1971; Caniels et al, 2014). Based on a negative experience like this, the organization may likely draw the conclusion that all serious play approaches are useless and refrain from applying them in the future when in fact they failed to match the serious play approach with the character of the knowledge work—and thereby picked the wrong type of serious play method from the process toolbox. Thus, organizations need guidance on: 1) distinguishing between different types of serious play, and 2) matching a useful type of serious play with the character of the knowledge and the stage in the process.

Untangling Serious Play Approaches for Knowledge Sharing and Innovation

It is critical to provide succinct definitions and to discern how the characteristic affordances of serious play approaches differentiate before deriving guidelines about their applicability. This section serves to disaggregate selected approaches that are often conflated and used interchangeably under the umbrella term serious play.

Inadequate Distinctions

For decades serious play approaches such as models, prototypes, simulations, and games have been appreciated for their ability to stimulate innovation, support complex problem solving (Schrage, 2000), scaffold experiential learning (Abt, 1970) and enable strategic decision-making (Brewer & Shubik, 1979). While these authors do provide real-world examples of how serious play approaches can serve to reunite *action* and *thought* in various contexts (e.g. military,

industry, education, government, Abt, 1970)—they neglect to distill what differentiates models, prototypes, simulations, and games. Brewer and Shubik's book *War Games* (1979) first identified the confusion in the vocabulary by noticing that various disciplines use the same terms, but attribute different meaning to them. They presented some basic definitions, but end up nesting concept that make them difficult to classify—e.g., games are described as being based on simulations, which again are based on models. Even after acknowledging the inaccuracy of using the terms interchangeably, Schrage (2000) claims that the term model embraces both simulations and prototypes, and avoids providing succinct definitions with the excuse that advances in technology makes distinguishing between them less and less meaningful.

The lack of a consistent vocabulary presents an obstacle to establishing a shared scholarly understanding of these tools and for advancing the field of serious play methods for knowledge sharing and integration. Distinguishing the semantics can enhance the understanding of what is meant when referring to a manifestation as a model, prototype, simulation, or game. Having a shared vocabulary can support and direct collaborations across disciplines by clearly signaling the purpose and intend of a given manifestation.

Even if practitioners will continue to use the terms interchangeably, succinct definitions and differentiations of serious play approaches are necessary for scholars to be able to formulate a theory that provide guidance on which knowledge process each serious play approach is suitable for.

Models

Models are simplified representations of reality (Greca & Moreira, 2000). They emphasize certain features (of reality) to draw our attention to them and allow us to draw inferences about the real world based upon what we perceive in the models. In contrast to prototypes, models are descriptive -- i.e., tools by which the creator investigates and develops theories about what *is* (Vorms, 2011) rather than envisioning what *could be*. They also serve to share and illustrate these theories to a wider audience (Monk, 2012). The term model derives from the Latin word modellus—meaning a standard or measure. Hence, the term in modern English can either refer

to an idealization, such as a fashion model or model home, or a scale model that faithfully reproduces relationships present in the real world. However, all models are distortions of the reality they represent. For example, if a model of a car or a handbag is 100% accurate in its representation of materials, scale, relationships, and functionality, it is a copy, not a model (Kühne, 2005). Models are representations – not direct reflections - of reality, which means that the creator's interpretations and knowledge of reality influence the outcome (Monk, 2012).

Various disciplines use different types of models, including physical, digital, textual, graphical, numerical, and mathematical (Kulakowski et al., 2007). Models can employ metaphors, analogies, and symbols (McCusker, 2014) and be literal or abstract. This also means that models need not have a physical or even digital instantiation. In fact, some models are tacit and exist solely in the mind. These internal models, known as mental models, are systems of beliefs constructed in our mind to make sense of how the external world (physical or social) might work (Johnson-Laird, 1983). A mental model is not a model in a formal sense, as it does not necessarily have a strict mapping between elements in the mental model and how they are in the real world (Morgan et al., 2001). Rather, a mental model is a hypothesis that can be more or less accurate, i.e. it can be incomplete or even in conflict with the accepted scientific model. However, mental models serve as a starting point for formulating a theory, test our assumptions against observations, and presumably revise our belief system when it is contradicted by observations. This process provides opportunities to adjust our mental models and thereby improve their accuracy (Chi, 2008).

For an applied project to benefit from the insights residing in the mental models of the individual collaborators, mental models must be made shared. This is difficult because mental models are tacit (Erden et al, 2008). However, a great way of externalizing mental models and integrating knowledge from various disciplines in a project can be through the creation of socalled *boundary objects* (Gorman, 2010), which can be physical models, prototypes, diagrams, or sketches that are “plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. The creation and management of boundary objects is key in developing and maintaining coherence across

intersecting social worlds" (Star & Griesemer, 1989, p. 393). A context relevant example of boundary objects is influence diagrams (Sweet et al., 2014), which are graphical representations of cause-effect relationship beliefs that have been employed to improve environmental risk communication between expert and lay audiences (Chess et al., 2002).

Prototypes

Prototypes are representations of design (Buchenau & Suri, 2000). In contrast to models, prototypes are prescriptive and thus emphasize what should be (according to the designer), rather than what is. As the prefix proto- (meaning "first" or "original") suggests, prototypes are typically tentative representations of design ideals, meant to be experimented with and tested, so that changes to the prototype can result from the experience.

Prototypes are integral steppingstones when changing something from an existing to a preferred state (Simon, 1969). Due to the challenging ambiguity and uncertainty of such a process, prototypes play an integral role in the work of designers and engineers (Gerber & Carroll, 2012). The purpose of prototypes varies in the different stages of the design process: from exploring and generating ideas, to understanding the experiences, needs, and values of the user, to evaluating and testing the design. Across the process prototypes serve as important means of communication among the design team members (Lim et al., 2008) and when eliciting feedback from stakeholders. During the design process a multitude of prototypes are made to express and test certain aspects of a product or system as the design team discovers a satisfactory solution. Hence, a good prototype is a "manifestation that, in its simplest form, will filter the qualities in which the designer is interested without distorting the understanding of the whole." (Lim et al., 2008, p. 7:4).

A key difference between a model and a prototype is in what constitutes improvement. Should the creator of an artifact (model or prototype) improve it by making it a more true representation *of* reality, then the creator intends the artifact as a model. However, should the artifact be improved in the mind of the creator by making it an improvement *on* reality (i.e., a design), then it is intended as a prototype. Thus, whether something is a model or a

prototype depends entirely on the meaning imparted to it. Because the critical difference between a model and a prototype is not determined by inspection of the characteristics of the artifact, but by the intention of the creator and interpretation by the observer (and these can be in conflict) —the terms model and prototype are often confused and used interchangeably in the literature on innovation, creativity, design, and serious play.

While *products* are typically an example of a final outcome of a value-creation process, current technology enables constant iterations and updates to apps and software products, allowing them to be released before they are fully tested and done. Actually, "done" seems like an overstatement considering the constant changes post-release. Developers harness end-user feedback gathered through online surveys and communities and leverage these insights to continuously improve their products and thereby better accommodate user needs. I hold that it makes sense to refer to this category of products as *proto-products* - in that they are released products but under constant revision, making them a hybrid between products and prototypes.

Simulations

A simulation is the process of interacting with a model or a prototype (Smith, 1998). In a simulation users may experiment with key characteristics of a system by manipulating independent variables. Hence, simulations require *doing*. Simulations offer a way to model or prototype system behavior and to test the consequences of decisions when it would be too expensive, dangerous, complicated, or impractical to experiment with the real-life system—or when the real life systems simply does not exist yet (Sokolowski & Banks, 2009). Examples of simulations range from fire drills and weather forecasting to "tangible landscapes" (Sternstein, 2016), flight simulators (Axelrod, 1997), and robotic patients (Kunkler, 2006). When the purpose of simulation is to gain insights into how a system currently functions and how to operate within these constraints, the representation is a model. Take for example pilots training in a Boeing 747 flight simulator. They are in a simulation based on a model because it is a simulation of something that already exists. In this case, the simulation would be improved by making it more true to the real situation that the pilots may later face, because the purpose of the simulation is to

increase their ability to act in the real world. If in contrast, a simulation is developed to discover the long-term real-world effects of alternative conditions and courses of action for improving a design, the representation is a prototype. Say the pilots are asked to offer lead-user feedback on a concept stealth aircraft that is still being conceived of, they would be in a simulator based on a prototype. Here the goal of the simulation would be to improve a future design, not the pilots. The quality of the simulation can be measured by it's ability to convey the relevant aspects of the design, allow for interactive experimentation, and elicit feedback, since these parameters are key to improving the design. Whether the simulation is based on a model or a prototype have everything to do with the intention behind the representation and whether it is a representation of the world as it is or the world as it could be.

Games & Gamification

Games can be described as ‘structured forms of play’ (Dubbels, 2008) that motivate certain behaviors and behavior changes in the participants. Like simulations, games offer experience-based learning and the act of doing is key to both. However, in contrast to simulations, games bring an extra layer of engagement by involving, not just the players' cognitive capacity, but also their *affective* state of mind. In that sense a game can be defined as “a rule-based system with variable, quantifiable outcomes, where the different outcomes are assigned different values, and where the player exerts effort to influence the outcome and *feels deeply attached to the outcome”* (Juul, 2002, https://www.jesperjuul.net/text/gameplayerworld/). There are four defining traits that games share across genres and technological complexity: 1) *goals* that provides the player a sense of purpose, 2) *rules* that place constraints on how the player can attain the goal, 3) a *feedback system* that tells the player about their progress towards attaining the goal, and 4) *voluntary participation* which ensures that every player accepts the goals, rules, and feedback. (McGonigal, 2011)

While the word “game” often evokes references to frivolous fun and childish activities, there is considerable research indicating that games can improve learning and motivation (Mabogunje et al., 2006; Forlizzi et al., 2016). Games have been used for education and training

in the military since the 1970s (Brewer & Shubik, 1979; Abt, 1970) and in recent decades higher education and private industries have started to follow suit (Walz & Deterding, 2015).

The applications of serious games are two-fold, both have to do with facilitating behavior change. Much like prototypes, models, and simulations, innovation games can be "tools to think with" during the creative process to break out of habitual thinking and to elicit input from stakeholders (Gray et al., 2010; Hohmann, 2006). Games can also be the product of a creative process, i.e. a solution to real world problems, especially those that require behavior change. An example is the financial management tool, Mint.com, which leverages gaming principles to help its users become aware of and motivate them to change their financial behaviors (Dole, 2010).

The terms game and simulation are often used interchangeably, which can cause confusion. While there exists an overlap between games and simulations, "only some games are simulations, and only some simulations are games." (Ochoa, 1969, p. 105). That is, many games make use of simulated environments, but not all simulations are games (Brewer & Shubik, 1979). The cases in the overlap can be referred to as simulation games (see Figure 2). Simulation games have game-like characteristics, for instance feedback such as point systems or badges (Ochoa, 1969; Juul, 2002), but do exhibit not all game defining characteristics, e.g. simulation games might not have a valorization of outcomes (Juul, 2002).

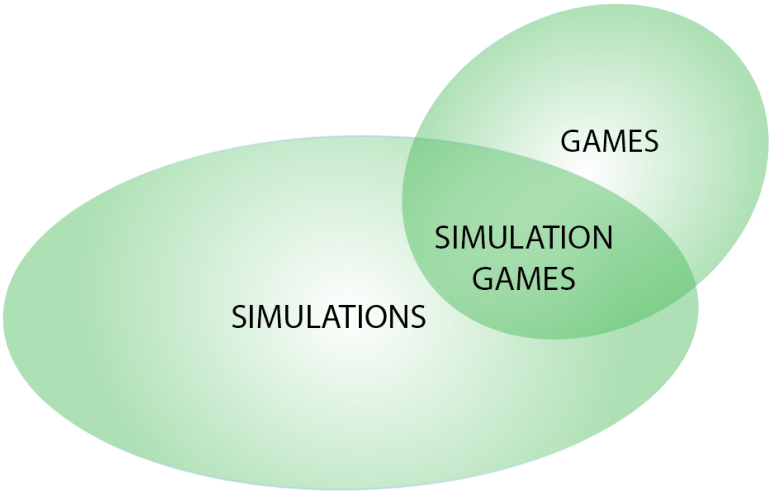


Figure 11. Simulation games exist in the overlap between games and simulations.

Generally, simulations strive for an accurate representation of a current or future reality and map primarily to the cognitive aspects of the mind. In contrast, games can be fictional, tend to focus on the experience and deep engagement, and thereby map to the affective aspects of the mind (Mabogunje et al., 2006). Thus, games are improved by making them more engaging, while simulations are improved by making them more true to reality. Consequently, simulation games are improved by both parameters. To recognize a game one might notice whether the interaction with the representation creates intrinsic motivation in the player, e.g. in the form of being emotionally invested in the outcome.

Simulations can also be confused with visualizations. Visualizations can be defined as visual representations of information or concepts (Tufte, 2006), e.g. diagrams, charts, MRI pictures. However, visualizations can also be tacit and exist only in the imagination—e.g. the techniques professional athletes make use of when they imagine themselves achieving their goals as a way of programming their mind for success (Porter, 1990). To be differentiated from visualizations, models, and prototypes, simulations must offer some sort of sensory experience that allows users to interact with it through manipulating independent decision variables. Hence, a system is only a simulation if it allows the user an active role as a decision maker, and not just as a passive observer.

Mapping The Applicability of Different Approaches

Figure 2 below offers a visual representation that maps models, prototypes, simulations, and games according to their applicability in the phases of the Wheel of Knowledge. The vertical axis of *prescriptive* to *descriptive* is one dimension that helps organize these examples of serious play approaches, while the horizontal axis from intrinsic to extrinsic motivation as drivers of the work is another.

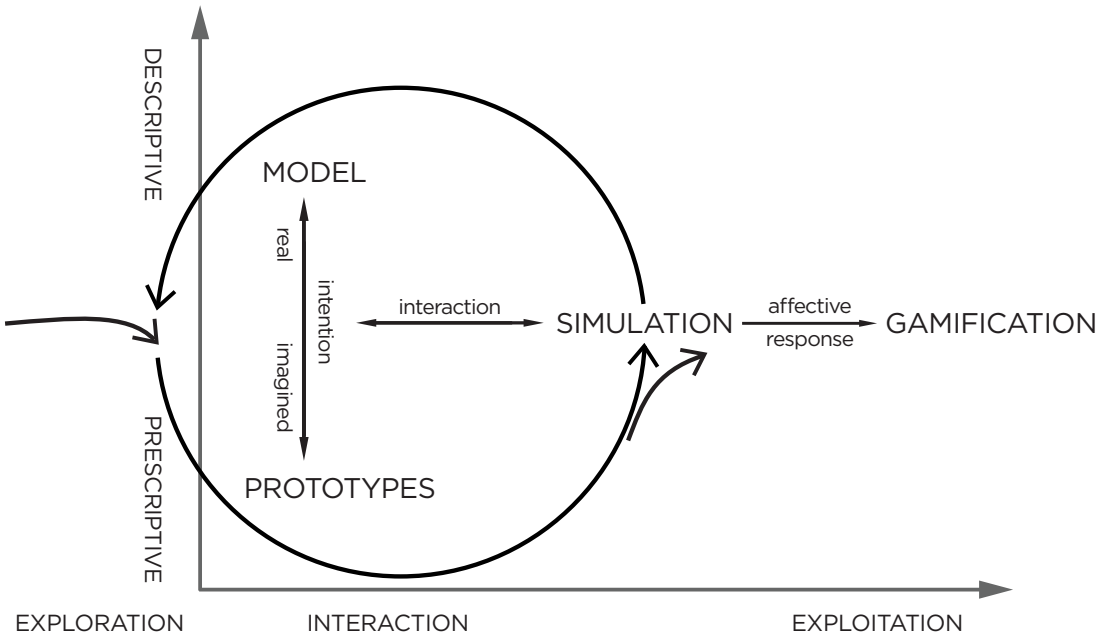


Figure 12. The relationship between models, prototypes, simulations, and games/gamification arranged according to their suitability for representing descriptive versus prescriptive purposes and whether the motivation for doing the work is mainly intrinsic or extrinsic. The Wheel of Knowledge graphic is superimposed to indicate in which phase each approach is most applicable.

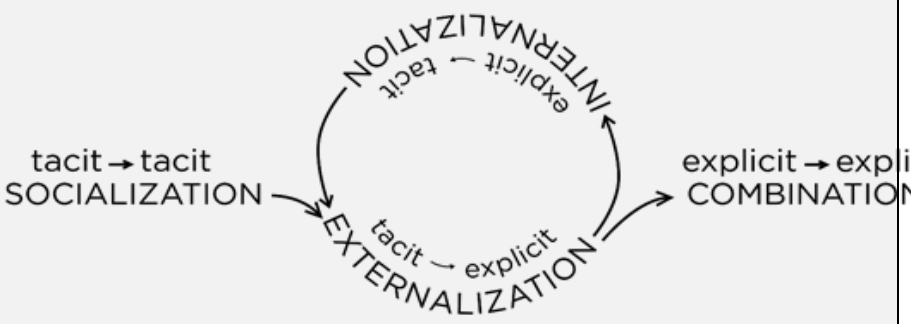
When an organization is faced with a challenge related to knowledge-driven value creation and must select between different serious play approaches, it is useful to be clear about the goal—i.e. consider what *end* the type of method should be a *means* to. According to Figure 2, if the focus is future-oriented, for example developing new products and services, it makes sense to work with prototypes rather than models, as prototypes are *prescriptive*. If, on the other hand, the goal is to convey a current or historical situation, it is better conveyed through a model, as models are *descriptive*.

Mobilizing Knowledge Throughout The Value Creation Process

By synthesizing three different definitions of knowledge – belief, technique, and embodiment – the WoK's pluralistic understanding of knowledge spans the entire value creation process (Jensen et al., 2017a). What the WoK superimposed on Figure 2 reveals is that the popular literature on serious play, as exemplified by Schrage (2000) and others, is predominantly focused on approaches for the *innovation* phase of the value creation process, where the iterative externalization and internalization loops dominate the knowledge conversion processes. However, these popular books on serious play neglect the prerequisite *creation of knowledge* through the *socialization* phase*,* which creates the foundation for *innovation* that reduces new ideas to practice. To some extent these sources also neglect the *exploitation of knowledge* in the final *combination* phase, where value is extracted from the application of knowledge validated in the preceding innovation phase.

Different types of serious play approaches can be useful across the spectrum of the value creation process. Therefore, it is also critical to include serious play approaches that support the socialization phase and the combination phase. The literature describing these phases of the WoK exist in other areas that have heretofore been largely disconnected: knowledge management, serious play approaches for creativity, and gamification approaches to improving productivity. Many authors have presented overlapping concepts that describe similar attributes and characteristics of the value creation process using different terms. Figure 3 synthesizes concepts from several different communities and lexicons into a whole—making the connection between these separate bodies of literature to show how they all relate to the WoK for value creation.

Table 9. Conceptual guidance table that illustrates the relationship between the main concepts: types of knowledge (Martin, 2009; Polanyi, 1969; Grant, 1996, Pink, 2011), organization goals (March, 1991; McCarthy & Gordon, 2011), knowledge conversion processes (Nonaka et al., 2000), process purpose (Jensen et al., 2017a; Caniëls et al., 2014), motivation, role of rewards (Caniëls et al., 2014; McGonigal, 2015), approach (Suorsa, 2015; McGonigal, 2015), what must be facilitated, and interactional characteristics/dimensions of play (Soursa, 2015).

Types of Knowledge	Mystery	Heuristic	Algorithmic
	Tacit		Explicit
Org. Goal	Exploration		Exploitation
Knowledge Conversion Processes			
Process Purpose	**Creativity** Idea generation	**Innovation** Idea promotion	**Value Extraction** Idea implementation
Motivation	Intrinsic		Extrinsic
Role of rewards	Hinders creativity	No or demotivating effect	Motivating effect
Approach	Playful	Purposeful experimentation	Gameful
Facilitating	Building group tacit knowledge through shared experiences Mutual trust Sense of security and safety for speaking up Become familiar with collaborators (their personality, expertise, and skills) Explore opportunities Goal alignment	Test concepts (E & I) Concept maturation (E & I) Convey ideas, thoughts, and values (E) Understand and empathize (I) Active listening (I) Asking clarifying questions (I) Asking what-if?-questions (E) Building on others' ideas (E)	Perfecting capacity and skills Getting better / more effective Practice future challenges in a safe context Meeting a quota Optimizing Standardizing Measuring

			Benchmarking
Interactional characteristics/ **Dimensions of being in play**	Openness Familiarity Interpersonal trust Equality Commitment Being present	Criticality Reflectivity Interpersonal trust Commitment Being present	Seriousness Being present Commitment Interpersonal trust Criticality

Conceptual Guidance

Based on Figure 3, which organizes existing bodies of literature around the WoK – it is possible to move from thinking about managing the knowledge worker to managing the knowledge – and thereby provide guidance that connects knowledge challenges to serious play approaches.

Different serious play approaches invite different types of interactions among collaborators as well as different ways of knowing, doing, and extracting value (Kane, 2011). By connecting play affordances to the knowledge need and process activities necessary for each phase of the value-creation process, it is possible to distill guidance about which serious play approaches catalyze the knowledge processes in respectively socialization, externalization/internalization, and combination.

Socialization: Creativity and Idea Generation

All knowledge-based value creation starts at the fuzzy front-end with a socialization phase that provides the foundation of social cohesiveness and creative ideas necessary for the following phases. Thompson & Heron (2005) found that affective commitment cements relationships founded on social capital, and leads to more innovation because collaborators feel safe sharing their knowledge. In socialization the knowledge work is to make sense of a mystery (Martin, 2009) – i.e. explore the possibilities. This phase is particularly important to prioritize when starting up new projects and when striving to integrate knowledge from collaborators or stakeholders of diverse disciplines.

In the socialization phase the challenges include building a level of mutual trust and a shared frame of reference among team members, which in turn enables them to understand each other's perspective and generate and share creative ideas based on their individual tacit knowledge (Nonaka et al., 2000). Engaging in collective, playful experiences can help build a foundation of shared tacit knowledge, referred to as Group Tacit Knowledge (GTK), which constitutes an essential driver for collective creativity and successful innovation in organizations (Erden et al., 2008).

Suorsa, (2015) identified an overlap between the types of *interactional characteristics* necessary for knowledge creation and dimensions related to *being in play*. To catalyze knowledge creation and socialization, the interactions taking place between collaborators must be supported by types of play which fosters openness, trust, being present, and gives the collaborators the sense that "it is safe to fail", so that they share ideas more freely.

Based on an analysis of 22 case studies of parameters associated with creativity and reward structures in organizations-Caniëls et al. (2014) found that, counter to common management strategies, *extrinsic rewards*, such as bonuses and monetary incentives, actually have a *negative effect* when it comes to knowledge work that requires idea generation and creativity.

Playful methods that allows for experimentation with for example roles, materials, and perspectives can instill *interpersonal trust* and *openness* to new viewpoints, thereby creating a safe setting for sharing disparate views and a multitude of creative ideas. Being *playful* enables us to better tolerate the ambiguity and uncertainty that characterizes many of the problems modern organizations face (Statler et al., 2011), particularly in the early stages where the type of knowledge work can be characterized as dealing with a mystery (Martin, 2009). Through their non-judgmental and cross sector/hierarchy communicative approaches, playful methods allow for ideas, perspectives, and connections to emerge that more conventional, analysis-based methods might have missed.

Serious play approaches inspired by constructionist play and pretend play (paired with storytelling) can be useful in the socialization phase, due to their playful and open-ended nature.

Examples include methods for material deliberation (ref) —such as LEGO® Serious Play® (ref) and low fidelity prototyping (ref) —and acting-inspired activities—such as improv theater (Johnstone, 2012) and energizers (Lloyd Smith & Meyerson, 2015; Gray et al., 2010). Improv theater and material deliberation activities can support knowledge sharing and exploration both with the purpose to describe (expressing a current state) or prescribe (expressing and trying on a suggested future state).

Externalization / Internalization: Innovation and Idea Promotion

While socialization is great for building relationships and creating an abundance of ideas, it is also limited, as most ideas go nowhere (Schrage, 2014). Even good ideas must be challenged and improved upon. In innovation (externalization / internalization) the knowledge work is *heuristic* because it entails problem-solving and finding a way through unchartered territory (Pink, 2011; Martin, 2009). An iterative process of *experimentation* and *testing* proposed concepts is amenable for this purpose (Nielsen, 1993; Schrage, 2014). Through the consecutive processes of externalization and internalization knowledge is made explicit for then to be tried on and evaluated (internalization), leading to new suggestions for improvement (externalization), and so forth. It is a dance between possibilities and constraint.

Complex innovations require the integration of knowledge from various disciplines. However, in interdisciplinary teams conversation is often insufficient for externalization to occur effectively, due to different vocabularies (Borego et al., 2007), cultures, and information needs (O'Brien et al., 2003). Only within small, specialized, and well-socialized groups does sufficient group tacit knowledge (Erden et al., 2008) exist for conversations to be fully understood as explicit knowledge sharing. Hence, the creations of explicit artifacts that go beyond conversation are useful for the externalization phase. These representations are sometimes referred to as "boundary objects" and have been know to aid the understanding of complex topics across disciplines (Gorman, 2010). They are explicit representations of knowledge and serve as anchors to focus the project and the knowledge synthesis around. Examples include collages, sketches, models, prototypes, simulations, simulation-games (Schrage 2000; Brewer & Shubik, 1979). They

are often, but not always, a physical instantiation. Common for them are that they put experience and multi-sensory interaction center stage—and literally allow collaborators to *build onto and improve* each other's solutions.

As extrinsic rewards have no—and potentially even a negative influence—when it comes to innovation (Caniëls et al., 2014), what will help knowledge workers stay committed and persevere through the externalization / internalization phase are the autonomy, relatedness, and the opportunity to exercise their competencies on something they find meaningful – all parameters identified to increase intrinsic motivation in knowledge workers (Deci & Ryan, 1995). When working together on material instantiations, progress becomes tangible, and collaborators experience how their joined efforts lead to improvements.

Combination: Value Extraction and Idea Implementation

When knowledge is applied to tasks that are new and different, we call it 'innovation'. If we apply knowledge to tasks we already know how to do, we call it 'productivity' (Drucker, 1992). This distinction of knowledge applications also serves as a reminder that the types of knowledge work in these processes differ too. The type of knowledge work relevant for *value extraction* and *idea implementation* in the *combination* phase is *algorithmic* (Martin, 2009). In this phase the focus is on *scaling and exploiting* a solution that has now found its final, explicit form. Hence, the tasks, in terms of production and logistics, can now be clearly defined and the desired outcomes made *measurable and quantifiable*. This means that it is time to *follow procedures* and execute a "one right way" of doing things, leaving less room for creativity. Activities associated with productivity lend themselves well to *gameful* approaches (McGonical, 2015; Pink, 2011).

Gamification is the concept of applying game principles to a non-game context to increase engagement and motivation (Huotari & Hamari, 2012). Gamified incentive structures—extrinsic rewards, e.g. points and badges—are confirmed by Caniëls et al. (2014) to have a motivational effect in the idea implementation phase. Gamification is a powerful driver of behavior modification, partly because the immediate game feedback—e.g. acknowledging and celebrating accomplishments—leads to increased levels of dopamine in the brain (McGonigal, 2011; 2015).

Games have been used to modify behavior in various contexts, from smoking cessation and medical adherence (King et al., 2013) to forming meditation habits (Choo & May, 2014) and improving assembly line workers' motivation and experience during this monotonous work (Roh et al., 2016). Hence, organizations are realizing that facilitating behavioral change through gamification is a powerful strategy that delivers a competitive advantage (Dole, 2010).

The superpower of games is in their ability to foster deep engagement and full immersion in the present moment. Games help create a sense of 'urgent optimism' (McGonigal, 2011), tight social groups, blissful productivity, and meaning. Csikszentmihalyi (1975, p. xiii) describes games as an obvious source of flow, which can be defined as a 'state of optimal experience' and happiness characterized by "the satisfying, exhilarating feeling of creative accomplishment and heightened functioning." This supports the argument for the affective component of games and makes them great tools for increased motivation, joy, and focus—during complicated problem-solving activities.

Serious Play Approach Guidance

The phase descriptions above provide conceptual guidance as to which types of serious play affordances and approaches are applicable to which knowledge challenges. Figure 4 offers a visual summary by mapping types of serious play approaches onto the different phases of the Wheel of Knowledge.

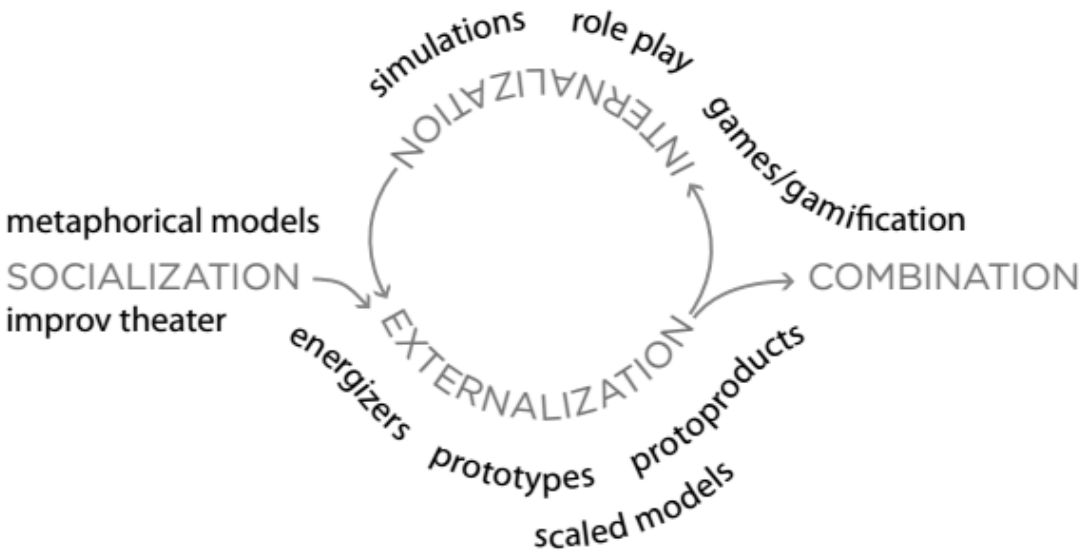


Figure 13. Maps types of serious play approaches to where they may be suitable in the different phases of the Wheel of Knowledge.

Starting with knowledge creation, *playful* approaches facilitate and accelerate *the* socialization processes that allow ideas to be shared and *creativity* to flourish. At the innovation stage, ideas are matured and reduced to *practice* through iterative, experimental processes of externalization / internalization with physical and digital manifestations. At the entrepreneurial stage, the hard work of manufacturing and production become critical for value extraction. Thus, *play* and the deliberate *practice* of experimentation must give way to the *performance* based activities. Here, *gameful* approaches that include pay incentives and social recognition are essential to optimize performance.

Conclusion

When advancing knowledge-driven value-creation, serious play approaches can be a powerful catalyst for *knowing, doing,* and extracting value in the phases associated with respectively creativity, innovation, and entrepreneurship. Based on a pluralistic understanding of knowledge—which synthesizes three narrow, disparate views of what knowledge is—this chapter allows for a shift from managing knowledge workers to managing the knowledge. The Wheel of

Knowledge is a knowledge management theory model that synthesizes the different types of knowledge definitions, processes, and conversion that occur across the span of a knowledge-driven value creation process. In this chapter the WoK model serves as a lens to match the right type of play with the appropriate phase to enable knowledge workers to exhibit the traits and actions conducive for the challenge present in the respective phases.

The main contributions of this chapter are to 1) disaggregate serious play approaches, 2) organize concepts and vocabulary in the literature, and 3) match up serious play approaches with the character of knowledge challenges—thereby providing guidance about where in the wheel of Knowledge they are applicable. For practitioners, having a shared vocabulary can support and direct collaborations across disciplines by clearly signaling the purpose and intend of a given manifestation—for example, whether it is meant as a model or a prototype. For scholars, having succinct definitions and differentiations of serious play approaches are necessary for the advancement of the serious play field as a scholarly discipline. For practitioners and organizations, having guidance on which types of serious play approaches applies when, can save them the costly mistakes of for example applying gameful approaches in the exploration phase and thereby narrowing focus and stifling creativity as a result—or applying playful approaches in the exploitation phase, thereby inviting divergent thinking and jeopardizing quality control. By matching the right type of serious play to the knowledge challenge organizations can unleash their potential for creativity and productivity e.g., as ways of building trust in teams and generating ideas, improving and accelerating innovation efforts, as well as infusing more fun into rote, algorithmic tasks—thereby attaining a competitive advantage in knowledge-based value creation.

Even after identifying a suitable type of serious play, two challenges remain: 1) deciding which specific serious play method to use, and 2) executing it well. The criticality of a skilled facilitation of serious play methods cannot be overemphasized, as well-prescribed methods can fail when not carried out properly. Hence, be meticulous when choosing/training/recruiting team leaders and facilitators.

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CHAPTER 4:

PLAY AT WORK: MAPPING THE SERIOUS PLAY LITERATURE ACCORDING TO THE WHEEL OF KNOWLEDGE

Introduction

An explosion of publications in both popular and scholarly literature reflects a rising interest in serious play methods (e.g., Schrage, 2014; McGonigal, 2015; Johnson, 2016; Hamari, 2013, Mabogunje et al., 2008; Hansen et al., 2009; Davies et al., 2012). The umbrella term "serious play" has undergone an evolution over the years. It was framed by Michael Schrage (2000, p. 2), who helped popularize the concept, as being "about improvising with the unanticipated in ways that create new value". This means that the serious play arsenal includes "any tools, technologies, techniques, or toys that let people improve how they play seriously with uncertainty" (Schrage, 2000, p. 2),. More recently, serious play has been defined as "a mode of activity that draws on the imagination, integrates cognitive, social and emotional dimensions of experience and intentionally brings the emergent benefits of play to bear on organizational challenges" (Roos et al., 2004, p. 563). In that vein, serious play has further been framed as a "practice characterized by the paradox of intentionality"—that is, when participants "engage deliberately in a fun, intrinsically motivating activity as a means to achieve a serious, extrinsically motivated work objective" (Statler et al., 2011, p. 236). These definitions extend the term "serious play" to encompass a variety of organizational phenomena not understood heretofore as serious play. This expansive understanding of serious play is desirable now that playful and gameful approaches are being adopted in various contexts and contribute to multiple areas of the value creation life cycle (Jensen et al., 2017b).

The motivation for adopting serious play approaches varies by context, but framed in terms of the value creation life cycle the benefits of serious play include: (1) Creating collaborative environments, characterized by trust, creativity, and commitment, to bring forth a broad range of ideas as well as the knowledge and mindsets conducive to reframing and tackling complex, interdisciplinary problems (Hansen et al., 2009). (2) Accelerating integrated innovation

processes and reducing uncertainty through iterative experiments that test assumptions and make tacit knowledge shared (Schrage, 2014). (3) Providing extrinsic incentive structures that motivate desired behaviors and affects in the workplace with the purpose of increasing productivity, quality, as well as workers" engagement, job satisfaction, and retention (Hamari, 2013).

Hence, it is well established that organizational processes can benefit from serious play approaches as an alternative to conventional organizational development, innovation practices, and management incentives (Statler et al., 2011). However, the serious play literature remains fragmented (Jensen et al., 2017b) and most authors—scholars and practitioners alike—are narrowly focused on their own subsection of serious play interventions. For instance, organizational researchers assert that improvisational play at work may lead to substantial benefits related to performance, learning, and personal fulfillment (Starbuck & Webster, 1991; Ibarra, 2003; Sandelands & Buckner, 1989; Hatch, 1999). Whereas, LEGO® Serious Play (LSP) is heralded among business scholars and facilitators as a useful method for developing and testing strategy scenarios (Lund et al., 2011; Roos et al., 2004)—as well as in higher education both for active, reflective learning in the classroom (Montesa-Andres et al., 2014; James, 2015; Jensen et al., 2017d; Bulmer, 2011) and for enhancing communication in research (Hinthorne & Schneider, 2012). In the field of design and engineering, the iterative innovation practice of building prototypes and simulations serves to reduce uncertainty by making the proposed solution more concrete and testable (Selin & Boradkar, 2010; Schrage 2000; 2014). Models, simulations, and serious games are appreciated by the military for strategizing, training (Brewer & Shubik, 1979) and recruitment (e.g. http://www.americasarmy.com/; Susi et al., 2007). Most recently, gamification—characterized by its external incentive structures added to non-game contexts—has become almost ubiquitous (Raftopoulos, 2014; Llagostera, 2012; Hamari, 2013), and companies that apply it are experiencing unparalleled effects (Penenberg, 2015). The application areas include production management (Korn, 2012; Roh et al., 2016), taking care of one's health (fitocracy), motivating knowledge-workers (Nikkila et al., 2011), as well as more generally making

employees more motivated and happier, improving worker safety, and customer service (Penenberg, 2015).

Figure 14. The rising popularity of gamification as a web search term worldwide between 2004-2017. [2] (Data source: Google Trends, 17.3.2017).

As is typical for emergent, practice-led fields (Selin et al., 2015) the above-mentioned fractions operate largely separate and few papers (Statler et al., 2011) start to establish a theoretical overview. Consequently, the field of serious play has an ill-defined terminology, a lack of shared vocabulary (Schrage, 2000; Jensen et al., 2017b), and no comprehensive overview of multiple methods. While the previous chapter (Jensen et al., 2017b) started the diligent work of aggregating the terms conflated under the serious play umbrella, there remains a need of guidance when it comes to matching which kinds of serious play characteristics are suitable for which types of knowledge challenges (Jensen et al., 2017b).

[2] According to Google Trends numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. Likewise a score of 0 means the term was less than 1% as popular as the peak.

Theory Development

One way of making sense of the serious play literature may be through the Wheel of Knowledge (WoK)—a knowledge conversion model for advancing knowledge-based creativity, innovation, and value extraction (Jensen et al., 2017a; 2017b). The WoK expands upon the SECI model (Nonaka & Takeuchi, 1995) and is based on the premise that all knowledge originates as tacit knowledge (Polanyi, 1966), but must be made shared and explicit for organizations to extract value from it (Nonaka, 2007; Nonaka & Teece, 2001). To scaffold and accelerate this development of knowledge the WoK consists of four types of knowledge conversion processes: socialization, externalization, internalization, and combination. In socialization, the knowledge conversion is *tacit to tacit* and achieved through direct experiences that serve to build the relational trust, alignment, and commitment that are prerequisites to fluid ideation and knowledge sharing. Externalization and internalization occurs in an iterative loop of continuous experimentation, testing, reflection, feedback, and decision-making. In externalization, the knowledge conversion is *tacit to explicit* and achieved through the creation of (most often) tangible representations of proposed solutions that seek to minimize ambiguity and uncertainty[3]. In internalization the functionality, appeal, and underlying assumptions embedded in these representations are tested through embodied learning, in which the knowledge conversion is *explicit to tacit*. In combination the design has arrived at a satisfying solution, through numerous iterations, and can now be brought to scale. Here the goals and means are clear, thus the knowledge conversion is *explicit to explicit* (Jensen et al., 2017a; 2017b).

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3 This understanding of what constitutes externalization is stricter than that of Nonaka & Takeuchi (1995). While they hold that externalization can happen through verbal communication, for example scaffolded by metaphors, Jensen et al. (2017a;b) assert that words alone are insufficient means for externalization, except under special circumstances in which the parties already share high levels of tacit knowledge, such as the use of specialized jargon among experts. In the absence hereof, physical representations (e.g. material deliberation methods, boundary objects, model, prototypes) can serve as some sort of symbolic representation that scaffold communication among collaborators. Words, pictures, equations, models and prototypes are all examples of symbolic representations. (See the sliding scale of tacit to explicit representations of knowledge in chapter 1). The extent, to which these representations are externalizations, rather than socializations, depends on the extent to which they are explicit. Metaphorical boundary objects are insufficient, because they are only imparted with meaning when they are interpreted in words. However, scale drawings, mathematical equations (to the extent that the parties share an understanding of the math), scale models and prototypes, and functional representations are externalizations, because they are more explicit and less ambiguous.

Using the WoK as a lens, it is possible to change focus from managing different knowledge workers to managing different knowledge conversions, because the WoK relates different types of knowledge work to the corresponding types of knowledge conversion (Jensen et al., 2017a; 2017b). Further, I propose that serious play serves as a catalyst for mobilizing knowledge through these conversion processes (Jensen et al., 2017b). If that is the case, it should be possible to identify those characteristics of serious play methods described in the literature that advance each of the four types of knowledge conversion processes, and identify commonalities among those methods that cluster around each.

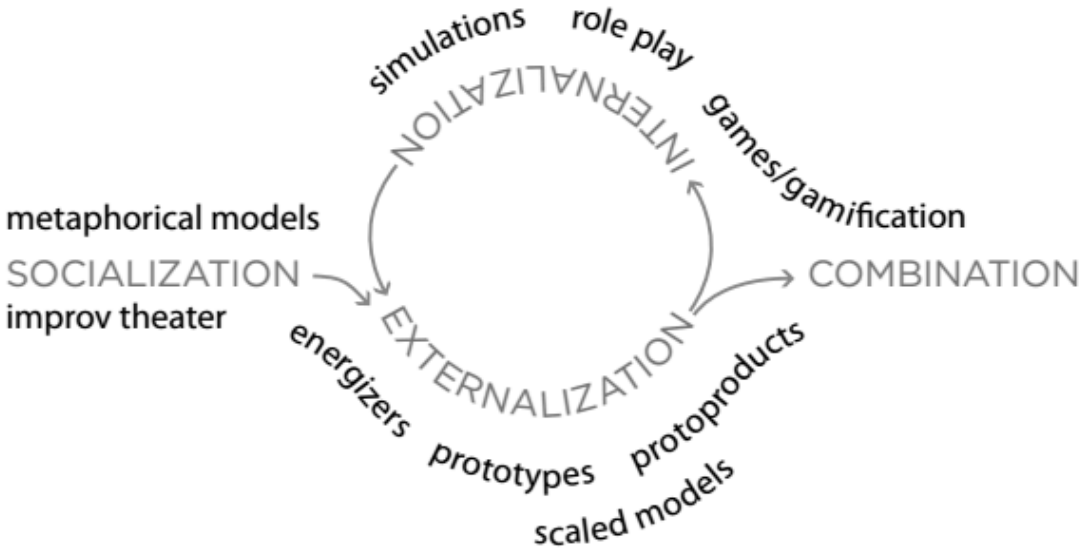

Figure 15. Illustration of how different types of serious play methods may align with the WoK phases.

This chapter investigates the conjecture that *the WoK is useful for matching serious play methods with knowledge conversion challenges*. The chapter establishes an overview of which serious play methods are present in the academic literature and develops a framework for understanding key properties/affordances of serious play methods that determines their suitability for different types of knowledge conversion processes. Mapping the literature to phases of the WoK, the chapter reveals research areas worthy of further investigation.

Investigating the Conjecture

By using the WoK as a lens through which to segregate the methods present in the literature, it becomes possible to identify which methods are useful in which context, and to ascertain whether certain types of methods are underrepresented in the research literature.

If the WoK is a valid guide for identifying the characteristics of serious play methods that match knowledge management conversion needs, it should be possible to identify those characteristics of serious play methods described in the literature that advance each of the four types of knowledge conversion processes, and identify commonalities among those methods that cluster around each. This investigation can be conducted by categorizing the serious play literature according to the knowledge conversion processes referred to as socialization, externalization, internalization, and combination. For the WoK to provide a useful classification system there must be a clear distinction between each of these categories.

Possible outcomes

There are certain outcomes that would render this conjecture false or in need of improvement. The following three outcomes would not qualify the WoK as a suitable categorization system:

Figure 16. The Lucky Charm Outcome.

The Lucky Charm Outcome *('random noise')*

Denotes a condition where there is no detectable pattern of common characteristics among the papers that are categorized into the same bin. This failure indicates a mismatch between the categorization requirements and the characteristics of the papers. This outcome is equivalent to random noise, which means that the model fails as a categorization system.

Socialization Externalization Internalization Combination

Figure 17. The Platypus Outcome.

The Platypus Outcome *('missing-bin')*

This outcome occurs if some papers do not fit into any of the defined bins. If this happens with more than a very rare platypus the categorization taxonomy is insufficient and has failed. This outcome is an indication that something should be added to the model.

Socialization Externalization Internalization Combination

Figure 18. The Higgs-Boson Outcome.

The Higgs-Boson Outcome *(‘missing-observations’)*

This outcome occurs if there are no papers (observations) that fit into one or more bins (theories) – and if such paper could not even exist in theory. In the serious play context this would be that there exists no such paper – not just because it has not been written yet, but because there are no serious play methods to write about which characteristics match this particular bin. This outcome is likely an indication that something should be subtracted from the model.

To sum up, the conjecture is not validated if some papers are impossible to categorize according to the Wheel of Knowledge, because one of the following conditions apply:

- Similar papers cannot consistently be categorized as belonging within the same bin, rather they seem to fit into any of the bins,
- Some papers do not fit into any of the defined bins, or
- None of the identified papers serve a particular bin.

In the event that the theory transcends all of these invalidated outcomes, I arrive at:

Figure 19. The Beer flight Outcome.

The Beer Flight Outcome (‘the WoK rocks’)

In this outcome:

- Papers share similar characteristics within each of the bins.
- It is possible to categorize all papers into the four defined bins.
- A sufficient breadth of serious play papers has been found in the literature to populate all bins.

In this case the WoK can serve as a useful tool for matching the right types of serious play characteristics with the type of knowledge challenge that they are suitable for.

Investigative Methods

Searching and Sorting Serious Play

For this investigation to take place it is critical to first identify a relevant subset of the literature, that provides a broad overview of the serious play field. Then narrow it down to a manageable amount of high-quality papers, which focus within the scope of this research—that is, “serious play” in the context of knowledge-based value creation in the workplace. Because serious play is an emergent field, “serious play” as a search term is underdetermined and will provide too many irrelevant results—for example about chess strategy, sport games, and theater. It will also miss any activity that is not labeled serious play—even if it fits the definition of what constitutes serious play (see the introduction). In exploring the concept and to illuminate some of the ambiguity of serious play, strategic play” and “playful inquiry” (e.g. Sullivan, 2011), as well as “war games” (Lu, 2008) appear as synonyms or overlapping concepts. Serious play is also often involved with “material deliberation” (e.g. Davies et al., 2012; Svejvig & Møller, 2012) in the sense that the participants of the intervention are offered physical artifacts to construct representations of their ideas. Expanding the search to include “arts-based interventions/initiatives” and “workarts” (Barry & Meisiek, 2010; Pässilä, Oikarinen, & Kallio, 2013) are not likely to produce relevant results, not already captured by the main keywords. Exploring a series of keywords including, “business games”, “hands-on”, “3d thinking/games”, “learning games”, “simulation games”, “communication games”, “group games”, “experiential learning”, “interactive learning” will lead to a multitude of hits, but only a few relevant. In contrast, “serious games”, “prototypes”, “models”, “simulations” and particularly “gamification” (Deterding et al., 2011) will provide some useful results.

The Futility of Solely Algorithmic Approaches

Algorithmic attempts at searching serious play are futile because the field is emergent, expansive, and fragmented. Calibrating this type of search to cover the full serious play spectrum leads to an excessive amount of papers—some relevant, but also a lot that are irrelevant. Even when narrowing it down by filtering for strategically chosen inclusion and exclusion criteria (see table 1), an algorithmic search still does not ensure high quality and relevance. In an emergent field the algorithmic search must be complimented by more iterative and heuristic approaches, as the vocabulary is still ambiguous and underdetermined.

Table 10. Inclusion/ exclusion criteria for sorting the literature.

Inclusion	Exclusion
Peer-reviewed (e.g. journal papers, conference proceedings, book chapters). Serious play as a workplace or higher education intervention. Adults. Context: creativity, problem solving, innovation, design, teambuilding, strategy, production, incentives, value creation, collaborative inquiry. Written in English. Full text available.	Non-peer-reviewed (e.g. master thesis, blog posts, reviews, commentaries, books, editorials, viewpoints, opinions, thought pieces). Frivolous play. Children. No abstract available.

Heuristic and Iterative Search Approaches For an Emergent Field

Another approach is to examine popular books belonging to the genre of serious play, including “Play” by Stuart Brown (2009), “Play Anything” by Ian Bogost (2016), “Play at work” by Adam L. Penenberg (2015), and “The Gameful World” by Walz & Deterding (2015). However, three recent titles stand out: “Wonderland” by Steven Johnson (2016), “The Innovator's Hypothesis” by Michael Schrage (2014), and “Superbetter “ by Jane McGonigal (2015), as each of these books is a sequel to an antecedent book, and examination of these in pairings allows for

a deeper understanding of the evolution of the authors' ideas. The foci of these three authors are consistently correlated with the phases of the WoK, respectively: socialization, externalization/internalization, and combination (see table 2).

Table 11. Popular literature in the serious play genre as it pertains to the phases of the WoK. In tier I: Three columns of serious play related concepts extracted from a broad review of popular literature.

Johnson	**Schrage**	**McGonigal**
Wonderland: How Play Made the Modern World (2016)	*The Innovator"s Hypothesis: How Cheap Experiments Are Worth More than Good Ideas (2014)*	*Superbetter: A Revolutionary Approach to Getting Stronger, Happier, Braver and More Resilient--Powered by the Science of Games (2015)*
Where Good Ideas Come From: The Natural History of Innovation (2010)	*Serious Play: How the World"s Best Companies Simulate to Innovate (2000)*	*Reality Is Broken: Why Games Make Us Better and How They Can Change the World (2011)*
Socialization	Externalization / Internalization	Combination
Tier I: concepts extracted from a broad review of popular literature		
Generate ideas	Innovation	Games / gamification
Emergence	Experiments	Improvement
Creativity	Iterative	Extrinsic rewards
Play	Prototypes	Clear goals
Social experience	Models	Flow
Exploring	Simulations	Instant feedback
Hunches	Test	Effectiveness
Connecting	Collaborate	Fun
Metaphors	Learn	Rote tasks
Imagination	Modify	Algorithmic rules
Coming together	Practice	Game mechanics
Frequent interactions	Interact	Achievement
Serendipity	Adapt	Measurable
Complex	Making concrete	Engagement

After developing a broad, tacit understanding of the popular literature it is possible to advance the literature search in a targeted fashion. By extracting concepts that are prevalent across relevant texts example search terms at each stage of the WoK can be identified (see tier I

in table 2). From there, additional results can be obtained from chain-referral sampling (or snowball sampling) of key literature (Tracy, 2013; Biernacki & Waldorf, 1981), which is done by studying texts referenced in the papers resulting from the initial search. Likewise, the new papers may also reference sources of interest—hence the term chain-referral sampling. This type of non-random search method is useful when characteristics to be possessed by samples are rare and difficult to find. Another benefit of this kind of emergent search is that tacit knowledge is accumulated as the search takes place, which enables further refinement of the search activities and the filtering, leading to high quality papers that that would otherwise have been hard to find. One way of confirming the relevance of a paper is to notice if it echoes several of the concepts identified in tier I in table 2. Through a review of the second wave of literature additional commonalities appear, creating a fuller picture of the field and what distinguish the serious play methods in each of the WoK phases (see table 3 below).

Table 12. Tier II: Common phrases in the literature that distinguish serious play methods by WoK phase.

Socialization	Externalization / Internalization	Combination
Conceptualize thoughts	Co-creation	Increased motivation
Build confidence and trust	Intrinsically motivating	Employee engagement
Construct meaning	Iterative problem-solving	Employee retention
Conversation/ Dialogue	Mission	Making meaningful
Creating knowledge	Feedback	Best practice
Imagination	Immersive engagement	Performance
Inclusion	Perspective taking	Pre-defined behaviors
Making the invisible visible	Demonstrating	Gameful
Reframing	Constraints	Experience
Shared experience	Engage effort	Completion
Strategy	Dilemmas/trade-offs	Track and visualize progress
Planning	Determination	Celebrate achievement
Alignment	Figuring out a way	Transparent rules
Freedom to express	Having agency	Social status
Discover	Heuristic	Repetition
Commitment	Manipulable	Competitive
Non-judgmental	Representing	Incentives
Free-thinking	Technique	Combine
Engagement	Engagement	(Lack of) agency
Playful	Empathize	Recognition

Sorting the Literature According to the WoK

The purpose of the Wheel of Knowledge in relation to serious play methods is to provide a lens through which to organize and understand the applicability of the methods along the value creation process. This purpose is fulfilled only under the condition that it is possible to identify literature that fits each of the phases of this process—and that various examples of any given method consistently fit into the same phase.

In the context of the paper sorting process, tier I and tier II in tables 2 and 3 above can be considered emergent coding schemes. These common terms/phrases become words a reader can look for to quickly get an initial sense of what type of knowledge conversion a paper and its serious play methods are focused on. For a conclusive categorization of serious play examples into a conceptual framework it is however advisable to consult the parameters defined in the theory development section and consider the example in terms of: the purpose, the degree of structure, the degree of materiality, the role of the participant, the type of knowledge, the underlying questions, the temporality, and the facilitation.

Development of a Conceptual Framework

In this emergent field, serious play methods are constantly evolving and being re-invented anew. This might be part of the reason why there is no comprehensive multi-method overview to be found—as any current overview of existing methods would be dated soon after it is published. However, a conceptual framework—an analytical tool for making conceptual distinctions and organizing ideas—can accommodate several variations and contexts. It may therefore be a helpful organizing and sense-making devices in the context of identifying phase applicability for current and future serious play methods—as it is "reusable" and more methods can be added. In the development of a framework it is important to ensure that it will provide the end-users the following knowledge:

- Which questions to ask.
- Where to find the answers.

- How to interpret the answers.

Guiding Parameters For Assessing The Applicability Of Serious Play Methods

The guiding parameters identified and explained below can help readers ascertain in which phase and for which purposes a serious play method might be suitable. When encountering a serious play method it is essential to notice the following characteristics: the purpose of its application, the degree of materiality, the role of the participants, the degree of structure, and what under-lying questions the method is helping participants get to the heart of. These characteristics help to assess what type of knowledge conversion is in play–i.e. tacit, tacit/explicit, or explicit, as that provides insights as to which type of knowledge challenge is addressed. The following describes the role of each of these parameters and how they relate to each of the phases of the WoK. It is important to bear in mind that a method can be applicable in multiple phases.

Purpose

Table 13. Purpose as a guiding parameters for identifying phase applicability within the WoK.

Parameters	Socialization	Externalization	Internalization	Combination
Purpose	Build trust Incite creativity Generate ideas Explore possibilities Allow for tacit knowledge to emerge.	Make ideas real and testable Propose solutions Integrate feedback	Learn by doing Challenge assumptions Practicing Embody know-how	Optimal performance Increase job-satisfaction Ensure quality Achieve flow Persuasive feedback Behavior change

Serious play methods should be applied in accordance with their purpose and affordances.

- In the socialization phase methods serve the purpose of bringing together collaborators and building trust among them, i.e. by creating a context for sharing something personal (Paulus et al., 2003; Nonaka et al., 2000). So do methods that incite creativity, help participants explore possibilities, generate a plethora of ideas, and allow for tacit

knowledge to emerge (Mabogunje et al., 2008). This means that *playful* methods can help participants feel less judgmental and self-conscious, thereby enabling them to let their guards down and think beyond their go-to solutions (Nisula et al., 2015; Gauntlett & Holzwarth, 2006; de Bono, 2010). This can be particularly useful when developing a new strategy, eliciting requirements for a new product/service, or seeking to build stakeholder buy-in and team commitment for a new project.

- In the externalization phase the main purpose of methods is to propose solutions in the form of explicit representations that make the ideas concrete and thereby testable. Another important purpose of this phase is eliciting and integrating feedback.
- In the internalization phase methods serve to create an opportunity for participants to learn-by-doing and truly embody know-how through direct experience and practice. Because externalization and internalization typically happen in an iterative fashion, another important purpose that indicate that a method belongs in internalization is that the participants get to challenge the assumptions embedded in the representations (e.g. models or prototypes) created in externalization and provide feedback.
- In the combination phase methods seek to simultaneously increase job-performance and job-satisfaction for the participants. The ultimate goals of the organization are typically to ensure high quality products/outcomes as well as high employee- productivity, capability, and retention rate. The methods that are useful in this phase are often *gameful* (McGonigal, 2011), because game-mechanics can lead to *'flow'* – also known as *the zone of optimal experience* (Csikszentmihalyi, 1997)– by aligning the level of challenge with the level of skill and by providing persuasive feedback that enable the player to monitor his/her performance and progression – thereby motivating a behavior change.

Degree of structure

Table 14. Degree of structure as a guiding parameters for identifying phase applicability.

Parameters	Socialization	Externalization	Internalization	Combination
Degree of structure	Open-ended. Allows for meaning to emerge.	Emergent, yet deliberate. Iteratively working towards an adaptive vision informed by feedback.		Constrained. Clear, measurable goals. One right way.

- In socialization methods are characterized by a low degree of structure and few constraints. Because the purpose of these methods is to explore and generate a multitude of ideas the structure is *open-ended* in order to allow for new insights and meaning to emerge. The methods might however still have structural elements such as turn-taking and rules.
- In externalization/internalization methods are characterized by more constraints, but still allow for new insights, as employees are iteratively working towards an adaptive vision informed by feedback from for example end-users.
- In the combination phase methods have a high degree of structure. The goal has now been clearly defined, as has the “one best way” (Taylor, 1911) of achieving it. Success has been made measurable and the serious play-based interventions in this phase make use of explicit algorithms and rules to track performance and provide extrinsic feedback to motivate employees.

Materiality

Table 15. Materiality as a guiding parameters for identifying phase applicability within the WoK.

Parameters	Socialization	Externalization	Internalization	Combination
Materiality	Can be immaterial or incl. props. Can incl. symbolic or *metaphorical* boundary objects that support storytelling.	Entail creating literal, material (or digital) scale models, blueprints, or prototypes that make assumptions explicit and proposed solutions concrete and testable.	May include physical or *virtual* props or environments – e.g. simulations. May offer sensory feedback.	Typically include real, explicit, literal, physical products. May include literal, explicit, digital representations. May offer sensory and affective feedback.

Materiality is a reoccurring aspect across many serious play methods, as making material representations is a powerful means for enabling humans to work with possibility by making tacit notions (ideas, belief, knowledge, and assumptions) more explicit, concrete and sharable (Lund et al., 2011; Resnick, 2011; Hansen et al., 2013; Gore, 2004; Carlile, 2002). According to the theory of constructionism (Harel & Papert, 1991) people develop their mental models and achieve a deeper understanding of abstract, real-world relationships and concepts when they construct physical representations. Core to both ideas is the notion that when we "think with objects" and engage in hands-on material construction in the context of abstract knowledge work the activity unleashes more creativity and imagination in the participants (Grienitz et al., 2013; Lund et al., 2011). This is referred to as the hand-mind-connection: by using our hands more segments of the brain are activated than solely working memory and the processing power of the prefrontal cortex (Wilson, 1998). By giving concrete form to the abstractions of language, material representations facilitate discussion of speculative entities, making them more real and relatable. In this way materiality is an important parameter, as it scaffolds communication both among stakeholders, and between practitioners and stakeholders of diverse backgrounds. It "deepens stakeholders" insight into speculative worlds by engaging the sensory and emotional dimensions of their experience." (Resnick, 2011, p. 89). Materiality also provides a *shared language* that can lower

the communicative barriers associated with crossdisciplinary collaboration, such as lack of shared vocabulary, conflicting epistemologies, and scant knowledge of collaborators" information needs (O'Brien et al., 2003; Borrego et al., 2003).

- In the socialization phase methods utilize material representations that are *metaphorical* and accompanied by verbal explanations. In socialization materiality serves to express one own thoughts and ideas.
- In the externalization/internalization phase methods include (material) representations that are literal approximations of an actual reality (e.g. model or simulations) or of a desired reality (e.g. prototypes or role-plays) belong. Here materiality serves to test and improve upon ideas.
- In the combination phase methods include the participants producing explicit, material representations that actually *are* the real thing. Here materiality is typically a dimension of the final product, which the accumulated knowledge is embedded in. While explicit and goal-oriented, the serious play method itself might not be characterized by a high degree of materiality. It can be an intangible set of rules (e.g. a game or policy) and feedback that serve as a catalyst for the value extraction process.

Role of the participant

Table 16. Role of participant(s) as a guiding parameters for identifying phase applicability.

Parameters	**Socialization**	**Externalization**	**Internalization**	**Combination**
Role of the participant	Share insights and generate ideas	Propose and mature solutions.	Engage with intervention and provide feedback or learn by doing.	Perform and adapt based on feedback.

- In the socialization phase the role of participants is to be tacit knowledge-sharing agents and *generate ideas* that cross-pollinate through collisions with other ideas (Johnson, 2011).

- In the externalization phase the role of participants is to create material, *symbolic* representations that make tacit knowledge *explicit* and *testable* (Schrage, 2014) without the need of a verbal explanation.
- In the internalization phase the role of participants is *to interact* with the literal representation and be a *learner, a feedback-provider*, or both.
- In the combination phase the role of participants is to *perform and adapt* based on feedback.

Knowledge

Table 17. Type of knowledge work as a guiding parameters for identifying phase applicability.

Parameters	**Socialization**	**Externalization**	**Internalization**	**Combination**
Knowledge	Exploring a *mystery*. Mainly tacit.	*Heuristic* experimentation. Shifting between tacit and explicit.		Executing *algorithmic* tasks. Mainly explicit.

Identifying what type of knowledge work is at play can be a shortcut to placing the serious play activity on the Wheel of Knowledge spectrum.

- In the socialization phase, at the fuzzy front-end of a project, the knowledge work is like exploring a *mystery* (Martin, 2009). Participants contribute their tacit knowledge and perspectives to get to know one another, to find out what the solution space might look like, to generate ideas, and to conceive of a plan or strategy. Hence, if a method is facilitates those types of activities – it likely belongs in socialization. Examples include brainstorming (Paulus et al., 2003), ice-breakers (Cantoni et al., 2009), serious play for familiarizing oneself with a context for re-design (Sukovic et al., 2011) and strategy workshops (Roos et al., 2004; Jacobs & Heracleous, 2007; Statler & Oliver, 2008).
- In the externalization/internalization phase the overall vision is clear and the knowledge work becomes *heuristic* (Martin, 2009; Pink, 2011) – meaning that the work consists of figuring out how to achieve the goal. This is characteristic in normative fields, such as design, where the goal is to change the current condition to a preferred one (Simon,

1969). When the project is sufficiently complex it is typically done through iterative learning-by-doing approaches. Examples of methods include creating prototypes (Lim et al, 2008; Selin & Boradkar, 2010), models (Schrage, 2000), and simulations (Benedettini & Tjahjono, 2009) for eliciting feedback from stakeholders in the internalization phase.

- In the combination phase—a satisfying design solution has already been devised and made explicit, for example in the form of blueprints—it is time to hand it over from the design to manufacturing. Bringing the solution to scale takes place in the combination phase. Here there is one right way of for example assembling a product and the procedure has been defined, optimized, and broken down into incremental routing steps—which make this type of knowledge work *algorithmic (*Martin, 2009; *Pink, 2011).* In combination serious play methods characterized by game-like incentives can help make the rote task more fun and engaging (Jagoda, 2013).

Underlying Questions

Table 18. Underlying questions as a guiding parameters for identifying phase applicability.

Parameters	**Socialization**	**Externalization**	**Internalization**	**Combination**
Underlying questions	What could be? What if..? Why?	How might we…? What if we…? Would it work if…?	How would I… act, do, feel, know? But what if…?	What is the best way to…? How many/ much? What is in it for me/ the team?

- In the socialization phase serious play methods serve to explore possibilities and discover novel, meaningful strategies and innovation potentials by creating a context for people to connect and share their tacit knowledge. Examples that embody these underlying guiding questions in socialization include, a bank envisioning what might be characteristic of their future relationship with their clients (Statler & Oliver, 2008), and the process of eliciting the design requirements for a corporate website (Cantoni et al., 2009).
- In the externalization phase methods serve to make the abstract concrete and testable though physical representations. Examples that embody these underlying guiding

questions in externalization include, designers grabbling with how to develop prototypes that conveys the functionality of a nano-enchanced product (Selin & Boradkar, 2010), or IDEO striving to hit the right level of resolution and fidelity in their prototypes that will result in useful feedback from their end-users and clients (Buchenau & Suri, 2000).

- In the internalization phase methods serves to embody and make sense of an experience and potentially providing feedback. Examples that embody these underlying guiding questions in internalization include, end-users experimenting with and critiquing prototypes (Buchenau & Suri, 2000) or soldiers training combat in a simulated environment.
- In the combination phase methods serve to optimize the measurable and make incremental improvements towards a defined ideal way of doing. Here extrinsic incentives and a sense of fun/accomplishment induce motivation for high performance. Examples that embody these underlying guiding questions in combination include workers getting gamified feedback on how best to tighten bolts by the assembly line (Roh et al., 2016) or Mint.com a financial management tool that makes use of gaming principles to make tracking personal finances fun (Dole, 2010).

Temporality

Table 19. Temporality as a guiding parameters for identifying phase applicability within the WoK.

Parameters	**Socialization**	**Externalization**	**Internalization**	**Combination**
Temporality	Event (workshop)	Iterative, project-specific practice		On-going

- In the socialization phase many serious play methods are characterized by being episodic interventions—for example, a LEGO® Serious Play® workshop retreat where a bank seeks to reinvent their relationship with their customers (Statler & Oliver, 2008) or the exploration for development (ED) seminar described by Paulus et al. (2003).
- In the externalization/ internalization phase temporality plays a different role. These methods are typically medium term. For example, the creation of literal models or

prototypes is an iterative, project-specific practice (Lim et al., 2008; Buchenau & Suri, 2000).

- In the combination phase serious play methods are typically ongoing, long-term practices, because production (exploitation) is the most consistent practice in established organizations (McCarthy & Gordon, 2011). While it may take several iterations to get the incentive structure or gamified production environment just right, once it has been calibrated to have the desired effect, such interventions can lead to decades of competitive edge, as is the case for the steel giant, Nucor (Gupta & Govindarajan, 2000).

Facilitation

Table 20. Facilitation as a guiding parameters for identifying phase applicability within the WoK.

Parameters	Socialization	Externalization	Internalization	Combination
Facilitation	Skilled facilitator	Self-driven team	Organization or automated environment.	Typically automated/ computerized or part of organization"s incentive structure

- In the socialization phase external consultants typically facilitate the episodic serious play interventions.
- In the externalization/internalization phase R&D teams are typically self-reliant when it comes to externalizing prototypes, models, and simulations. They might also facilitate participatory design sessions where end-users internalize the prototype and provide feedback for the next iteration. Internalization may also take place in less facilitated, more automated fashion—for example if the participant is learning through a virtual environment.
- In the combination phase the serious play methods are typically fully automated, as the serious play incentive structure may be part of the organization's compensation policy (Gupta & Govindarajan, 2000**)** or a gamified work system (Nikkila et al., 2011; Roh et al., 2016).

Examining a paper according to one of the parameters defined above does not necessarily lead to a clear categorization of the method beyond any reasonable doubt. However,

examining a paper by applying multiple of these parameters allows for a preponderance of the evidence—leading to a categorization that is generally true and accurate.

How to Categorize Serious Play Methods

When seeking to characterize a serious play method and discern its applicability in the value creation process based on the parameters described above, ask questions such as: “Are the participants engage in knowledge work related to making tacit knowledge shared and exploring “what might be”?” In that case it belongs in socialization. Or “Is the knowledge work participants engage in related to making tacit knowledge explicit through concrete representations?” If yes, that indicates that it is a method suitable for externalization. As was the case with methods identified through the papers examined in this literature review, some are simple to categorize, others more challenging. It may be necessary to assess the method along several dimensions before a match emerges.

Among the examples categorized in this literature review is Grienitz et al. (2013). This paper describes a case of using LEGO® Serious Play® for identifying of a vision statement with a company in the automotive field. Such method belongs in socialization, because: 1) the material representations are metaphorical, 2) It is about exploring “what might be” (developing a vision and a strategy), 3) participants contribute by sharing their tacit knowledge, which leads to better alignment, 4) it is a facilitated workshop that occurs only once. Another example that is easy to categorize is Hartmann et al. (2006). This paper describes a user study of the d.tools software for supporting prototyping processes. Because the method is about the iterative process of developing prototypes and getting feedback—which is about making tacit knowledge explicit and explicit knowledge tacit—it is easy to conclude that it belongs in externalization. Finally, Roh et al. (2016) belongs in combination because the task of tightening bolts is an algorithmic task that can be quantified and translated into explicit knowledge, as in the case in this example of gamification for assembly line workers.

Because the field of serious play is characterized by multiple and idiosyncratic vocabularies, characterization of methods cannot rely solely on the author’s terminology. For

example, Watson (2012) refers to the serious play method as “medical improv”. The improvisational component and emphasis on human interaction makes it tempting to automatically categorize the paper as belonging in socialization. However, the paper does not depict traditional improve theater (which would have belonged in socialization) in the sense “anything goes”. More over, the main purpose of this serious play method was not to build trust and relationships among the participants, but rather to build capacity within each student. The medical students were *embodying and practicing* the behaviors and patient *interactions* of a highly qualified doctor. This means that it is actually a role-playing activity, not improv. Hence, this serious play method belongs in *internalization*! The students playing doctors are not socializing with the students playing patients. On the contrary, the latter group serves as *models* of real-life patients for the future doctors to practice communication with.

Results & Discussion

A total of 56 papers on serious play are included in this investigation. By examining them according to the nine guiding parameters for assessing the applicability of serious play methods, it is possible to categorize them as they pertain to the phases of the WoK. The results are listed in a 25-page table, which can be found in appendix. As depicted in figure x, which shows the first page of the table, the columns from left to right convey:

(1) Papers (Author, year)

(2) Socialization

(3) Externalization

(4) Internalization

(5) Combination

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Paper	**Socialization**	**Externalization**	**Internalization**	**Combination**	**Serious Play method(s)**	**Type of Study**	**Type of Evidence**	**Findings**
Benedettini & Tjahjono, 2008					Test of Computer-based simulation tool for complex manufacturing systems design.	Qualitative assessment of the extent to which this interface can support the simulation modeling process.	Analysis based on the self-reported experience of the users. Semi-structured interviews guided by questionnaire form with open-ended questions.	Proposes developments that can support the uptake of simulation techniques within the manufacturing industry.
Brandt, 2006					This paper discusses the use of exploratory design games to organize participation in participatory design projects.	No. Describes various methods for collaborator inquiry: Scenario development and –enacting.	Anecdotal.	While 3D and 4D (video) methods are more time consuming, they are "probably the best way to open for participation and inquire into existing practice and jointly create future visions than using verbal language alone."

Figure 20. Subsection preview of the 25-page table that provides an overview of the serious play literature (for the entire table see appendix).

This table also provides an overview of the contents of the literature by summarizing each of the 56 papers in terms of:

(6) Serious play method(s) reported on,

(7) Type of study reported on,

(8) Type of evidence presented, and

(9) Main findings.

An underlining of the reference in the left-most column (e.g. Hansen et al., 2009) indicates that this is a key paper I recommend for readers seeking to familiarize themselves with the serious play field.

In the next four columns (socialization, externalization, internalization, and combination) the shading indicates to which phase(s) of the Wheel of Knowledge the method(s) described in the paper applies. Note that more than one phase can be shaded under the following conditions: (1) if the paper describes more than one serious play method, or (2) if the way a single method is applied and described means that it serves to facilitate more than one type of knowledge conversion. Condition (1) is the case in for example Brandt (2006) where an array of methods is described—some for socialization and some to internalization. Condition (2) is the case in for

example Hartmann et al. (2006) where the authors describe both the process of creating (externalizing) prototypes, and the process of end-users interacting with (internalizing) them to be able to suggest modifications.

The light and the dark shade of grey indicate the strength of evidence presented in the paper.

- A light grey denotes subjective, anecdotal evidence. Here the authors either theorize based on preponderance recounting past experiences (without an actual study), or report on a study that are conveyed through anecdotal evidence. They might report to have included follow-up interviews or questionnaires, but there is no account in the paper of the rigor, contents, or analysis of these.
- A dark grey denotes stronger evidence—often times mixed-methods approaches, providing both qualitative and quantitative evidence.

Table 21. The sum of papers categorized as being relevant to each of the WoK phases sorted according to the strength of the evidence presented. Light grey: anecdotal evidence. Dark grey: mixed methods. White: total sum.

Socialization		Externalization		Internalization		Combination	
30	9	11	2	16	5	5	4
39		13		21		9	

It is worth noting in table 12 above that the majority of papers described methods catalytic for the tacit to tacit knowledge conversion (30). Less that 25% of these papers presented strong (mixed methods) evidence. In contrast, 80% of the papers categorized as pertaining to combination do present quantifiable data. The explanation may be two-fold: (1) the tacit to tacit knowledge conversion process in the socialization phase are experience-focused. It could be argued that they typically do not lend themselves as well to quantification as methods suitable for the explicit to explicit knowledge conversion processes in the combination phase. (2) Studies of methods applicable in the socialization phase and studies of methods applicable in the combination phase are often conducted by different types of authors. Whereas, professional facilitators write many

case studies, categorized as lightweight in the socialization phase—computer scientists, game scholars, and production engineers are the authors behind many of the studies categorized as belonging to the combination phase. These fractions differ in terms of epistemology and research approach.

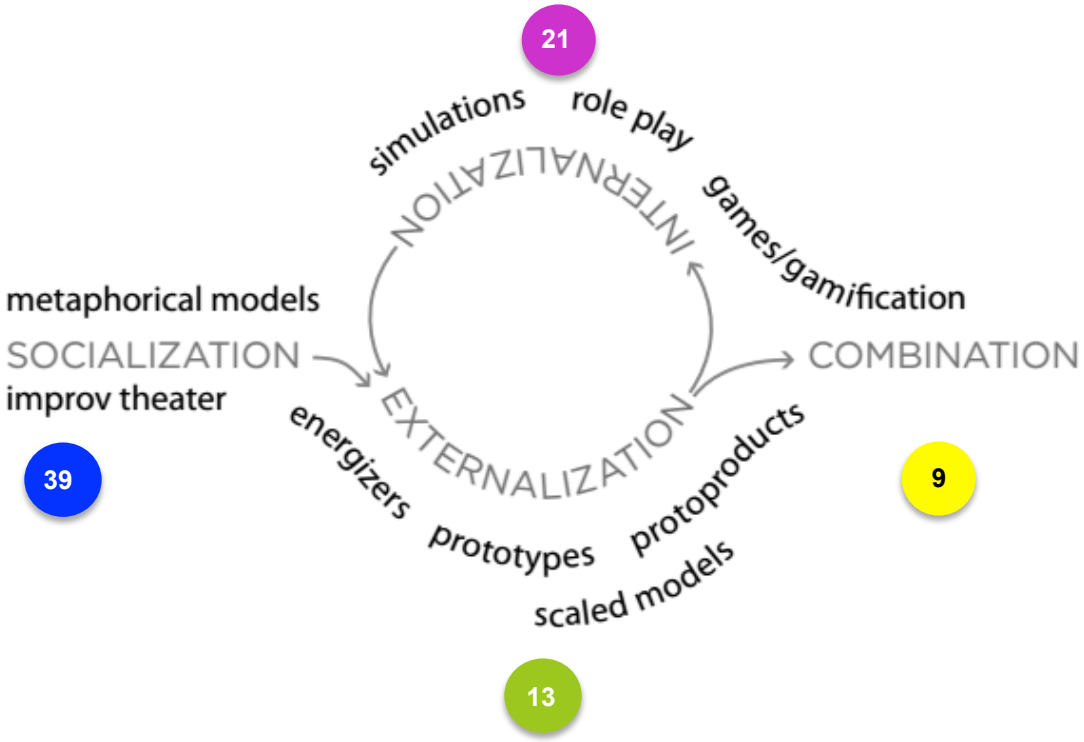

Figure 21. The sum of papers categorized as being relevant to each of the WoK phases.

Shared Characteristics

Since the characteristics (filters) of the bins are differentiated, the papers and methods that match each bin are different too—and it is possible to identify commonalities among those methods that cluster around each.

Papers that belong in socialization—see table in appendix—report on methods such as improv theater, brainstorming, mind-mapping, or methods for material deliberation like: low fidelity prototyping, LEGO® Serious Play®, or collaging. Common for these methods are that they facilitate tacit to tacit knowledge conversion, and serve to create collaborative environments characterized by collective trust, creativity, improvisation, and commitment (Hansen et al., 2009),

to bring forth a broad range of ideas as well as the knowledge and mindsets conducive to reframing and tackling often times complex, interdisciplinary problems. When they do this through methods that have a material component, the materiality is metaphorical and requires that the creator of the artifact share the thoughts behind. In other words, the methods concretize issues through embodied metaphors (Jacobs & Heracleous, 2007). Examples of application range from strategy workshops (Bürgi et al., 2004; Roos et al., 2004), product design (Brandt, 2006; Mabogunje et al., 2008), establishing design requirements (Cantoni et al., 2009), developing a visionary business plan (Grienitz, et al., 2013; Sukovic & Litting, 2011; Lund et al., 2011).

Papers that belong in externalization report on various methods for modeling (representing an existing reality) and prototyping (representing a proposed, future reality)—which manifest in explicit externalizations that can be physical or digital. Common for these methods are that they facilitate tacit to explicit knowledge conversion by acting as a repository for shared concepts (Scharlau, 2013), thereby allowing for design assumptions to be tested and concepts to be validated and matured. Examples of applications are most common in product design and engineering, and can take the form of for example storyboards, models/prototypes of varying fidelity, and mockup environments (Suri & Buchenau, 2000; Selin & Boradkar, 2010).

Papers that belong in internalization report on various methods for simulation, which can be defined as the interactions with a model or a prototype (Jensen et al, 2017b). Common for simulation methods is that they facilitate explicit to tacit knowledge conversion, by allowing participants to embody (internalize) knowledge through interacting with the representation. Examples include real-life simulations (e.g. fire drills), virtual training simulations (Penenberg, 2015), simulation games, role-plays (Watson, 2011; Thoring & Mueller, 2012), body-storming techniques (Leifer & Sterinert, 2011), and play-testing of prototypes (Hartmann et al., 2006; Schrage, 2000, Suri & Buchenau, 2000).

Papers that belong in combination report on gamified approaches, which provide extrinsic incentive structures that motivate desired behaviors and affects in the workplace with the purpose of increasing productivity, quality, as well as workers' engagement, job satisfaction, and retention. Gamification facilitates explicit to tacit knowledge conversion, which means that goals and tasks

have been specified and made explicit. Hence, at this stage of the process, progress is measurable and quantifiable, and therefore suitable for gamified feedback. Examples of applications documented in the literature include organizational incentives structures (Gupta & Govindarajan, 2000), manufacturing work feedback systems (Roh et al., 2016; Korn, 2012), and knowledge worker productivity systems (Nikkila et al., 2011). As a concrete example, Microsoft has turned the essential, but boring and tedious job of debugging software, into a game by having employees collaborate and compete to find more bugs faster (Penenberg, 2015).

The Actual Results

Like in the beer-flight outcome defined under Possible Outcomes, the actually results transcend the alternative outcomes that would render the conjecture invalid. From the categorization (in appendix and figure 6), we first see that papers categorized in a bin share similar characteristics (e.g. all paper in combination relate to gamification)—the results thereby transcend the Lucky Charms outcome, in which distinctions between the categories are ambiguous or the papers within a given category fail to exhibit commonalities. Second, it was possible to categorize all papers within the defined categories—the results thereby transcend the platypus outcome, in which no category would be suitable for certain papers. Third, we notice a sufficient breadth of serious play methods for supporting all four types of knowledge conversion, which makes it possible to populate all bins—the results thereby transcend the Higgs-Boson outcome, in which one or more categories would remain unpopulated due to no fitting papers. Thus, the WoK can serve as a useful tool for matching the right types of serious play characteristics with the type of knowledge challenge that they are suitable for.

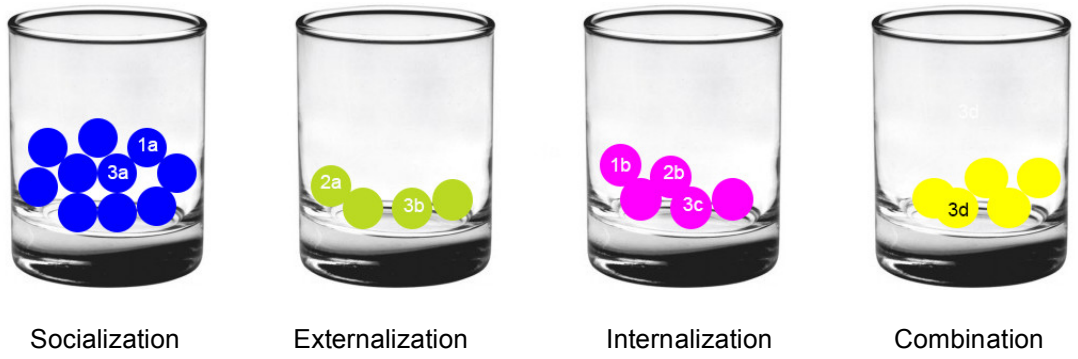

Figure 22. The actual results resembles the beer flight outcome, but with multiple knowledge conversion processes represented in some of the papers.

An interesting consideration is, that had this investigation been conducted ten years ago, we might have seen a Higgs-Boson outcome. Like in the case of the Higgs-Boson particle, it would have been possible to conceive of a true notion—in this case that game-like approaches could be useful in e.g. production—without being able to find any observations (papers) that substantiate this idea. Even if there were papers written on the topic, it is unlikely the authors would use the term 'gamification', as that did not gain popularity until 2010 (see figure 1). This outcome would not automatically render the hypothesis invalid. As in the Higgs-Boson case, it could just be ahead of its time.

Something that could theoretically challenge the validity of the conjecture is that it was not possible to categorize every single paper into just one of the four bins: The results show that some papers belong in more than one category. Yet, this does not invalidate the WoK's function as a sorting mechanism, as the reason for the multi-categorization is that these papers present more than one method—in that sense the WoK is not an 'either-or' categorization system. For example Brandt (2006) presents methods for socialization and then a role-play activity, which means that the paper can be categorized under internalization. This is represented as 1a and 1b in figure 7 above. In other instances, papers on tools for innovation may naturally report both on the prototypes and process of evaluating them. In such case (e.g. Hartmann et al., 2006) that paper can be categorized as belonging in both externalization and internalization. This is represented as 2a and 2b in figure 7 above. Only one paper can be categorized as reporting on

knowledge conversion of relevance to all of the categories. This is represented as 3a, 3b, 3c, and 3d in figure 7 above. It is important to note that this does not make Gupta & Govindarajan, 2000 a bad paper. It is in fact one of the papers I have marked as recommended reading, as it reports on Nucor, a steel company, which successfully incorporated serious play methods into all phases of their value creation.

Framework

Based on the guiding parameters for assessing the applicability of serious play methods/approaches defined in the beginning of this chapter, the following table presents four examples (LEGO® Serious Play®, prototyping, simulations, and gamification) found in the literature that pertain to respectively to socialization, externalization, internalization, and combination. More serious play methods can be added to the framework by using the guiding parameters to examine their characteristics and determine their applicability.

Table 22. Examples of serious play methods/approaches that pertain respectively to socialization, externalization, internalization, and combination plotted into the framework.

	Examples of serious play methods/approaches			
Parameters	**LEGO® Serious Play®** An example of Socialization	**Prototyping** An example of Externalization	**Simulations** An example of Internalization	**Gamification** An example of Combination
Purpose	Build trust Incite creativity Generate ideas Explore possibilities Allow for tacit knowledge to emerge.	Make ideas real and testable Propose solutions Integrate feedback	Learn by doing Challenge assumptions Practicing Embody know-how	Optimal performance Increase job-satisfaction Ensure quality Achieve flow Persuasive feedback Behavior change
Degree of structure	Open-ended. Allows for meaning to emerge.	Emergent, yet deliberate. Iteratively working towards an adaptive vision informed by feedback.		Constrained. Clear, measurable goals. One right way.

Materiality	Self-created physical, *metaphorical* boundary objects that support storytelling.	Entail creating material (or digital) representations that make assumptions explicit and proposed solutions concrete and testable.	May include physical or *virtual* props or environments. Offer sensory feedback.	Typically include real, explicit, literal, physical products. May include literal, explicit, digital representations. May offer sensory and affective feedback.
Role of the participant	Share insights and generate ideas.	Propose and mature solutions.	Engage with intervention. Learn by doing.	Perform and adapt based on feedback.
Knowledge	Exploring a *mystery*. Mainly tacit.	*Heuristic* experimentation. Shifting between tacit and explicit.		Executing *algorithmic* tasks. Mainly explicit.
Underlying questions	What could be? What if..? Why?	How might we…? What if we…? Would it work if…?	How would I… act, do, feel, know? But what if…?	What is the best way to…? How many/ much? What is in it for me/ the team?
Temporality	Event (workshop).	Iterative, project-specific practice		On-going.
Facilitation	Skilled facilitator.	Self-driven team.	Automated environment.	Typically automated/ computerized or part of organization's incentive structure.

Patterns and Under-explored Areas

Examining the selected serious play literature reveals certain patterns and under-explored areas of study.

Being young and emergent, serious play is still a disjointed field with a heterogeneous array of approaches, where specialized clusters focus narrowly on their own methods and seem largely unaware of one another's existence. The serious play literature describing the phases of the WoK exist in various areas that have heretofore been largely disconnected, notably

knowledge management for creativity, iterative approaches for innovation, and gamification approaches for improving productivity and job satisfaction.

In 2009 Hansen et al. stated that most effort in serious play "has been devoted to developing applications to facilitate strategy-making" (p. 1596). What has changed since then is the arrival of papers on gamification, which would have been a Higgs-Boson outcome in 2009.

The fact that the field is practice-led is reflected in the abundance of one-method case studies often (co)-authored by consultants. That the academic serious play communities lack behind, is evident by the absence of any scholarly frameworks that offer an objective overview of multiple methods. The majority of these papers convey one or more case studies—e.g. Burgi et al., 2004; Haase et al., 2009; Jacobs & Heracleous, 2007). A case study is the "detailed examination of a single example of a class of phenomena" (Abercrombie et al., 1984, p. 34). Case studies can be useful in distilling a hypothesis, which can then be investigated systematically in a broader empirical context (Flyvbjerg, 2006). While this could lead to an interesting progression of the field, and add more depth, very few of the papers distill a hypothesis for future investigation. In fact, most of these case studies found through this review of the serious play literature strive to validate the effectiveness of one select method (e.g. James, 2015; Peabody, 2015; Svejvig & Møller, 2011). The authors typically conclude that the method is useful – for instance Wengel et al. (2016, p. 162) argues that "the LSP method offers an effective methodology for exploring the depth of socially constructed realities that are complex, dynamic and therefore demand a multidimensional approach". While this may be true, as there is consensus on it across papers, it does not offer guidance as to when to choose LSP over another serious play method.

Another dominant trend is that many case studies, particularly in socialization rely solely on anecdotal evidence, which makes them less objective—particularly when the researcher is also the facilitator. What did not appear in the literature were mixed-methods studies with quantifiable data that compare the effectiveness and feasibility of different serious play methods for the same purpose.

While many papers seek to validate and praise a chosen serious play method, relatively

few papers (Statler et al., 2008) touch upon the challenges, downsides, or negative participant reactions. Examples of this type of experiences may include: participants feeling outside of their comfort-zone, e.g. due to the novelty of the experience they might adopt an “am I doing this right?”-mentality, they resist working with a ‘childish medium’ (e.g. play dough or LEGO® bricks), or find it uncomfortable to blur of the border between private and professional life (Jentsch et al., 2013). Furthermore, making thoughts and ideas explicit mean that they can be subject to criticism, which might provoke a sense of anxiety. Here is it critical that the process is well-facilitated or that the organization has cultivated a culture of constructive criticism that makes it safe to share—even bad ideas. The downsides and potential implications of serious play approaches have been explored to a higher extent in the realm of gamification, for example by Ian Bogost (in Walz & Deterding, 2015) and Raftopoulos (2014).

While there are natural ebbs and tides in organizational learning, scholars emphasize the importance of being ambidextrous in terms of balancing exploration and exploitation (He & Wong, 2004; Reeves & Harnoss, 2015). From the literature it however appears that organizations fail to integrate serious play practices for socialization into their everyday routines, but instead resort to these approaches when they have grown stale and experience a pressing need for reinventing themselves and accelerate their pace of innovation.

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CHAPTER 5

SERIOUS PLAY IN MULTIDISCIPLINARY STUDENT TEAMS

Introduction

The intractable social and environmental challenges of the 21st century are often referred to as wicked problems (e.g., Sweet et al., 2014). First introduced in the literature by Churchman (1967) and later defined by Rittel (1973), the term wicked problem denotes a class of complex challenges that are characterized by difficulties in problem formulation, confusing feedback loops, multiple stakeholders and decision makers with conflicting values, and uniqueness, or lack of reproducibility (Buchanan, 1992, 2010; Rittel & Webber, 1973; Seager et al., 2012). Examples of wicked problems range from changing climate, wealth inequity and poverty, to lack of education opportunity, diverse issues in health care, as well as the ethical, societal, and environmental aspects of emerging technologies, including nanotechnology—which is the deliberation topic in the case study described in this paper.

A shared characteristic for wicked problems is that they are not amendable to reductionism (Rittel & Webber, 1973). On the contrary, because all wicked problems are complex and part of intersecting systems, approaching them requires a bigger picture perspective. Churchman (1967) critiqued the managerial scientists of the industrial era for being morally wrong when taking reductionist approaches and solving only the feasible parts of a wicked problem. If a problem is actually a wicked problem this can be a recipe for disaster. Sooner or later, its intractable and interconnected nature will resurface as unintended consequences, stakeholder resistance, unexpected constraints, or volatile requirements. Thus, taking a reductionist approach to wicked problems can lead to situations that constitute a metaphorical Chinese finger trap: the harder we work to solve them, the more stuck we get—and the messier the problems get. This can be exemplified by problems "solved" by industrialization, that have lead to many of the environmental and societal problem of the 21st century:

- Antibiotics cured bacterial infection, but overuse has resulted in especially deadly strains of resistant bacteria (e.g., Yong, 2016, Arias & Murray, 2009),

- Cheap fossil fuels have created tremendous wealth, but carbon dioxide levels in the atmosphere is driving climate change and extreme weather conditions (e.g., Solomon et al, 2009),
- Highly optimized industrial agriculture has ended starvation in the western world and replaced it with obesity (e.g., Tillotson, 2004) and other unintended environmental consequences (e.g., Martin & Zering, 1997),
- Finally, efficient manufacturing has ended scarcity of goods, but lead to an abundance of garbage, including poisonous electronic wastes (e.g., Dunlap & Jorgenson, 2012) and oceans full of plastic debris (e.g., Andrady, 2011).

Nanotechnology is a current example of an emerging technological platform, which may lead to sever, unintended social, ethical, and environmental consequences (Roco, 2003), and for which existing risk assessment practices are not suitable (Wender et al., 2014). Alongside raising hopes, many aspects of nanotechnology remain uncertain and are potentially risky (Pidgeon, Harthorn & Satterfield, 2011). Increasing interest from government, industry and public stakeholders has pushed research on societal implications forward, but discussion about the long-term environmental and governance risks of nanotechnology remain submerged (Karinen & Guston, 2010; Pidgeon et al., 2011) and are difficult to predict (Roco & Bainbridge, 2005).

It is however acknowledged—as is the case with all wicked problems—that nanotechnology has different implications for different stakeholders, and therefore require a synthesis of various types of knowledge and perspectives from multiple disciplines and communities (e.g., Gorman, 2010; Rittel, 1972). For example, Gorman (2010) proposes that effective management of cross-disciplinary nanotechnology issues must involve the creation of "trading zones". These are environments for applied expert deliberations, which can produce common languages (e.g., semispecific pidgins that work across disciplines, Galison, 1997), and thereby enabling better communication and shared understanding among stakeholders to facilitate a more complete assessment of the risks and realities of nanotechnology development. The involvement of diverse stakeholders requires a participatory methodology that avoids the

traditional framing of dialogue as experts vs. non-experts (Kurath & Gisler, 2009) and offers a more realistic assessment of technical facts informed by human values (Roco & Bainbridge, 2005). Moreover, to reach consensus and make informed decisions about nanotechnology and its products, engineers, humanists, and policymakers alike, must be aware of the social and environmental facts, as well as the governance challenges pertaining to nanotechnology. They must also develop skills in communicating expert-to-expert (Anbar, Till & Hannah, 2016). Hence, part of the difficulty in approaching wicked problems is an issue of communicating across disciplines.

Chairman and Chief Executive of the W.M. Keck Foundation, Robert A. Day, observes that "Training individuals who are conversant in ideas and languages of other fields is central to the continued march of scientific progress in the 21st century" (quoted in NAS 2004). For example, engineers are increasingly asked to help solve complex societal problems that are not confined to single disciplines or stakeholder groups. To address these challenges, they are asked to collaborate with designers, policy makers, social scientists, industrialists, and the public (Gorman, 2010). For these collaborations to be generative, collaborators must be able to take the perspectives of others, think creatively, be solution-oriented, and self-reflective. Another key to success is their ability to communicate constructively and share knowledge across disciplines. Barriers to the cultivation of cross-disciplinary knowledge and communication however still exist at all levels—from student to faculty and practitioner. These include: 1) a lack of knowledge about collaborators' information needs (O'Brien et al., 2003), 2) a variation of cultural expectations between individuals and disciplines (O'Brien et al., 2003), and 3) an absence of shared vocabularies for communicating about complex societal problems within and across disciplines (Borego et al., 2007).

Development of interactional expertise (IE) is critical to overcoming communication barriers (Richter and Paretti, 2009). IE refers to an individuals' ability to converse and contribute meaningfully in one or more disciplines other than one's primary (Collins & Evans, 2002). Someone with interactional expertise can see the world from another specialist's perspective and knows enough of their vocabulary to be able to proffer authoritative technical judgments and raise

questions about aspects typically known only to specialists. This makes IE essential to cross-disciplinary verbal deliberations about wicked problems. However, the only documented mechanism for acquiring IE is through intensive linguistic socialization (Collins, 2004; Selinger & Mix 2004). Unfortunately, that is a time-consuming and expensive process (Erden et al., 2008), which in many situations simply is not feasible given the practical, temporal, and financial constraints.

The reliance on linguistic aspects is also central to Rittel's & Webber's (1973) second generation approaches to wicked problems, which emphasize verbal dialogue and "argumentative processes" as the main mode of communication for involvement of diverse stakeholders. This view, however, has two persistent shortcomings: 1) a failure to address the difficulty of cross-disciplinary communication in praxis in the absence of interactional expertise, and 2) a failure to acknowledge the need for creativity and integrate proven creative problem solving methods. Despite nearly five decades of maturation in practices since the term 'wicked problems' first appeared in the literature in 1967, conventional approaches, such as public participation, stakeholder engagement, and multi-criteria decision analysis, are insufficient and there remains a need for exploring and refining suitable approaches to wicked problems that help overcome communicative barriers and boost collective creativity (Masuhara et al., 2016; Camillus, 2008; Roberts, 2000). While practice-based foresight methods, such as mediated scenario planning, which leverage more creative means of expression are being advanced in parallel to more conventional methods, Selin (2014, p. 4) concludes that "Little has been pursued in the literature about these emerging practices, how they should be conceptualized, or how they work and why." This paper sheds more light on the how and the why based on empirical evidence from our experiment of implementing the LEGO® Serious Play® method (James, 2013; Frick et al., 2013) for facilitating material dialogue and deliberation with metaphorical boundary objects in an undergraduate class, and assessed it through the students' gains, reactions, and opinions.

The research team set out to explore an alternative way of supporting cross-disciplinary communication and knowledge sharing in lieu of fully developed interactional expertise. As an

alternative to conventional trading zones, which are enabled by interactional expertise (Collins et al., 2007), scholars and practitioners have suggested boundary object-based trading zones (Collins et al., 2007; Gorman, 2010; Søndergård, 2004; von Hipple, 2005). Building on emerging facilitation practices that incorporate physical boundary objects into the deliberation process (e.g., Davis et al., 2012), this paper explores novel, communicative strategies for approaching wicked problems by reporting on a curriculum developed in response to a NUE NSF proposal solicitation for new, cross-disciplinary approaches to nano-ethics engineering curriculum. With the objective of empowering students from multiple disciplines to engage in creative and generative deliberations about the wicked problem of nanoethics, it was crucial to: 1) offer an engaging and compelling active learning experience, 2) promote a deeper understanding of the basic, technical nano-knowledge and of the social, ethical, and environmental issues in particular, and to 3) support the cross-disciplinary communication in terms or ideation, knowledge-sharing, and perspective-taking.

Approach

To meet the challenges outlined above, and as a way to explore a novel approach to wicked problems, we developed and ran a unique, four-week curriculum, called NanoEthics At Play (NEAP). The curriculum was designed to enable cross-disciplinary teams of undergraduate students to understand and discuss social, ethical, and environmental dimensions of nanotechnology and build cross-disciplinary communicative competence.

Because wicked problems require constant resolution and reiteration (Rittel & Webber, 1973), a particular kind of cross-disciplinary communicative competence is essential in this context – the type that fosters knowledge creation and conversion leading to innovation (Nonaka, 2000), by deepening mutual understanding and developing an active, ongoing community of interest (Roberts, 2000).

Three processes that are known to be fundamental to an organization's ability to explore new possibilities, innovate, and create value (Nonaka, 2000, Jensen et al., 2017), are:

Socialization, which is characterized by shared experiences that allows for building trust and making tacit knowledge shared within a group. This is essential to cultivating collective creativity and a precursor for making knowledge shared and explicit (Nonaka, 1994).

Externalization, which serves to make tacit, personal knowledge and perspectives more explicit and shared among collaborators. This is essential to conveying knowledge and perspectives , especially across disciplines, without major misconceptions.

Internalization, which is about learning by doing (Kawamura, 2016)—i.e. actively taking in new knowledge and perspectives. This is an essential part of active listening and actually trying on, and building onto other people's perspectives instead of just listening with the intent to reply.

The concepts of socialization, externalization and internalization are part of the Wheel of Knowledge—a model for knowledge creation, sharing and exploitation (see figure 1 below and chapter 1).

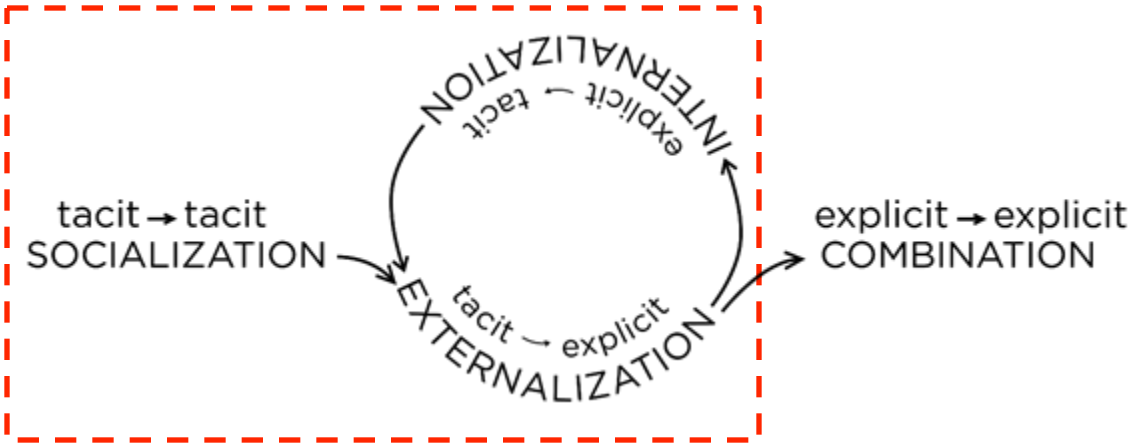

Figure 23. Material deliberation methods, such as LSP, may be useful interventions in the first three phases of the Wheel of Knowledge: Socialization, Externalization, and Internalization.

The LEGO® Serious Play® Method

LEGO® Serious Play® (LSP) is an innovation and strategy facilitation process designed to uncover, share, and synthesize insights, ideas, and perspectives in small groups. The LEGO™ Group originally developed the method in the late 1990s as a way to infuse the creativity and communication benefits of constructionist play and storytelling into their own and other corporations' strategy sessions. LSP workshops are typically lead by a certified LEGO® Serious Play® facilitator and have been used by companies such as Google, NASA, Coca-Cola, Toyota, and Unilever (Choi, 2015). In academia LSP has been used in multiple ways: as a future foresight technique (Grienitz & Schmidt, 2012), to explore identity and prompt self-reflection (Gauntlett & Holzwarth, 2006), in engineering design classrooms (Bulmer, 2011), as a multisensory approach to reflecting on learning (James, 2003), to enhance participatory development communication (Hinthorne & Schneider, 2012), and as a hands on thinking tool for idea generation (Hadida, 2013). In the context of artificial intelligence, as an example of an emerging technology that will pave the way to a wicked problem, Holtel (2016) specifically recommends – but does not test – LEGO® Serious Play® as a valuable approach for unveiling hidden aspects of wicked problems by encouraging stakeholders to share their hidden insights and perspectives.

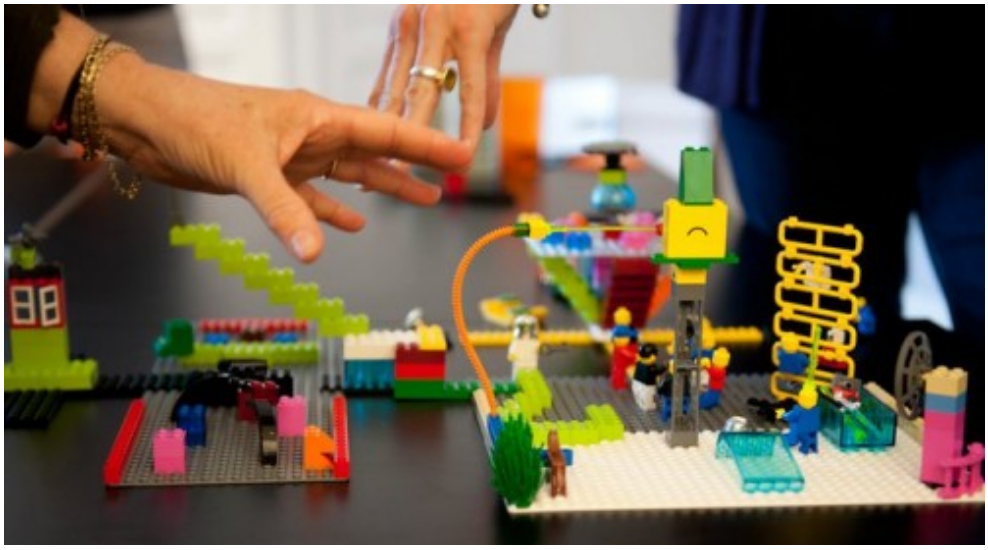

Figure 24. Verbal explanation supported by self-constructed metaphor-rich boundary objects.

The LEGO® Serious Play® method itself is content-neutral and suitable for any topic that is multi-faceted and warrants many perspectives in framing the problem-space and exploring possible futures. LEGO® Serious Play® is suitable for mitigating the intractable challenges that characterize nanoethics and other wicked problems, because it offers 1) a supportive structure for cross-disciplinary communication, in lieu of interactional expertise, through the use of boundary objects and metaphors, 2) a way of integrating a proven approach for eliciting and sharing creative ideas through playful, hands-on engagement. LSP uses boundary objects as a metaphorical vehicle for lowering the barriers to communication, thereby increasing the "collision" of ideas (Johnson, 2010) and building empathetic perspective taking.

An important aspect of the LSP process is the free-thinking, non-judgmental, and playful interactions between participants (Gauntlett & Holzwarth, 2006). The "Hands on, Minds on" philosophy of LSP is based on constructionist learning theory (Papert & Harel, 1991) and ensures active engagement of all participants and helps them explore and verbalize issues through the use of metaphor in their building process (Burgi et al., 2005; Heracleous & Jacobs, 2011). Metaphors can aid the understanding of complex and intangible topics (Lakoff & Johnson, 2003)—which is why the LSP platform is suitable for dealing with wicked problems such as nanotechnology. This built-in flexibility accommodates diverse learning modes (e.g., kinetic, visual, auditory) and allows for imagination and out of the box thinking. LSP reduces barriers to communication by focusing participants on what are called boundary objects. Sociological research characterizes boundary objects as "plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites". The creation and management of boundary objects is key in developing and maintaining coherence across intersecting social worlds" (Star & Griesemer, 1989, p. 393).

Playful activities help us access a free-thinking and creative state of being and interacting, which facilitates improved communication through a liberated, unfiltered, and less self-preserving expression (e.g., Gauntlett, 2007; Mainemelis & Ronson, 2006). When we are at play we learn better, form stronger social bonds, and make more imaginative leaps, because the mind at play is a mind open to new possibilities, willing to explore in ways that more serious-

minded states often impede. This allows novel and edgier ideas to emerge and be shared (e.g., Johnson, 2016; Brown, 2009; Mabogunje et al., 2008; Roos, 2006). These capacities can be directed towards creative problem-solving efforts through methods like LEGO® Serious Play®.

How LSP May Support Dialogue & Deliberation

Communication means “to share”, to literally “make common” (Harper, 2017) and refers to the act of conveying intended meaning, knowledge, or information from one entity or group to another through a mutually understood language or protocol. It can take many forms – e.g. verbal or non-verbal – but communication can also be distinguished in terms of purpose. Both dialogue and deliberation are useful modes of communication, when stakeholders see a discrepancy between the current situation and what they think should be happening – yet have no common agreement or understanding of what should change. This is the case when dealing with wicked problems, as they derive “from the interdependencies and complexities of living together without a shared set of values and views” (Roberts, 2000, p. 16). Dialogue is a process that allows people to share their views and experiences in small groups about challenging topics. Focus is on the sharing aspect, as opposed to convincing others or coming to an agreement. The purpose of dialogue is to build trust, dispel stereotypes, and enable individuals to be open to perspectives that differ from their own (Heierbacher, 2010). While closely related, deliberation is a process that allows people to reflect carefully on an issue, examining options and trade-offs of alternative solutions to a problem. The goal of deliberation is “to arrive at a decision or judgment based on not only facts and data but also values, emotions, and other less technical considerations” (Gastil, 2006, p. 2). As dialogue lays the groundwork for deliberation the National Coalition for Dialogue & Deliberation recommends starting with dialogue and moving on to deliberation when facilitating exchanges about difficult topics (Heierbacher, 2010). The LSP process embodies and supports this progression, as participants always build and storytell about the topic from their individual point of view first (dialogue)—before advancing to the process of constructing a shared team model, which has to reflect the shared perspectives and recommendation that the team arrive at through deliberation (Blair & Rillo, 2016).

Investigative Method

We explored LSP's potential to serve as a structured, creative approach to facilitate cross-disciplinary deliberation about a wicked problem through a series of workshops hosted at Arizona State University. In the NanoEthics At Play (NEAP), delivered as a 1 credit hour class in Spring 2015, undergraduate students in multi-disciplinary teams were challenged to learn about, reflect upon, and deliberate about the social, ethical, and environmental implications of nanotechnology. In preparation, we had conducted four rounds of pilot workshops in spring and fall of 2014, iteratively refining the curriculum design, exploring different course contents, guest lecturers, assessment methods, and workshop locations.

Research Questions

This study explores the following research questions:

R1: To what extent are collaborative inquiry activities adapted from the LEGO® Serious Play® (LSP) method a useful approach for advancing the processes of socialization, externalization, and internalization?

R2: Does the NEAP curriculum expand students' knowledge about nanotechnology and its implications?

R3: What empirical recommendations can be derived from the NEAP class to guide others looking to apply LSP in higher education and beyond?

Parameters

Both the process of engaging in dialogue and deliberation about wicked problems, for which there are no "one right answer", and the topic of nanotechnology are new to most of the class participants. Consequently, a successful intervention must support their ability to: 1) remain actively engaged in the deliberative process, even when it gets challenging, as well as 2) acquire sufficient topic matter knowledge to engage in deliberations free of major misconceptions. To assess the impact of the LSP curriculum we focus on the following parameters.

Confidence as a Driver for Motivation and Persistence

In education, particularly in active learning activities, motivation is considered a critical driver of student engagement (Graham et al., 2013). One way motivation can manifest is as *persistence*, which is key to acquiring new knowledge and mastering new skills (Dweck, 2008). The concept of persistence originates in social cognitive psychology and focuses on student agency (Bandura, 1989). Another important construct underlying motivation is the powerful influence of *confidence* (i.e., self-efficacy), which is a requirement for persistence (Dweck, 1986). Thus, it is imperative to address confidence, motivation, and persistence when assessing active learning activities. All of these concepts relate to the theory of *flow* (Csikszentmihalyi, 2000), which has been described as the '*zone of optimal experience'* and refers to a balance between difficulty level of an activity and the skill level of the participant. When people experience flow they often underestimate the time they spent on the activity (Csikszentmihalyi, 2000). As confidence and motivation are internal by nature, they can be assessed through self-reporting. Persistence and creativity can be assessed though observations of how students deal with challenging activities (e.g. the shared model builds) and what quality of outcome they arrived at. We assessed the impact of the LSP curriculum on students' self-reported measures of confidence in their ability to communicate across disciplines through pre- and post course surveys and summative focus groups.

Understanding Of Nanotechnology Contents

Achieving a conceptual, technical knowledge of a complex topic matter area such as nanotechnology and the societal and environmental implications is challenging, but necessary to engage in an informed conversation about these complex dimensions.

Thus, stakeholders (students, in this case) must be able to acquire some understanding of the technical details that is free of major misconceptions. It is valuable to know whether LSP facilitated acquisition of this knowledge, especially for those students without disciplinary preparation in the physical sciences. We investigated that through pre- and post course surveys,

and followed up with focus group questions. These investigate methods are described under Methods of Data Collection in the next section.

Student Recruitment

The class was promoted through a number of channels, including presentations in seven existing classes (Engineering Business Practices, English, Innovation Space, Graphic Design, Arts, Media & Engineering, Business & Marketing, and Ethics & Society), announcements to available list-servs, as well as word of mouth of professors and graduate students affiliated with the project. Over 60 students applied to partake in the 1 credit hour class via the course website, which contained a course description, information about the LSP method, a blog with student experiences from the pilot sessions and the course twitter feed. Nineteen students were selected based on discipline to ensure the multi-disciplinarity of the class. Upon email notification that they had been selected they could officially register for the class on the university website. Within the class four small groups were formed to maximize the LSP experience and the opportunities to interact with students from multiple disciplines.

Class Structure & Activities

The Nano Ethics at Play (NEAP) workshop series was conducted over four sessions and primarily led by two graduate students certified in the LSP method. Two faculty guest speakers provided technical subject matter expertise during the course. One additional session was held on the topic of *conation* (Kolbe, 2004), which is a theory that characterizes natural ways of taking action that has been applied in educational team settings (Sandhu & Kaur, 2016). For this session, each student completed a natural strengths assessment called the Kolbe A (Kolbe.com) to understand their own and other's instinctive work-, learning-, and communication approaches. While this workshop was optional, all but one student participated in the session.

Both the session on conation (IV in table 1 below) and the first session, focused on LEGO® Serious Play® skill-building (I in table 1 below), were two developmental classes designed to build individual understanding, skills, and capacity for group deliberation. These

components were important for the initial socialization, which build communicative capacity and trust among classmates. Another element that is essential to consider when engaging in deliberations about wicked problems is where the perspectives articulated by both yourself and other group members come from. Session I and IV also served to strengthen the students capacity for self-reflection and perspective-taking, helping them understand who they are (e.g. in terms of instincts, major, values, experiences) in relation to other team members and in the bigger picture, for example in relation to technologies, the environment, other stakeholders (3rd world worker, governing entities, and industry).

Table 23. The class consisted of the five following 3-hour sessions

Class Session Overview
I. Lego Serious Play skill-building workshop Introduction to the LSP method, LSP ground rules, learning the language of LSP: Tower exercise, fantasy creature - modify represent a good collaborator, build a model of yourself – use it to introduce yourself to your team. Pre-surveys and pre-model "my current perception of nanotechnology".
II. Nano-related applications and implications Introduction to the nano-scale, what makes nano "nano"?, applications, implications, in-depth example: nanosilver (guest lecture by Dr. Thomas Seager), LSP builds about applications and implications of nanotechnology.
III. Expert opinions and social justice issues Singularity video (Wohlens, 2013), Nano Around the World game (https://cns.asu.edu/sites/default/files/highlights/nanoequity_card_game.pdf), LSP builds tying it all together, integrating into shared team model, distilling recommendations for the office of Science & Technology, gallery walk to learn from other teams.
IV. Conation workshop Introduction to Conation, Explaining the Kolbe framework that allows students to better understand their instinctive ways of doing (measured by the Kolbe A index, which they took before the first class). This awareness enables students to work with their conative strengths individually and in a team context. Activities: LSP duck exercise, conation glob shop, and paper plane competition.
V. Local nano-application: PhotoVoltaics Example of nanotechnology's role in a specific transdisciplinary field (guest lecturer by Dr. Zachary Holman), LSP build "how does nanotechnology relate to my field?" Post-surveys, Post-LSP model "my current perception of nanotechnology", Focus groups.

The other three sessions (see II, III, and V in table 1 above) had a technical focus on nano-related applications and implications. During these sessions the students were first introduced to new topic matter knowledge either through a guest lecture or a game activity and video. Next, they were guided through material deliberation challenges using the LSP method to build and storytell their individual insights and perspectives. In some sessions the teams were tasked to integrate aspects of their individual models into shared team models and convey the outcome of their deliberations—e.g. the team's recommendations for the office of Science & Technology on governance of nano-related technologies, that take social, ethical, and environmental considerations into account.

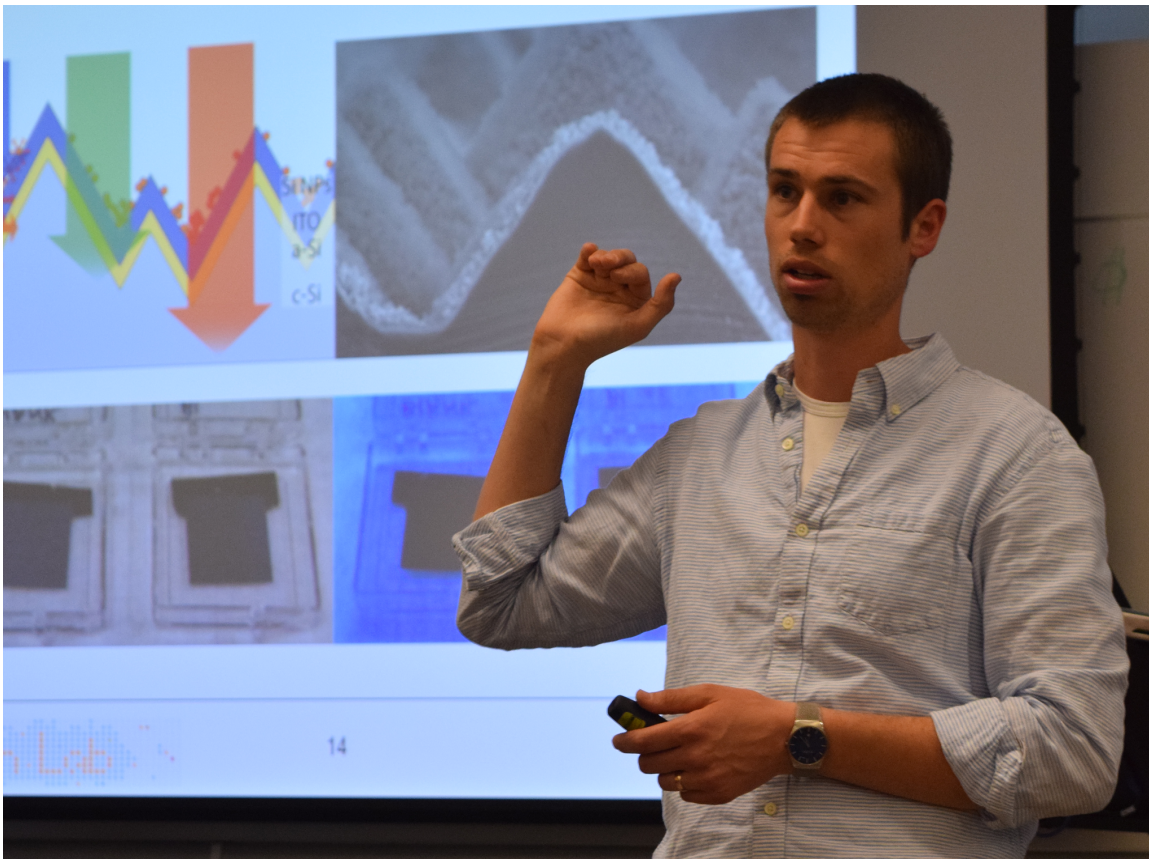

Figure 25. Professor Holman delivering a guest lecture about the use of nanotechnology in photovoltaics.

Figure 26. A student using an LSP model to explain his understanding of nanotechnology.

Methods of Data Collection

We assessed the effect of using LSP to support cross-disciplinary communication about wicked problems through several types of data collection, including:

Pre- And Post Course Surveys (Formative And Summative)

At the beginning of the first workshop participants filled out a pre-survey, which was both formative and summative. It was formative in the sense that it served to clarify student expectations for the class, how they had come to know of it, and what attracted them to it. It was summative in the sense that it provided a baseline for their pre-existing knowledge about nanotechnology, familiarity with LEGO, and their confidence in their ability to work and communicate across disciplines, etc. At the end of the last class participants filled out the post

survey to rate their gains from the class in terms of nanotechnology knowledge, the LSP method, and confidence in their ability to communicate across disciplines. They were also asked to provide qualitative answer, such as explaining how nanotechnology relates to their discipline. Finally, the post survey gave participants the opportunity to offer input on how to improve the class.

Twitter Reflections (formative)

As a debrief/reflection activity we asked students after each class to tweet at the class' twitter page (@ASUSeriousPlay): Three things that stood out to you (#triangle), one thing that squared (resonated) with you (#square), and one thing that is still circling (confusing, unresolved) for you (#circle). This mode of public reflection offered an opportunity for students to learn from each other and to keep the nano-conversations going between classes both among students and with professors, who provided answers to nano-related questions. The method further enabled facilitators to tie consecutive classes together by starting a class session clarifying what had been "circling" for students the week before. From an assessment perspective the tweets provided self-reported insights into what students took away from each class session and offered an opportunity to identify and correct common misconceptions.

Focus Group (summative)

At the end of the final class we hosted three parallel focus groups with the students to solicit their qualitative feedback on the class experience. For these sessions students were mixed across the teams that they have been in for the class, which allowed them to speak candidly about their team dynamics as well. Each focus group lasted for ~30 minutes and was guided by a list of questions prepared by the class facilitators aided by an external evaluator. Each session was audio recorded and transcribed by a transcription service.

Observations (formative and summative)

To gain insights about how the students interacted within the teams, with the LSP method and their reactions to the curriculum in general we conducted observations. Throughout the class the facilitators, associated faculty members, and ethnographic observers made observations about how the LSP method influence the interactions in the teams. The facilitators summarized what they noticed after each class, whereas the ethnographic observers had been provided an observation guide and took notes while the session was in progress. An external evaluator observed and assessed one of the classes.

Results & Discussion

While this chapter focuses on the effect of applying the LEGO® Serious Play intervention, a full account of the survey and focus group results can be found in the course evaluation report: https://awsum.box.com/v/UOEEEevaluationreport. This report accounts in more detail for aspects such as course discovery, course attraction, prior familiarity with nanotechnology, alignment between expectations and gains as well as suggestions for course improvements.

The results are based on the following student demographic and response rate:

Student Demographics

Approximately 56% of respondents identified as white, 22% as Hispanic, and 17% as Asian or Pacific Islander, and less than 7% identified as “Other” specifying “Hispanic/White.” Sixty-one percent of the students were male. The age of students ranged from 18 years to 28 years. The median age was 21 years. Half of the students (50%) were Engineering majors. However the other half represented a range of majors including, Social Sciences (17%), Business (11%), Design (11%), Sustainability (6%), and Engineering/Pre-med (6%). In total 11 different disciplines were represented in the class.

Response Rate

All workshop participants (n=19) were invited to participate in the evaluation activities. Nineteen students participated in the Pre-survey (a 100% response rate) and 18 students participated in the Post-Survey (a 95% response rate). On the final class date, all participants (n=18) were divided up and each participated in one of three focus groups.

Persistence, Creativity, and Motivation

That the LSP activities incited creativity and inspired persistence could be observed, for example when the teams persevered through the challenges of literally building consensus in their shared models—i.e. combine ideas among the team members to create a single model. This was confirmed in the post survey, as one student described these challenges as "fun frustration" that led them to "be creative and think of a story that's going to effectively describe what [they were] talking about". Another student wrote, "When we made our concerns of future nanotech model, we combined our concerns into one overarching story. It took some work, but we were effective."

Confidence In Their Own Abilities

For instance, one of the most significant results in the pre and post-survey was the increase in students' confidence in their ability to deliberate about complex issues (wicked problems). More specifically students reported an increase in their confidence in their ability to "form new ways of thinking about complex issues" (see figure 2) and an increase in their confidence in their ability to "work collaboratively to explore complex issues" (see figure 3).

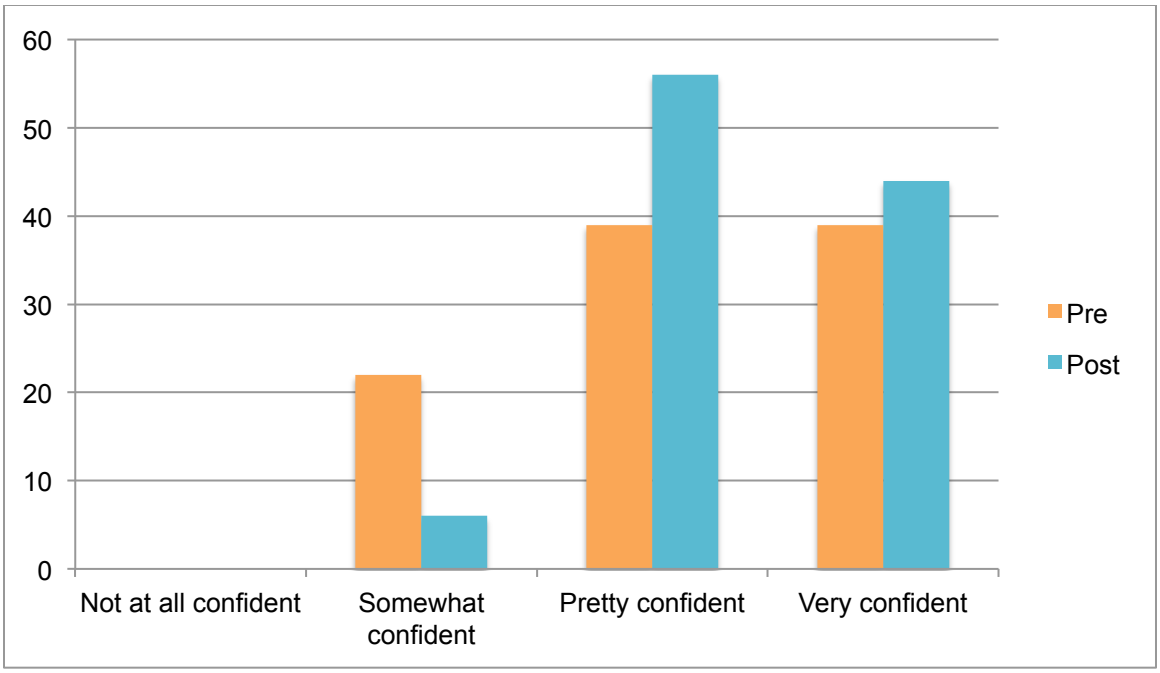

Figure 27. Students indicated an increased confidence in being able to "form new ways of thinking about complex issues" in the pre and post survey.

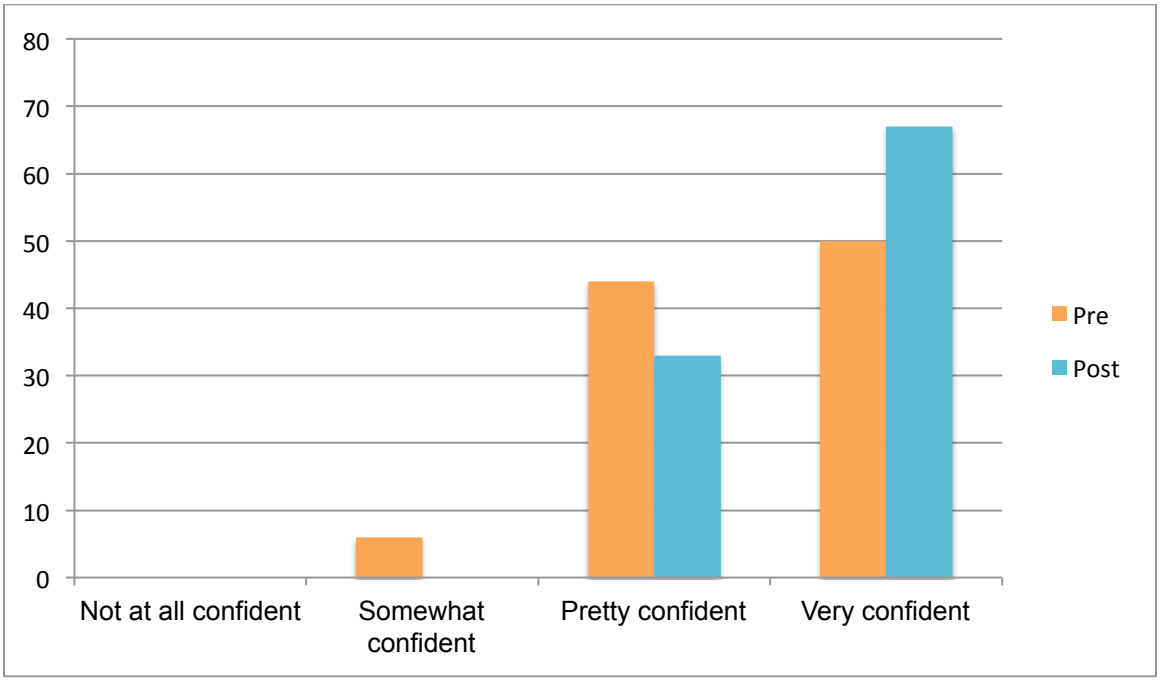

Figure 28. Students indicated an increased confidence in their ability to "work collaboratively to explore complex issues".

The confidence ratings above are consistent with students ranking “opportunities to collaborate with students outside my major” and “increased openness to consider different perspectives” among their most significant gains from the class. Responses to the post survey indicated that what 47% of students liked most about the class was learning about other perspectives and working with individuals outside their majors. One student indicated that s/he liked, “[b]eing able to listen to other ideas and compare them to [her or his own].” Another noted, “I loved being able to work closely with people from other disciplines.” A third responded that s/he liked that “it was completely out of my field and let me peek into the world of engineering.” This indicates that the LSP intervention helped break down barriers to cross-disciplinary collaboration and communication. This can likely be attributed to the method’s structured turn-taking process of sharing views and insights scaffolded by metaphor-rich boundary objects, which occurred to incite curiosity about perspectives from other disciplines.

Understanding Of Nanotechnology Contents

Through the course material and the LSP method for participatory deliberation students demonstrated the ability to understand, contextualize, and synthesize knowledge about a complex issue – in this case the applications and ethical implications of nanotechnology.

The majority of students found that nanotechnology related, even if remotely, to all disciplines. Students in Engineering disciplines related nanotechnology to building materials, energy technology, or biomedical applications. Students in Philosophy, Psychology, and Business related their majors to the ethical, medical or health, and economic implications of nanotechnology.

According to the pre-course survey only a third of the students had “some” familiarity with nanotechnology prior to the class. On the post survey, students were asked to explain what made nanotechnology “nano” and all respondents correctly indicated that it was the size. In the focus groups a participant expressed that beforehand s/he “didn’t realize nano meant a literal size.” Another one had been surprised that “properties start changing when you get a certain

surface area to volume ratio." Hence, after the class students clearly articulated an increased understanding of nanotechnology.

In the context of nanotechnology, students came to appreciate the complexity and interconnectedness that characterize wicked problems. They were surprised by the social and ethical implications of the nanotechnology and in the focus groups they mentioned "the effect it has on the environment," and "politics involved in it, how money has a play in it…" One student expressed his or her concerns about nanotechnology, "…you can lose control, and they can be spread around in the environment and various places. The result of that aren't really understood right now." Another student was surprised to learn about the cultural considerations and inequality issues involved when bringing nanotechnology production to third-world countries. Another student emphasized the importance of bringing awareness to nanotechnology and its implications, "not just educating people who are in research, but everyone else, because no one's going to put money into something they don't understand." These types of insights and concerns were also expressed in the twitter reflections, which the students wrote as a debrief exercise following each class session. Judged by the surveys, focus groups, and the external evaluators observations the course piqued the students' interests in both the topic matter and the LSP, they were eager to learn more about the applications and implications of nanotechnology and suggested the LSP method be used in more classes. In the focus group a student suggested, "The use of LEGO to teach students about challenging issues should be used in more disciplines!"

While the workshops focused on nanotechnology, the findings are not unique to that topic matter area and offer broader, more generalizable contributions—i.e. indicating the potential in terms of applying the LSP method to other contexts that will benefit from increased communicative competence across disciplines and amplified creativity.

Socialization, Externalization, and Internalization

According to my findings the LSP method proved useful in three generalizable respects:

1) it accelerated the *socialization process* essential for generating and sharing creative ideas by structuring interactions with material boundary objects, 2) it enabled students to *externalize* their ideas and perspectives in more explicit forms through the use of material metaphors, and 3) it facilitated the *internalization* of new knowledge. These aspects are known to be fundamental to an organization's ability to explore new possibilities, innovate, and create value (Nonaka, 2000, Jensen et al., 2017).

The concepts of socialization, externalization and internalization are part of the Wheel of Knowledge—a model for knowledge creation, sharing and exploitation (see figure 1 below and chapter 1).

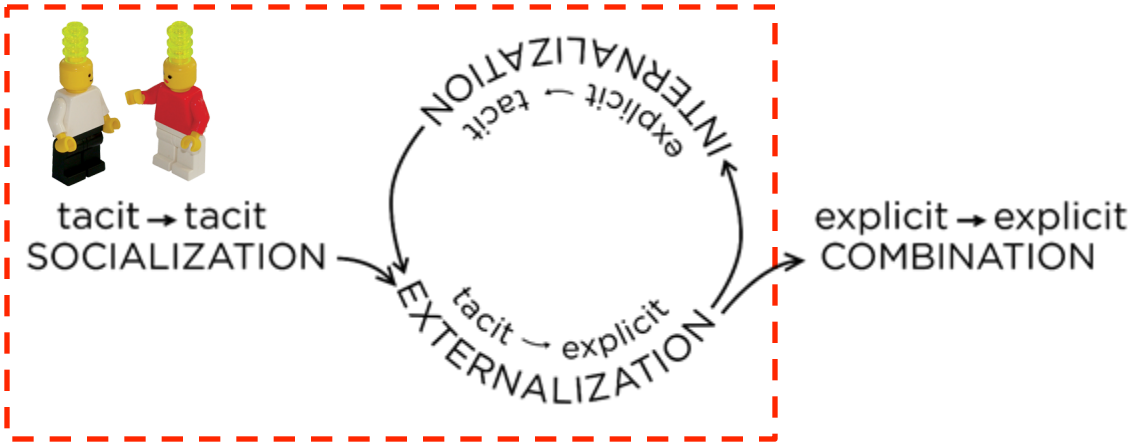

Figure 29. Material deliberation methods, such as LSP, are useful interventions in the first three phases of the Wheel of Knowledge: Socialization, Externalization, and Internalization.

The socialization process was accelerated through LSP exercises that prompted self-reflection and encouraged participants to share personal stories and qualities with their teammates. Examples of prompts included: build a model that represents what traits you value in a good collaborator, build a model that represents you and use it to introduce yourself to your teammates, and build a model of a time you were fully immerged in play. Students built and shared quite personal content. As a result students reported feeling like they knew people in this 5-week class better than classmates they had spent a full semester with—something they attributed to the LSP activities. In describing the communication within their teams, it was noted by several students in the focus groups that team members took turns speaking, and that those

who were more comfortable speaking up made an effort to bring out the ideas of some of the less outspoken individuals by asking questions about their LSP models. In this way, participants showed leadership and sought to promote a team approach within their groups. Furthermore, ethnographic observers noted that teammates often helped each other find the LEGO pieces needed for their individual models. These behaviors can be interpreted as a sign that teams had a successful socialization process. Participants reported that what they appreciated most about the class experience was the chance to engage with students outside of their major and be exposed to new perspectives. This reaffirms the importance of socialization and perspective taking (empathy).

The externalization process was supported by LSP by letting participants translate their knowledge into tangible, metaphor-rich models and then convey it through storytelling. Because LSP contains these two consecutive steps, it scaffolds participants' ability to externalize and share their insights: First they use their hands to *think from within* and make the content explicit in a physical model. Then they share what the model represents in words. It may feel less daunting to just build about it because the knowledge remains tacit in a metaphorical model. Once the knowledge is already embedded in the model, articulating it and making the meaning known may seem like a smaller step, because it is already out there on the table. This may be an explanation for the participants' trust, open sharing, and candidness mentioned under socialization above.

Student teams also externalized collaboratively. Gathered around a table, team members took turns describing their individual models and then had to create a shared model, which integrated the essential perspectives from all team members. The teams then presented to all of the other teams. Each team told a story that characterized both the social and ethical implications of the nanotechnology and used their co-constructed boundary object (shared LSP model) as a symbolic representation of the story that encompassed the diversity of perspectives. The post-course survey invited participants to provide an example that illustrates the communication within their teams. About 29% of the responses emphasized the externalization process of both creating a model and then collaborating with team members to create a shared model. One student explained, "Our varying disciplines and personal interests combined in

creating group models, conveying a broad consensus on the implications of nanotech[nology]." Several students noted that the LEGO model helped them to convey their ideas, as one student articulated, "I was able to show visuals of what I was thinking and express more of my ideas through the symbolism of my Legos." When asked in the focus groups and post–course survey what LSP does for communication, one respondent noted that "[LSP] was an awesome and effective concept." Another added, "The communication via building is very expressive!" A third explained "I think that was successful because you're physically putting your ideas on the table." The metaphor-rich, physical model on the table acts as a memory aid for the storyteller to recall what points to convey. The storyteller can also actively use the model as a tangible, dynamic demo prop, which makes for more multi-sensory communication.

The internalization process, like the externalization process, also benefitted from the multi-sensory communication, as the physical models provided a visual anchor for the listener to focus on as they took in the story. This increased engagement cultivated active listening— which could be observed as head nodding, saying "mm-hmm", and posing clarifying, open-ended questions. Also, acknowledging statements like "that's really interesting what Matt is saying. I never thought about it like that before" (said by a Civil Engineering major about insights from a Psychology major), indicated that the perspectives from teammates of other majors were being internalized. Another result of effective internalization is retention. The combination of the physical models and the accompanying stories rich in metaphors resulted in strong retention. For example, 2-3 hours after the LSP introduction exercise in the first workshop some students were able to recall almost verbatim details that other students had shared, just by looking at their model again.

Communication and the LEGO® Serious Play® Method

An objective was to explore whether LSP supported cross-disciplinary communicative competence. Students reported being able to communicate effectively within the team and assessed that their team members also communicated effectively. While many students suggested that the collaborative builds were challenging, they inspired extemporaneous stories

and creativity to accomplish the integration of multiple perspectives. The interactions also appeared to prompt self-reflection, which led to improved communication. When asked to rate how effectively their team members communicated their ideas, 61% of students indicated "completely" on a 5-point scale from "Not at all" to "Completely." When asked to provide an example that illustrated their rating, 16 students responded and the majority of them noted the process of having to build, explain their ideas, and listen to the ideas of the other team members. One student clarified, "They often explained abstract ideas intelligently that they had encapsulated in a model." Another student described the LEGO builds as an effective method to "center our opinions and conversations." Students agreed that the LSP activities contributed to their ability to effectively communicate. All students either "agreed" or "strongly agreed" that the LSP activities increased understanding of their personal learning style, increased their ability to explain their ideas, and made it easier to understand the ideas of team members (see Table 2 below).

Eighty-three percent of students "agreed" or "strongly agreed" that it made them lose track of time, which is consistent with experience of flow. It appears that for the majority of students, the LSP activities promoted communication and collaboration among team members, even though 71% "agreed" or "strongly agreed" that it "provided a challenging medium of expression." However, all participants "disagreed" or "strongly disagreed" with the statement that LSP "required too much effort." About 22% of students indicated that it made them "feel anxious." The anxiety was clarified in the focus groups as primarily pertaining to the amount of time for the LSP building assignments. One student expressed that s/he "felt rushed and pressured at times." From the focus group, there was a greater delineation between the two sides of this debate. To several students, the short time limits were constraining and they felt unable to fully convey their ideas. On the other side, some students felt the time constraints increased improvisation of the build and subsequent presentations. One student in particular said, "It made you think on your feet a lot more because [the builds] were timed." The latter is exactly the intention behind the time constraint imposed in the LSP method.

Table 24. Student feedback in post survey on the LSP activities used in the course.

Questions	Strongly disagree	Disagree	Agree	Strongly agree
Required too much effort.	39%	61%	0%	0%
Increased my understanding of my own personal learning style.	0%	0%	89%	11%
Provided a challenging medium of expression.	0%	29%	47%	24%
Made me feel anxious.	44%	33%	22%	0%
Increased my ability to explain my ideas.	0%	0%	78%	22%
Made it easier for me to understand the ideas of my team members.	0%	0%	61%	39%
Made me lose track of time.	0%	17%	72%	11%

Participants reported that they valued the perspectives of team members, felt actively engaged in the course, and that the course exceeded expectations (see Table 3 below). Most students (83%) “agreed” or “strongly agreed” that the course forced them to step outside of their comfort zone.

Table 25. Student feedback in post survey on the overall course experience.

Questions	Strongly disagree	Disagree	Agree	Strongly agree
I valued the perspectives of team members that came from other disciplines.	0%	0%	22%	78%
Overall, I felt actively engaged in this course.	0%	0%	50%	50%
This course forced me to step outside my comfort zone.	0%	17%	61%	22%
Overall, this course exceeded my expectations.	0%	0%	61%	39%

The fact that LSP was new to all participants leveled the communicative playing field and meant that it became a shared language, an Esperanto, for material deliberation across disciplines. The shared, new experiences of the socialization process offered a common frame of

reference and the trust building that LSP affords provided an important foundation for students to venture outside of their comfort zone and share (externalize) wild ideas about a topic which was new to them.

Figure 29. Students visit another team to hear the story of their shared model (LSP gallery walk).

Consistent with the playful and non-judgmental nature of the LSP method, many participants felt set free to experiment, take risks, and entertain extreme scenarios in their storytelling, which lead to more creative leaps and a broader exploration of the possibilities related to nanoethics. In the focus group several students spoke about the importance of play in the class as something that accelerated socialization, incited creativity, and improved communication. One student articulated, “I think that at the beginning of class, you can learn a lot [more] about a person through an hour of play than a lifetime of conversation.” Along the same lines, another student felt “play branches out your own train of thought, as well as other people’s” and another student added, “one of the most effective things it does is gives everybody the opportunity to speak…[using] your own creation.” One student noted, “I think [LSP is] a great

alternative to conveying ideas without having to write them down and type it out and make sure it's 12 point font and double spaced. It gives you the freedom do to whatever, however you feel, without judgment by others."

Conclusion

Our findings indicate that the constructionist activities with boundary objects and story telling with metaphors, provided through the LEGO® Serious Play® experience, were useful vehicles for the students to engage in cross-disciplinary discussions about the complex issues associated with nanotechnology.

In all three processes—socialization, externalization, and internalization—the scaffolded communication with physical boundary objects and metaphors helped bridge gaps between the different majors' knowledge, epistemology, and vocabulary. The role of LSP in advancing these three processes, known to be essential to creativity and knowledge sharing in organizations, validates the use of serious play methods with physical boundary objects as a valuable approach for facilitating dialogue and deliberation about wicked problems. The NEAP curriculum as a whole did expand students' topic matter knowledge of nanotechnology to be free of major misconceptions. This enabled them to realize that nanotechnology may pave the way to a wicked problem. Students were able to articulate their concerns and engage in deliberations about the complex, social and environmental implications, which nanotechnology has already lead to, as well as nano-scenarios the students imagined may occur. The curriculum piqued their interest in learning more about nanotechnology and they also suggested that the LSP method be used in more class to create a deeper understanding of complex problems. Students showed engagement and persisted when presented with difficult challenges—such as integrating all the perspectives present in the team into a shared model. Leveraging knowledge and values from a diverse group of stakeholders is essential when dealing with wicked problems. Students in this class indicated a high appreciation for the viewpoints and knowledge from other majors. They also expressed and increased confidence in their ability to form new ways in thinking about complex issues and in their ability to work collaboratively to explore these issues.

Recommendations

The circumstance that participants were undergraduate students and therefore less rooted in their home discipline may have influenced the results and findings in the following ways: 1) More openness toward the perspectives of other disciplines—as they may not yet be fully immerged in their own disciplinary jargon, epistemology, and culture, or on the contrary 2) More closed-mindedness toward the perspectives of other disciplines—which can come with a newfound identity which has not yet been fully formed or subjected to critical reflection, 3) Lack of deep disciplinary expertise and the self-knowledge necessary for taking a stance and arguing for it in substantive, heated deliberations. Based on the collected data it is not possible to say whether any of these conditions were present. It would, however, be worth exploring how the LSP method works for teams with high levels of expertise and experience as well as for teams with mixed levels of expertise and experience. Nonetheless, when it comes to dealing with wicked problems, the notion of having "complete knowledge" may be said to be an illusion in any case.

To prepare a workforce capable of taking on the wicked problems of the 21st century, academia must offer more classes that allow students to practice communicating their perspectives across disciplines. Students expressed a wish that more classes would make use of the LSP method. At Arizona State University we have since introduced it in engineering, sustainability, and communications classes. Other academic contexts we have identified as ripe for implementation is design, engineering business practices & ethics, veteran reintegration, infrastructure resilience, student success, and diversity training.

Based on the findings and tacit experiences from the design and implementation of the class, we can derive some recommendations for professors and facilitators seeking to apply the LEGO® Serious Play® facilitation method:

1. Get trained as a certified LEGO® Serious Play® facilitator. As with much else this method is only as good as the facilitator leading the session. While Lego made LSP open-source in 2010 with manuals available online, getting certified will enable you to articulate the purpose of the method, ground its functionality in the supporting theories, answer questions about the method, and to offer your participants a well-designed, well-facilitated workshop.

2. Practice, practice, practice! Do prototype workshops before offering a class or a high-stake workshop. Under pressure we perform at the level of our training, not at the level of our hopes. Running a successful LSP workshop requires a facilitator who is fully present and in tune with the state of the participants. Thus, the steps and contents of the activities should be rehearsed so that they are second nature.

3. Acknowledge that teaching and facilitating are different. Even if you are an experienced teacher brushing up on facilitation skills can be useful. We recommend seminars or books such as “Training from the back of the room!” (Bowman, 2008).

4. Plan and then improvise. Do make a thorough plan for your workshop outlining the time, purpose, and outcome of each activity, but do not be a slave to it. Use it as a guideline rather than a one-right-way to run the session. A new, rich direction may emerge during the course of the workshop that is more meaningful to explore than what you had envisioned.

5. Be a reflective facilitator. Part of growing as a facilitator is to assess what went well and what could have been different at the end of each session.

6. Divide into smaller groups. Do not run a class with 20 people in one LSP group. The storytelling step will take up a disproportional amount of your class time – and listening to that many stories will challenge participants’ patience, potentially leading them to disengage from the process. Rather, divide your class into groups of 3-7 people.

7. Consider table setup. Give each group their own table, so that they have space to build and can hear one another.

8. Engage co-facilitators. It is difficult for any facilitator to keep track of the activities at multiple tables. If possible have a LSP facilitator at each table to serve as your extension—clarifying prompts and signaling to you when their team is ready to move on. Table hosts can also ensure that the deliberations keep going until all tables are complete in their discussions.

9. Consider acoustics. Lego bricks make noise when they're shuffled. It's part of the appeal, but in a large room it can interfere with discussion. Seek out a venue with good acoustics and use tablecloths to dampen noise whenever facilitating more than one table at a time.

10. Go on gallery walks. To share insights uncovered in the groups, e.g. through shared model building, with the whole class, invite participants to visit one table at a time and hear the host-group convey the story of their shared model, as if they were art lovers going for a walk through a gallery.

11. Prioritize skill-building. Participants must build skills to become fluent in self-expression through models and metaphors – especially on complex topics.

12. Build in time for reflections. To complete the learning cycle allow time for a debrief activity at the end of each session. When you end your workshop with a debrief exercise participants take mental inventory of the experience.

13. Have a debrief protocol. One way to prompt reflection is to ask participants to write out what "squared" with them (#square), three things that stood out to them (#triangle), and something that is still "circling" form them (#circle).

14. Embrace public reflections. Have Participants read out their triangle, square and circle one by one as a way to end class. Alternatively, use Twitter for this, as it enables a public exchange of reflections to everybody's benefit—if something is unclear to one person it is probably unclear to others too.

15. Connect back to the familiar. In consecutive workshops, the written reflections serve to provide continuity—e.g. but clarifying what participants reported had been circling at the beginning of the next workshop.

16. Be strategic about your material selection. Not just any old Lego will do. There are multiple set of Lego kits developed for LEGO® Serious Play and curated with pieces that are great for building metaphor rich models. Consult with a master trainer about what Lego to get for your specific purposes.

17. Order your Lego early. LEGO® Serious Play® kits are sometimes sold out.

18. Practice inclusivity. Participants can feel disadvantaged in a LSP workshop due to a physical handicap or no prior experience building with Lego. It is important to emphasize that LSP is about the storytelling. The Lego models are a means not a goal. As a facilitator you can also

level the playing field by modifying the building prompt—e.g. telling everyone to build with their eyes closed or with a partner, each using only one hand.

This list of recommendations is an expansion of my contribution to the Serious Work (Blair & Rillo, 2016), which offer further guidance on how to facilitate workshops with the LEGO® Serious Play method.

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Dedication

This paper is dedicated to my beloved granddad, Per Eriksen Petersen, who fought bravely to regain his health after sudden illness, but passed away during the writing process.

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CHAPTER 6

CONCLUDING COMMMENTS

This synthesis chapter summarizes findings from the research papers put forward in this dissertation to address the guiding research question of 'How serious play methods can be employed to aid cross-disciplinary communication and complex problem solving?'

In investigating this inquiry the first paper creates a theoretical foundation that recognizes knowledge as the most important source of modern value creation, and that it plays a key role in different ways throughout the value creation process. By drawing on Nonaka, (2000), Drucker (2014), and Ayres (1994; 2016) the paper arrives at a new conceptualization of knowledge as pluralistic—evolving from justified true belief, over technique, to extra-somatic manifestations—across the span of the value creation process. The paper further establishes the notion that creativity (ideas) is a prerequisite for innovation to take place, which again is a necessary antecedent to value extraction (e.g. through entrepreneurship). Advancement through these stages of the value creation life cycle requires creation, sharing, and mobilization of tacit knowledge—all knowledge conversion processes which the paper explains and organizes in the Wheel of Knowledge (WoK).

Based on the pluralistic understanding of the character of knowledge and the related types of work as evolving over the course of the value creation process, introduced in the first paper, the second paper suggests serious play as an equally pluralistic management approach. First, it is necessary to disaggregate the fuzzy vocabulary in the literature of serious play. Next, guided by the Wheel of Knowledge (WoK) the chapter describes the essential role of serious play for each phase of the value creation process and matches serious play approaches with the character of knowledge work. Starting with knowledge creation, playful approaches facilitate and accelerate the socialization processes that allow ideas to be shared and creativity to flourish. Proceeding to innovation, ideas are matured and reduced to practice through iterative, experimental processes of externalization/internalization with physical and digital manifestations. Lastly, with a focus on value extraction, the hard work of manufacturing and production become essential. Here, gameful approaches that include pay incentives and social recognition are

essential to optimize performance. Matching forms of serious play to the right knowledge processes provides necessary guidance for the adaptation of serious play approaches at work. Seeking to test the conjecture proposed in the second paper and to establish an overview of the emergent field of serious play, the third paper conducts a literature search and organizes the literature according to the WoK. This is done through an iterative, heuristic examination of the literature, followed by an overview of how the existing literature pertains to the different knowledge conversion processes. Having distilled parameters that reveal the characteristics and affordances of the dominant serious play methods suitable for different knowledge challenges, the paper offers a comparative framework for classification of serious play methods and identifies under-explored areas of the field. One of the dominant trends is that many case studies, particularly in socialization rely solely on anecdotal evidence, which makes them less objective—particularly when the researcher is also the facilitator.

The fourth paper contributes a multi-session, mixed-methods case study and tests the recommendations of the previous paper by applying the LEGO® Serious Play® method to a knowledge conversion challenge focused on tacit knowledge sharing: to facilitate cross-disciplinary dialogue and deliberation about a wicked problem—in this case the societal and environmental implications related to nanotechnology. Results show that the LEGO® Serious Play method is particularly useful in the beginning of a value creation process and that it facilitates socialization and tacit knowledge sharing through dialogue and deliberation among the participants. It also enhanced their confidence in their own ability to collaborate across disciplines and grabble with complex societal and environmental issues.

Contributions

I believe that the knowledge conveyed in these papers will contribute to the understanding of serious play among practitioners, scholars, and organizations. For practitioners, having a shared vocabulary about serious play, can support and direct collaborations across disciplines by clearly signaling the purpose and intend of a given manifestation—for example, whether it is meant as a model or a prototype. For scholars, having succinct definitions and

differentiations of serious play approaches are necessary for the advancement of the serious play field as a scholarly discipline. For practitioners and organizations, having guidance on which types of serious play approaches applies when, can save them the costly mistakes of for example applying gameful approaches in the exploration phase and thereby narrowing focus and stifling creativity as a result—or applying playful approaches in the exploitation phase, thereby inviting divergent thinking and jeopardizing quality control. By matching the right type of serious play to the knowledge challenge organizations can unleash their potential for creativity and productivity e.g., as ways of building trust in teams and generating ideas, improving and accelerating innovation efforts, as well as infusing more fun into rote, algorithmic tasks—thereby attaining a competitive advantage in knowledge-based value creation.

Other contributions of this research that may have broader impacts is the new, pluralistic theory of knowledge and the model for knowledge conversion processes, the Wheel of Knowledge. They are applicable to knowledge work in general and provide a language for knowledge workers and organizations to talk about in which phase of the value creation process they are currently focusing their efforts. For example, a leader might realize that her team is performing sub-par due to a lack of socialization. Or collaborators (e.g. co-authors) might decide that it is time to stop talking about issues at hand and enter the externalization/ internalization loop.

Connection to design thinking

Herbert Simon (1996) encouraged his readers to "Think of the design process as involving first the generation of alternatives and then the testing of these alternatives against a whole array of requirements and restraints." Taking on this perspective makes the design process equivalent to the first two phases of the wheel of knowledge. Socialization focuses on the generation of alternatives—whereas externalization/ internalization is about testing these alternatives to arrive at a suitable design solution, ready to be implemented or brought to scale.

Table 26. Design thinking covers the design process, whereas the WoK covers the entire value creation process, including production/implementation.

Simon, 1996	Generating alternatives	Testing alternatives	
WoK	Socialization	Externalization/ Internalization	Combination
Design thinking	Empathize, Define, Ideate	Prototype, Test	

The way the WoK is organized, the serious play methods suitable in socialization seek to advance the focus of the early design thinking phases of empathizing, defining, and ideating (Brown, 2009). Similarly, methods used in externalization/ internalization advances the iterative process of prototyping and testing characteristics for the later phases of the design thinking process. Whereas, the phases in the WoK are occupied with knowledge-based creation, innovation, and value extraction, the modern day design processes do not include combination, as putting a product in full-scale production is not part of the scheme the design team's work is traditionally finished when a satisfactory solution has been achieved. Explicit manifestations of knowledge, such as blueprints or construction drawings, are then handed over to the client or production units responsible of bringing it to scale by combining explicit manifestations of knowledge–e.g. components–into desirable products or software that has value to the end-user.

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APPENDIX A

LITERATURE OVERVIEW TABLE

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Benedettini & Tjahjono, 2008					Test of Computer-based simulation tool for complex manufacturing systems design.	Qualitative assessment of the extent to which this interface can support the simulation modeling process.	Analysis based on the self-reported experience of the users. Semi-structured interviews guided by questionnaire form with open-ended questions.	Proposes developments that can support the uptake of simulation techniques within the manufacturing industry.
Brandt, 2006					This paper discusses the use of exploratory design games to organize participation in participatory design projects.	No. Describes various methods for collaborator inquiry: Scenario development and –enacting.	Anecdotal.	While 3D and 4D (video) methods are more time consuming, they are "probably the best way to open for participation and inquire into existing practice and jointly create future visions than using verbal language alone."

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Buchenau & Suri, 2000					Experience prototyping for: - Understanding existing user experiences and context. - Exploring and evaluating design ideas. - Communicating ideas to an audience.	No. Describes various examples of prototypes used at IDEO for developing specific product experiences, for example: - Embed designers in end-users' context. - Physical prototypes of different levels of fidelity. - Act it out/ body-storming (role-playing).	Anecdotal.	Higher levels of fidelity have their problems, too. Clients may become unshakably attached to early ideas when they experience a single convincing manifestation and perceive it as the final solution. Important that designers share their intent behind an Experience Prototype.
Bürgi et al., 2004					LEGO® Serious Play® for strategy making, playing emergence.	Case study: modeling how their business really works prepares managers for sudden change.	Authors' account.	The LEGO® Serious Play® workshops helped balance the planned approach to strategy by providing the participants with the means to explore how they would take pragmatic and flexible action in different situations.
Cameron et al, 2011					Epistemic games (or role-play simulations) for learning spaces.	No	–	–

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Cantoni et al., 2009					Real Time Web (RTW) adopts a playful approach to collaboratively elicit requirements and strategic web design issues, and extends the experience of LEGO® Serious Play®.	Presents a case study and the lessons learned from using Real Time Web (RTW).	Authors' account.	Lessons learned.
De Castell & Jenson, 2003					Games for education.	Literature review of edu- game history.	--	Identifies what edu-games can learn from commercial games and what is under-studied.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Dempsey et al., 2014					LEGO® Serious Play®.	Case study of a day workshop: Is LEGO® Serious Play® a suitable tool to support also the collective / participative reengineering of a more or less creative process like product development?	Observed and self-reported qualitative variables Number of observed groupthink events during the re-engineering process, self-reported satisfaction, identification and acceptance from the participants, tangible outcome of the reengineering process. Follow up interviews and surveys Only qualitative data (participant statements) reported on.	The responses from the participants indicate that incorporating LEGO® Serious Play® as a support tool for resulted in extremely engaged and creative managers who became absorbed in a process of improvement.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Djaouti et al., 2009					Play-testing of two multimedia applications: a play-based serious game (simulation game) and a serious game (educational game making use of game principals).	Case study describing how specific games were received by the general public.	Anecdotal account of a field study/ experiment conducted during the first day of the public release of these games. Observations (Video recorded the public playing the games), next proceeded to semi-guided interviews.	Not evaluating the approach but two different applications resulting from applying it.
Ematinger & Schulze, 2011					LEGO® Serious Play® and the "Selberdenken" framework for strategic preparedness.	LSP/ "selberdenken" case study-approach outlined.	Anecdotal No data or research methods conveyed.	Authors conclude that pilot project was very well received. They identify questioning and rethinking internal programs and processes and deciding what metrics are to be used to judge whether applying this approach has been successful or not, as the next steps in exploring the concept of Serious Play in organizations.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Evans & Palmer, 1989					Experimented with different activities to support group-relations among academics at five different events. E.g. as a group, build the highest tower of these Lego bricks, or find a way to share these three bottles of wine between the four groups.	Five case studies of applying playful ways of collaborating on research projects in higher educations	Anecdotal. he researchers' findings are based on their observations of their own direct experience of the institution under examination. No data collection methods described. No data shared.	the five events supposedly produced insights into the links between pedagogic practice and the nature of the material specific to the discipline. Oval model of the research process. Lower part resembles the WoK.
Gauntlett & Holzwarth, 2006					Social science version of LEGO® Serious Play®. Focusing on individuals identities, personalities, influences and aspirations.	No specific study mentioned.	--	Emphasizes the potential of hands-on learning in higher ed.
Gore, 2004					Learning through hands on, direct experience.	Advocates for (e.g. architecture) students to interact with and shape materials. Repetitions are the way to mastery.	--	Play is a fundamental human trait, and its creative potential can be brought to bear on the problems of architecture and construction, as well as other problems in life.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Grienitz et al., 2013					Use of LEGO® Serious Play® for the identification of vision statement with company in the automotive field.	Facilitation – case study - no research, no assessment methods.	--	*Claims* to have shown how LEGO® Serious Play® made a valuable contribution to the development of a vision statement.
Gupta & Govindarajan, 2000					Social ecology, experimentation friendly culture, and motivating incentives structures	Case study: Review of Nucor results and practices over 3 decades (70s-90s)	Quantitative.	Best practices for knowledge sharing and mobilization.
Haase et al., 2009					LEGO® Serious Play® used for a real-time transformation design project called The Good Elderly Life.	Case study.	Anecdotal. Empirical observation. Paper is based on a first, brief review of a large set of empirical data (video recordings that were coded).	Found indicators that intentional emergence, in relation to project scoping and problem investigation can be facilitated by a constant shift between a project mindset and a modeling mindset.
Hadida, 2013					A case for the use of LEGO® Serious Play® in business strategy contexts.	No study.	--	This is what LEGO® Serious Play® is. This is why it is awesome.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Hamari, 2013					Testing the effect of badges in a gamified online environment. (www.sharetribe.com)	1.5 year long field experiment in a real existing service.	Hypothesis driven Looking for correlations between e.g. browsing other users' badges and one own's posting activity.	Users who actively monitored their own badges and those of others in the study showed increased user activity.
Hansen et al., 2009					Presents a framework (SWING) and an on-going case (LEGO® Serious Play® scoping workshop for "The good elderly life" project).	Case study.	Anecdotal.	Reports on how the LEGO® Serious Play® method enabled participants to articulate their insights. Due to the complexity of such cross-disciplinary concepts, we need to design more thorough research while still conducting broad application oriented case-studies in organizations.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Harris et al., 2009					Documents the pre-production design process of "The HIV Game," an interactive serious game with cultural and socio-technological implications for youths living in the Yucatan.	Case study This paper describes the research, pre-production design, and decision-making process that went into designing The HIV Game.	Reports on survey answers from potential end-users.	New interactive media, such as gaming or simulation, can play a significant role in encouraging underserved populations to understand and change unhealthy behaviors, such as those related to HIV.
Hartmann et al., 2006					Description and evaluation of the d.tools software that lowers the threshold for creating functional physical prototypes and integrates support for prototype testing and analysis into the workflow.	Controlled 1.5 hour laboratory study of d.tools to assess the ease of use of d.tools. 13 participants (6 male, 7 female) with general design experience	Observations Post-test surveys with likert-scale.	Participants gave d.tools high marks for enabling usability testing (μ=4.6 on 5 point Likert scale), shortening the time required to build a proto- type (μ=4.3), and helping to understand the user experience at design time (μ=4.25).

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Hinthorn & Schneider, 2012					Participatory theater and LEGO® Serious Play® for participatory development communication (PDC) in the context of international development research and practice.	2 case studies that examine two specific examples where serious play and PDC seamlessly intermingled.	Anecdotal.	Participatory theater was great for problem exploration. LEGO® Serious Play® allowed for a discussion about how might we approach these issues (take actions).
Hofferbert et al., 2015					Analysis of Gamification elements on the Thingiverse website.	Exploratory, single case study to gain a deep understanding of gamification and identify the mechanisms enabled by gamification.	Analysis of the Thingiverse community using netographic observation. Open and axial coding.	Conveys what elements characteristic of Gamification are present at the Thingiverse website. Authors will follow up by conducting 15-25 interviews with community participants using the rep grid technique.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Holliday et al., 2007					LEGO® Serious Play® as a means to develop practical wisdom (phronesis) in leaders	Case study of a workshop conducted with faculty members and administrators at an American university.	Anecdotal evidence. Recorded video.	The authors believe that the foregoing empirical illustration supports their theoretical proposition that serious play can enable the development of practical wisdom among leaders in organizations.
Jacobs & Heracleous, 2007					LEGO® Serious Play® for strategic planning and strategizing.	Case study Kick-off one day retreat workshop "I know my banker" for Swiss bank.	Anecdotal.	Strategizing through playful design can be a useful and productive complement to dry, conventional strategic planning processes that helps to open up and orient fruitful debate about an organization's particular strategic challenges.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
James, 2015					The Use of LEGO® Serious Play® for Personal and Professional Development in higher education	Review of traditional and non-traditional pedagogies within the context of creative arts education. LEGO® Serious Play® case study.	Anecdotal.	Students need to broker new ways of communicating and belonging. LEGO® Serious Play® can help them do this, strengthen their sense of ownership and control of their learning leaving them more energized and motivated.
Jentsch et al., 2013					3 different methods: - Lego bricks, sensors, actuators, and computer = PS. - LEGO® Serious Play® = LSP. - Standard ERP system (paper and pencil, computer = PPC).	"Comparative" study – but doesn't teach the same! Dependent variables are flow and self-reported learning. Independent variables: interventions and different levels of materiality. Conditions: - PS (hybrid, high) - LSP (high) - PPC (low).	Mixed-methods Self reporting. Data: Questionnaires Observations Interviews. Shares results of questionnaire (incl. p-values) Quotes from students.	Materiality often leads to increased engagement and flow – a few students will resist though due to learning style or finding it "childish". Flow seems to sometimes lead to "unintended learning outcomes"
Korn, 2012					Augmented reality game (Gamification) to enrich work for elderly or impaired persons in production facilities.	No study - this paper introduces an approach for integration of gamification elements.	–	Future research outlined.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Lim et al., 2008					Prototyping.	Proposes framework and analyses 2 cases.	2 cases explained with the framework.	Framework for conceptualizing prototypes.
Llagostera, 2012					Describes the gamification phenomenon and related concepts.	Lit review.	--	Calls for research, which questions the conformed and performance-focused rhetoric of gamification and looks for its ethical limits in applications.
Lund et al., 2011					Presents a framework (SWING) and illustrates with a LEGO® Serious Play® case study where the method is used to develop a business plan.	Reports on a LEGO® Serious Play® case study with a Danish Electronics company.	Anecdotal.	The complexity of modern business contexts warrants new methods. LEGO® Serious Play® seems useful for that.
Mabogunje et al., 2006					Presents a framework (SWING) and illustrates with a LEGO® Serious Play® case study. **S**imulations **W**orkshops **I**nteractive Environments **G**ames	Case study.	Anecdotal.	The SWING approach will serve as a time-out between the concept development- and the detailed product development phase. This is a strategic point in time because the financial commitment of the company is still low.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Mabogunje et al., 2008					Reports on the use of LEGO® Serious Play® to facilitate "intentional emergence" in a corporate strategy product development process context.	Reports on the authors' experience conducting more that 60 LEGO® Serious Play® workshops.	Anecdotal.	It is evident that emergence cannot be fully controlled; however it appears that it can be facilitated to a certain extent. Points out the need for more research.
Montesa-Andres, 2014					LEGO® Serious Play® in higher education, e.g. in conjunction with a Business Model Canvas, a Conceptual map, or a Mind map.	No specific study.	Vague anecdotal evidence, for instance: "Students usually enjoy these learning processes."	Advocates for the use of LEGO® Serious Play® in higher education.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Nikkila et al., 2011					User-testing of a a distributed social media workplace game played by teams on large, public displays. Taskville gamifies the process of routine task management, introducing light competitive play within and between teams.	Two, one-week long pilot studies with participants from two physically separated research groups. 6 active participants in the first study and 12 active participants in the second study, with some participant overlap between studies.	306 tasks submitted between the two studies. unstructured group interview session with participants after completion of each pilot study, allowing participants to discuss their experiences with Taskville.	Encouraged by high degree of participation: 306 tasks submitted between the two studies. Players had more focus on within team competition than between teams. Privacy concerns: whether or not a play did enough. Different definitions of what constitutes a "task" – it wasn't made explicit – players had to define that for themselves.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Nisula et al., 2015					Discusses what playfulness means in the context of creativity and innovativeness in organizations. This study explores development of team creativity and innovativeness with playfulness using three different methods: - Improvisational theatre. - Sketching with pictures. - Serious games.	Multi-case study: Illustrates the application of playfulness through three action research projects. Three different methods in three different contexts.	Case A: mixed methods Case B and C: qualitative assessment. Types of evidence: - Video - Feedback questionnaires - Diaries Rigorous qualitative assessment, e.g. Atlas coding. To ensure reliability of the coding, two researchers assessed it independently.	Proposes playfulness as a useful metaphor for illustrating creative activities and practical methods, which can encourage innovation and organizational renewal in non-creative businesses.
Palus et al., 2003					Mentions: Mediated dialogue Visual Explorer Collage Compendium (dialogue mapping) Story making Reframing Brainstorming Walk-and-talk Networking fair.	Description of how the methods are conducted – but no actual study.	–	–

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Peabody, 2015					Making a case for the use of LEGO® Serious Play® in play therapy supervision.	One individual case example One group case example.	Anecdotal. Shares excerpts of what supervisees have said about their experience with the method.	Proposes that modifications of the metaphor-rich LEGO® Serious Play® method may be useful in counseling and that experts in the field should continue to evaluate its utility and impact. By stopping to build, share, reflect, and receive, "serious play" shows great promise as a tool for the play therapy community of practice.
Raftopoulos, 2014					Provides a constructive criticism of gamification's applications and propose a conceptual design framework and process.	Design process for ethical Gamification development was tested with organizations looking to meaningfully engage their target audience with a gamified application.	Anecdotal.	Proposes a seven-step design process for developing ethical Gamification solutions synthesized from various game development, design thinking and innovation processes.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Resnick et al, 2005					Lists various creativity support methods: Brainstormers, TRIZ, sketching, storyboards, Flash, etc. Offers a set of design principles to guide the development of new creativity support tools –tools that enable people to express themselves creatively and to develop as creative thinkers.	Not a study.	--	It is still an open question how to measure the extent to which a tool fosters creative thinking. While the rigor of controlled studies makes them the traditional method of scientific research, longitudinal studies with active users for weeks or months seem a valid method to gain deep insights about what is helpful (and why) to creative individuals.
Roh et al., 2016					Gamification of bolt tightening process in manufacturing facility.	Exploratory, comparative study of three different conditions (e.g., default condition; reactive condition; and gamification condition).	The 5 participants' flow level and emotional state were assessed by experience sampling method (ESM) Self reported Likert scale questionnaire about perceived emotions (e.g., Bored/Excited; Passive/Active, Worthless/Worth, and Uncontrollable/ Controllable).	Results show that our gamification interface was successful to improve worker's flow experience by improving perceived challenge level com-pared to other interfaces. Worker's positive emotion, such as excitement level and sense of worth were also increased. Only 5 participants.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Roos & Bart, 1999					Introduces the process that would later become known as LEGO® Serious Play®.	Not a study. Describes the construct and offers a model of strategic imagination, (it's 3 distinct, but interrelated forms of imagination: descriptive, creative, and challenging). It can be cultivated through 3 phases: (1) Constructing to stimulate new ideas, (2) story telling to share meaning, and (3) deep engagement to assimilate new directions.	--	Highlights the shortcomings of conventional strategy meeting methods and submits the "serious work of play" as an "exciting potential yet to be fully realized."

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Roos et al., 2004					The authors examine the potential for using LEGO® Serious Play® in strategy making.	Exploratory case studies: Captured data from four firms over two action research cycles where they changed both the mode (only cognitive to also including social and emotional variables are all relevant to the strategy-making) and the constraints (materials) on the strategy-making process.	Action research: Facilitators collected the data. Anecdotal based on facilitators' notes, semi-structured interviews with some of the participants, and follow-up interviews the CEO.	Study suggests that their initial hunch that changes in strategic making mode and media may also change strategy content may be well justified.
Roos & Said, 2005					Makes the connection between commitment to a strategy and acting responsible (even if that interest is distinct from self-interest). Suggests that the process can be supported through LEGO® Serious Play®.	Reports on findings from 3 LEGO® Serious Play® retreats	Anecdotal action research (facilitators were also the data gatherers)	In two of the three cases, the managers committed to the strategy content and, hence, acted responsibly.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Scharlau, 2013					Using games and LEGO® Serious Play® to teach agile practices and concepts in the context of software development in higher education.	Describes their use of different types of playful design methods and games for teaching in higher education. No study.	Anecdotal.	Introducing games appears to have worked compared to when they only used lectures plus practical sessions on software practices such as TDD and version control. The projects are of better quality, the students are more engaged, and confident in their abilities.
Schrage, 2000					Serious play (prototyping, simulations etc.) in the context of innovation in organizations.	Descriptive case examples, but no study.	Anecdotal.	Argues that the real value in building models comes less from the help they offer with troubleshooting and problem solving than from the insights they reveal about the organization itself.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Schulz et al., 2015					Comparing tool kit-based modeling (low fidelity prototyping) with LEGO® Serious Play® for co-participatory design processes.	Exploratory, two case studies each one day workshops. Two different methods, two different contexts with two different objectives.	Reports on the experiences of applying the two methods. Qualitative evidence. No statistical results.	Inter-organizational and inter-disciplinary stakeholder groups, which are generally inexperienced in design processes, require simple-to-use tools that enable them to bring about innovation.
Selin & Boradkar, 2010					Prototyping in the context of integrated design of products that leverage nanotechnologies.	Description.	Anecdotal.	Unraveling the stories underlying nanotechnology and building prototypes is a means to articulate the socio-technical complexities of nanotechnology and teach about the ethics of responsible innovation.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Sørensen & Spoelstra, 2012					Organization 'shadow story': through a set of reports on a fictitious football team's accomplishments employees use playful story-telling as a way to critique and comment on the events in the company.	Field study of the role of play in a Danish design company:	The study was based on 18 interviews and a document analysis of 51 football reports and one video. interpretive approach.	Identifies three ways in which workplaces engage in play: play as a (serious) continuation of work, play as a (critical) intervention into work and play as an (uninvited) usurpation of work. Play opens the organization for critique and can even subsume 'serious' work under its own authority.
Statler & Oliver, 2008					Description of the design, facilitation, and follow-up on organizational interventions involving LEGO® Serious Play® and a dozen other methods (clay, theater, yoga, painting, etc.)	Reports on 4 industry case studies with LEGO® Serious Play®. Describes the process they went through.	Action research. Interpretive and anecdotal based on authors' observations and participants' comment sheets.	The paper closes with critical reflections on the positive and negative organizational impacts associated with these interventions, as well as the significance of these anecdotal outcomes for future organizational decision making research.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Statler et al., 2009					This paper attempts to develop a theoretical framework that will allow play to be taken seriously in organizations.	No study. Psychological, sociological, anthropological and philosophical literature streams are reviewed to establish a coherent understanding of the emotional, social and cognitive benefits of play.	–	Future research should investigate whether ethically respecting each other and sustaining imaginative processes through play activities allows teams and groups to access the source of resilience which sustain collective mind.
Statler et al., 2011					The authors reframe of serious play as a practice involving a paradox of intentionality, whereby people engage in autotelic, playful activities deliberately to achieve emergent outcomes that have serious consequences for the organization. Serious play for OD contexts, by the developers of what would later be known as LEGO® Serious Play®.	No study.	–	By reframing serious play as a practice of paradox, the authors have developed a descriptive framework that can encompass the various semiotic interpretations of the phenomenon offered by previous researchers, while providing practitioners with a more concrete sense of how it can be enacted in a variety of organizational contexts.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Sukovic et al., 2011					Serious play methods (metaphorical models, "un-tour", and "create space") are used with staff and students as a way of enabling experimentation and exploration of future roles of libraries.	Two case studies (organizational projects from the University of Technology, Sydney Library) are used as examples to demonstrate how playful engagement can be applied to planning for the library of the future.	Online surveys to gather participants' feedback (their feelings about the methods used). Collected anecdotal evidence from tweets.	Playful engagement proved to be a powerful approach to aid libraries' transition in the new information landscape. Based on the study's findings a desirable library of the future is one, which promotes playful engagement.
Svejvig & Møller, 2011					Reconceptualizing Enterprise Information Systems (EIS) using LEGO® Serious Play®.	Case study.	–	Summarizes the outcome of the workshop in terms of imagined scenarios. Concludes that LEGO® Serious Play® is a promising method that supports multimodal imagery through verbal/narrative, visual/imagistic, and kinesthetic/haptic modes

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Watson, 2011					"Medical improv." – an *improvisational role-playing technique* to train physicians for communication with patients. Physicians and improvisers both need to prepare for the unpredictable.	reports on medical students' positive response to the medical improv seminar Based on Students' Self reported responses to the class evaluation survey.	Data provided. Anonymous course evaluations for Playing Doctor asked students to respond to prompts on a five-point scale (1 = strongly disagree, 5 = strongly agree) students anonymously evaluating the seminar from 2002 to 2010.	95% of students anonymously evaluating the seminar from 2002 to 2010 agreed with the statement, "Studying improv could make me a better doctor". Playing Doctor course evaluations establish that students believe medical improv could improve their medical skills.

Paper	Socialization	Externalization	Internalization	Combination	Serious Play method(s)	Type of Study	Type of Evidence	Findings
Wengel et al., 2016					In our farm tourism research, LEGO® Serious Play® has proven an effective method in revealing the social non-commercial interactions between hosts and volunteers' on organic farms in New Zealand.	Proposes LSP as an alternative to conventional Qualitative methods (e.g. interviews, focus groups and observation), and alternative creative and visual methods (e.g. photography, drawing, self-portrait, collage, digital and graphic elicitation) – as they might not adequately capture the co-construction of realities or address the impact of wider social dynamics.	Shares no data, just a photo of a more or less literal LEGO® Serious Play® model (supposedly co-produced by the hosts and volunteers at one farm sampled) the 'ideal farm tourism experience.'	The LEGO® Serious Play® method offers an effective methodology for exploring the depth of socially constructed realities that are complex, dynamic and therefore demand a multidimensional approach.
Total papers with weak (e.g. anecdotal) evidence	**30**	**11**	**16**	**5**				
Total papers with strong evidence (e.g. mixed methods studies)	**9**	**2**	**5**	**4**				