PERFORMATIVE AUTHORING: NURTURING CHILDREN'S CREATIVITY AND CREATIVE SELF-EFFICACY THROUGH DIGITALLY-AUGMENTED ENACTMENT-BASED STORYTELLING

A Dissertation

by

SHARON LYNN CHU YEW YEE

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Chair of Committee,	Rodney C. Hill
Co-Chair of Committee,	Francis K. Quek
Committee Members,	Janet C. Read
	Stephen M. Caffey
	Steven M. Smith
Head of Department,	Ward V. Wells

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ABSTRACT

Psychological research, especially by Paul Torrance, has shown that the child's engagement in creative activities tends to drop precipitously at around the 3rd- to 4th-grade period (8 to 11 years old). This phenomenon, called the 'Fourth-Grade Slump', occurs possibly because of an increase in social awareness and critical self-evaluation of competence in the child during this period. Increasing awareness of the complexity of the world's problems, new paradigms of design focusing on the user, and advances in technology has led to rapid developments in the design and development of tools to support children's creativity. Research in creativity support tools has generally focused on augmenting creative performance within specific tasks, using strategies such as facilitating access to information, or exposing the user to a space of possible combinations. Much less studied however, is how tools may help to develop positive attitudes towards creativity in individuals. This is important, especially in systems designed for children where the focus on the development of the *person*, during critical periods of growth such as the period of the Fourth-Grade Slump, may be said to be of equivalent or greater importance than the support of *process* or the generation of *product*.

In the domain of storytelling or narrative construction, work in child development, educational pedagogy, social psychology, and performance studies have looked at how to tap into the power of children's imagination during pretend play to nurture their storytelling abilities and their sense of self-efficacy or confidence. These interventions typically take the form of drama workshops or classroom roleplaying exercises. While results appear to provide good evidence that drama interventions and theater-based methods have some positive effects on children's development of narratives, studies have shown mixed results in terms of the effects on children's self-efficacy. I refer here to self-efficacy in the sense of a child's perception of her creative abilities, in other words, her belief that she can produce creative outcomes. This creativity-oriented sense of self-efficacy has been called 'creative self-efficacy'.

This dissertation investigates how pretend play can be harnessed into the design of an interface to support children's creativity in storytelling and their sense of creative self-efficacy. This overarching question was explored through four phases of research: Exploration, Design, Evaluation, and Integration. The Exploration phase consisted of two studies: a) a set of interviews with elementary school teachers, and b) an experimental study of how the interface or medium may affect children's creative storytelling process;

The Design phase consisted of two experimental studies, and design and development: a) the first study investigated how the physicality of props may support children's enactment-based storytelling, and b) the second study explored the influence of the presentation of digital contextual/environmental cues on children's enactment-based storytelling, c) design and

development consisted of an exercise using the NEVO methodology to embody design knowledge gained from the Design phase into a concrete usable system, called *DiME*;

The Evaluation phase consisted of two studies: a) the first was a pilot study that tested the usability of DiME and protocol of use with children, and b) the second was an experimental study across two school districts with different profiles investigating the effects of digitally-augmented enactment-based storytelling using DiME, on children's creativity, story writing and creative self-efficacy;

The Integration phase of the research consisted of a workshop with elementary school teachers, which initiated an exploration into how such a story authoring approach may be used in an elementary school curriculum and setting.

The body of work that this dissertation presents elucidates (i) a physical enactment-based method for the authoring of stories by children, and (ii) how a digitally-augmented space may move beyond simple drama methods to positively influence the child's creativity and imagination during storytelling, as well as her self-belief and motivation to engage in creation. The digitally-augmented enactment-based storytelling environment, that I term *performative authoring*, allows the child to collaboratively create a story through pretend play with a partner, while her enactments are reflected in real-time in the form of animated cartoon characters and objects on a large screen display through the use of motion tracking technologies. I have found that performative authoring has positive effects not only on the child's creative self-efficacy, especially for the less extraverted children, but also on the richness of the child's retelling or written narrative of her story.

The significance of the results of the studies is with respect to the various domains and subareas represented (child-computer interaction, interactive storytelling, education and educational psychology, creativity and cognition). There is great potential to extend the concept of exploiting digitally-augmented enactment to support and scaffold higher-level cognition, beyond physical enactment. Extensions of this work include making use of more epistemic forms of enactment, instead of full-blown enactment, to support children's creative story brainstorming, or to make use of digitally-augmented enactment to support other forms of higher thought apart from creativity and imagination.

DEDICATION

The work in this dissertation represents a sincere attempt to contribute to the state of human knowledge. Thus I found it apt and necessary to dedicate it to a number of people. This dissertation is dedicated first to my father whose time was cut short way too soon. Although I have never really known him, I am sure that his influences during my childhood have made me who I am. Second, this dissertation is dedicated to my mother, who has toiled endlessly to provide me with all that I needed to have a good life growing up. Third, this dissertation is dedicated to my brother and sisters who have been my circle of support, and my source of fun and crazy times throughout the years. And last but not least, this dissertation is dedicated to my grandparents, particularly my grandfather, with whom I share many fond memories of reading fairy tales and children's storybooks in the car as he dropped me off to elementary school every morning.

"Others have seen what is and asked why.
I have seen what could be and asked why not."

~ Pablo Picasso *(1895-1972)*

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

Page

LIST OF TABLES

Page

CHAPTER I
INTRODUCTION

A teacher relates a classroom situation whereby she gave her group of fourth-graders a set of Halloween story starters, and asked them to start writing. A girl looked up at her and exclaimed: “so you want us to just make it up?”. Other elementary school teachers recount how, in the face of open-ended or creative assignments, students would “just sit there”, not knowing what to do or how to start, or others would simply refuse to do the activity, “they do not want to do it”. At the same time that such real-life scenarios become prominent in classrooms, we see a national, even international, need for a motivated and creative generation that is prepared to take on increasingly complex problems. A 2010 Newsweek article (Bronson & Merryman, 2010) reported on a study at the College of William & Mary that found that creativity quotient (CQ) scores have been falling since 1990, as opposed to rising intelligence quotient (IQ) scores. While the distinction between intelligence and creativity is still a matter of debate, these results amongst others point to a real concern about the unpreparedness of children’s creative abilities to engage the world at a deeper level beyond the typical doldrums of repetitive manual labor. It is unfortunate that technology is often seen as being antithetical to creative imagination. On the contrary, these innovations may offer unique opportunities to nurture creativity and infuse it back into the learning process within the existing framework of the school system.

Research in creativity abounds in the philosophical, psychological and organizational management science literature. Such research is commonly classified under four interlocking categories: the study of the person, process, product and press (person’s environment) (Rhodes, 1961). Myriad questions have been asked and remain to be asked in each of these areas. This literature provides us with many views, often conflicting, on the nature of creativity and how it applies within various domains. Couger et al. (Couger, Higgins, & McIntyre, 1993), in 1993, found more than 30 different definitions of the term ‘creativity’ used in prior research. However, in the field of Human-Computer Interaction (HCI), the space is somewhat less cluttered. Early in the 1990s, research in creativity and cognition in HCI began with foci on first, the use of artificial systems to model human creativity, and second, on what can be termed as ‘interactive art’ (artistic use of technology) (Candy & Hori, 2003). In the early 2000s, spurred greatly by Shneiderman’s book on ‘Human needs and the new computer technologies’ (B. Shneiderman, 2002) and the NSF-supported workshop on ‘Creativity Support Tools’ (Ben Shneiderman et al., 2006) (which tied the subject heavily to information visualization), creativity in HCI moved more towards the computational support of human creative activities.

Against this background, the research community has looked at supporting the child's creativity through computational means. Unfortunately, much research in creativity support environments for children has emphasized the development of systems (a 'technology agenda') over groundings in technologically-based empirical studies of "children's needs, abilities, or opportunities" (A. Antle, 2013). Studies on augmenting creative performance have generally focused on specific tasks, using strategies such as facilitating access to information (Andruid Kerne et al., 2014) or exposing the user to a space of possible combinations (Hori, 1994). Much less studied however, is how tools may help to develop positive attitudes towards creativity in individuals. This is important, especially in systems designed for children where the focus on the development of the *person* may be said to be of equivalent or greater importance than the support of *process* or the generation of *product* (Spendlove, 2008). The development of various aspects of one's self is critically important during the pre-adolescent phase. Psychological research (E.P. Torrance, 1967; Torrance, 1968) has shown that this age range of 8 to 11 years old is marked by a sharp decline in the quality and quantity of children's creative activity. This phenomenon, which has been called the 'Fourth-Grade Slump' (hereafter referred to as the Slump), presents a fitting 'failure condition' that provides us with tremendous opportunities to design impactful creativity support technology for children. The purpose of this work is not to solve the problem of the Slump per se, but to use this failure condition as an opportunity to explore how digital technology may help to nurture the child's creative process, person and product in a commonly used domain, such as storytelling.

Within this scope, we studied children creating stories using text-based medium as opposed to a media-based stop motion animation medium. We found that children make use of short episodes of body enactments to express, explain and think about their story ideas in the animation medium use condition. We call these '*micro-enactments'*. Briefly-speaking, micro-enactments can be defined as the use of embodied enactment (body-based or via the use of physical objects) to make sense of fragments of story scenes in the authoring of a story. Informed by a series of studies studying children enacting stories in different situations, we designed a story authoring system whereby a child can create an animated cartoon story by enacting story scenes. We define the operationalization of micro-enactments into a story authoring system for children as the design concept of '*performative authoring'*.

This dissertation covers research that began with phases of I. Exploration, II. Design, III. Evaluation, and IV. Integration. Each of these phases was guided by its own set of research questions, that are articulated throughout this document. The higher-level overarching question that encompasses all of the phases is to understand how embodied technologies may be designed to support children in terms of the process (creating the story), product (the quality of story created), and person (sense of creative self-efficacy and motivation to re-engage) in creative storytelling during the period of the Fourth-Grade Slump. The four phases of research are:

Phase 1 Exploration consisted of two studies: 1A) a set of interviews with elementary school teachers, and 1B) an experimental study of how the interface or medium may affect children's creative storytelling process; **Phase 2 Design** consisted of two experimental studies, and the design and development of a story authoring system: 2A) the first study investigates how the physicality of props may support children's enactment-based storytelling, and 2B) the second study explores the influence of the presentation of digital contextual/environmental cues on children's enactment-based storytelling, 2C) design and development consisted of an exercise using the NEVO methodology to embody design knowledge gained from Phase 2 into a concrete usable system, called *DiME*; **Phase 3 Evaluation** consisted of two studies: 3A) the first was a pilot study that tested the usability of DiME and protocol of use with children, and 3B) the second was an experimental study across two school districts with different profiles investigating the effects of digitally-augmented enactment-based storytelling, via the use of DiME, on children's creativity, story writing and creative self-efficacy; and **Phase 4 Integration** consisted of a workshop with elementary school teachers, which initiated an exploration into how such a story authoring approach may be used in an elementary school curriculum and setting.

The research presented in this dissertation is defined by the series of studies in Table 1 (the 'Section' column on the right indicates the section of this document where the study in question is discussed):

Table 1. Summary of studies

Study	Participants	Location	Year	Section
Medium effects	10 children aged eight to ten	*Gilbert Linkous Elementary School* afterschool program in Blacksburg, VA	2011	V.2
Interviews about the 'Fourth-grade Slump'	10 elementary school teachers	Multiple elementary schools in Salem, VA and Blacksburg, VA	2012	II.3
Enactment with physical objects	14 children aged nine or ten	*GW Carver Elementary School* afterschool program in Salem, VA	2012	VI.3
Interviews about HCI methodology	25 HCI researchers	Online teleconferencing (Skype)	2013	VI.5
Enactment with contextual backgrounds	6 children aged eight to eleven	Institute for Creativity, Arts and Technology @ Virginia Tech	2013	VI.6

Table 1. Continued,

Study	Participants	Location	Year	Section
Usability test of enactment system	2 children aged eight and eleven	Emerging Technologies Building @ Texas A&M campus	2014	VI.6
Pilot study of enactment system with props and avatar	7 children aged eight to ten	*The Lincoln Center* afterschool program in College Station, TX	2014	VI.7
Effectiveness Study of enactment system with props and avatar	20 children aged eight to ten	*Forest Ridge Elementary School* summer camp in College Station, TX; *Harvey Mitchell Elementary School* summer camp in Bryan, TX	2014	VII
Teachers' workshop	4 elementary school teachers	Emerging Technologies Building @ Texas A&M campus	2014	VIII

Other work that are presented within this document, but that are not directed related to the core question of this dissertation are listed below in Table 2, with the respective sections in which they are described:

Table 2. Summary of associated studies

Work	Nature	Section
A model of creativity in storytelling	Model development	III.2
Methodology for HCI research	Research/design NEVO methodology	VI.5
Evaluation of enactment-based creativity	MAIA evaluation methodology	VI.3

All the publications that resulted from the work presented in this dissertation are listed in Appendix A. The rest of this document is structured as follows: Chapter 2 lays out the context within which the research has been conducted. More specifically, it describes and reviews literature on the Fourth-Grade Slump phenomenon, and theories of the child's development. Chapter 3 provides

an overview of the numerous conceptions of creativity, and describes creative activities and creative storytelling as it is used in a formal classroom setting. Chapter 4 introduces the overarching research question of this dissertation in terms of the design of creativity support systems for children, and reviews creativity support systems that have been proposed in prior literature. Chapter 5 presents an exploration of how the medium of creation influences children's process of telling creative stories, and describes the concept of micro-enactment that was uncovered during a the study. Chapter 6 presents two studies, the first on the impact of physicality of objects and the second on the effects of digital context presentation on children's enactment of stories, and then introduces the NEVO methodology that we developed as a technique to design theoretically-grounded systems that remain faithful to its original seed idea. Chapter 6 ends by describing the design and development of the DiME (Digital Micro-Enactment) storytelling system for children, as an operationalization of the performative authoring approach to story authoring.

Chapter 7 details a study that investigated the potential of the DiME system and its associated performative authoring approach to support children's creativity, writing and creative self-efficacy in storytelling. Chapter 8 presents a workshop effort that begins to explore likely ways in which our proposed approach may be integrated into methods and exercises currently being used in schools by elementary school teachers. Chapter 9 summarizes the contributions made in this dissertation research, discusses the significance of the work, and sets forth a vision of a new class of interfaces that make use of the human propensity to enact to augment various aspects of high-level cognition. Finally, Chapter 10 acknowledges the limitations and scope of this work, and presents a conclusion.

CHAPTER II
BACKGROUND AND CONTEXT

II.1 The Fourth-Grade Slump in Creative Thinking

As defined by Paul Torrance, the Fourth-Grade Slump is a precipitous “decrement in all creative thinking abilities near the end of third grade or beginning of the fourth grade” (E.P. Torrance, 1967), that has been observed through intercultural longitudinal studies in seven countries, including the United States, Norway, India and Western Samoa. The Slump can be depicted as shown by the conceptual drawing in Figure 1. From the onset of speech, the manifested creativity of the child (black line) increases until around 9 years old, after which it goes into a trough period. We note that the period of the sudden slump interestingly coincides with the time when the child enters what Piaget called the ‘concrete operational phase’ (COP).

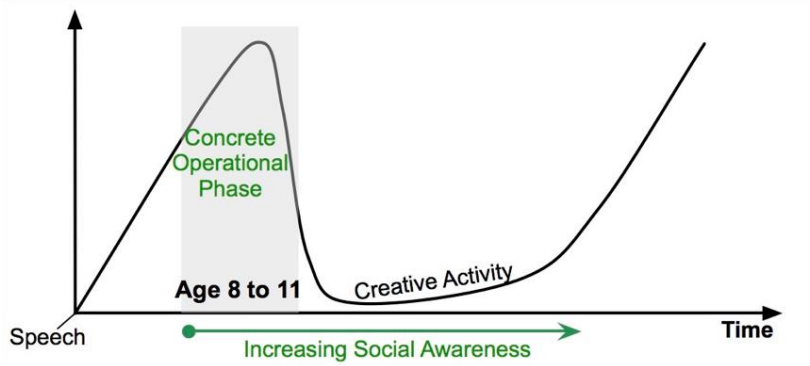

Figure 1. Conceptual diagram of the Fourth-Grade Slump based on Torrance’s generalized developmental curve of creative thinking

From the period of 1959 to 1964, Torrance administered a battery of tests of creative thinking measuring fluency, flexibility, originality and elaboration to 350 children in grades 1 to 6. He assessed ‘gains’ and ‘drops’ of the children’s scores as they progressed through the grades. His analysis showed that there were statistically significant differences between the frequency of decreases and increases in all of the creative thinking dimensions, except for elaboration. Based on his analysis, Torrance concluded that although it is true that “not all children show this decrease in creative functioning during the fourth grade period…fifty percent of the children, however, seem to show serious slumps at this particular stage of development” (Torrance, 1968). As for the results

of his tests across cultures, he stated that “some cultures did not show this slump, but neither did they show any gains” (E.P. Torrance, 1967). The battery of tests that Torrance used in his studies has now become part of the Torrance Test of Creative Thinking, which consists of a verbal and a figural component, and has become one of the common ways by which creativity is measured. Torrance observed the Slump in his administration of paper-and-pencil tests to the children, but he also collected supplementary data that presented other strong evidence of the decrease in engagement in creative activities among children of this age group. Some example behaviors given by Torrance are as follows: in a study whereby children were told to write “on their own outside of the curriculum”, fourth-grade children produced fewer contributions than did the children in grades 3, 5 and 6. In another study whereby children were shown inkblots and asked to list objects that they could perceive in them, fewer number of objects was articulated by the fourth-grade children (E.P. Torrance, 1967).

After Torrance’s studies, much work has debated on the actual existence of a Fourth-Grade Slump not only in creative functioning, but also in general and subject-specific academic performance and children’s self-identity. Among those who have found slumps in the 4th grade, Williams (1976) ran a study with elementary school children in two inner-city schools, surveying over 1000 students, measuring their feelings of school motivation and self-concept throughout 1st to 6th grade using the Self Concept and Motivation Inventory (SCAMIN) inventory. The results produced a graph that he reported as strikingly resembling Torrance’s Fourth-Grade Slump curve (see Figure 1), with the average self-reported scores dropping almost one whole standard deviation from the beginning of the 3rd to the beginning of the 4th grade. Hirsch (2001) describes a ‘verbal gap’ based on research by Loban (1963) who found that reading achievement is closely aligned for children from low-income and high-income families at kindergarten level, but the gap widens starting at about grade 4. Hirsch ascribes the gap to the difference in exposure to a diversity of daily experiences between the two groups of children. Sanacore and Palumbo (2008) discuss this same gap in reading in the 4th grade and onwards by referring to assessment results from the National Assessment of Educational Progress (NAEP) and findings from Roswell and Chall (1992). A study (K. H. Kim, 2011) analyzing creativity scores collected by means of Torrance’s tests at five points of time (1974, 1984, 1990, 1998 and 2008) showed that even as intellectual quotient (IQ) rose throughout the years, creative thinking in children especially of the age group from kindergarten to 3rd grade decreased. From 1990 to 2008, this occurred particularly for children’s fluency (i.e., their ability to produce ideas), which “increased up to 3rd grade and remained static between 4th and 5th grades, and then continuously decreased”. Kim concludes that the decline in creative thinking, especially in kindergarten through 3rd grade, “is steady and persistent, from 1990 to present, and ranges across the various components tested by the TTCT (Torrance’s Test of Creative Thinking)”.

Others such as Sak & Maker (2006) did not find a slump per se, but report, in a study with 841 students from 1st to 5th grade, stagnancy in creative development in Mathematics (originality, flexibility, elaboration and fluency as measured using the DISCOVER math assessment) at around 10 to 11 years of age, which coincides with the 4th grade. Many others have proposed that creative thinking development follows a U-shaped trajectory, for e.g., Rosenblatt and Winner (1988), Anderson (1992), Runco (M. Runco, 2003; Mark A Runco, 1991), Charles and Runco (2001).

It appears that the literature generally agrees that some sort of a slump occurs in children's creative development, but there is disagreement as to exactly when the slump happens. Besides the authors mentioned above who found support for the Slump at 4th grade, others place it later in the child's development. For example, in studying two classes taught by two specific teachers, Charles and Runco (2001) found that creative ideas among the students *peaked* at 4th grade before dropping. Yi, Hu, Plucker, and McWilliams (2013) carried out a study with Chinese students, and found that creativity slumps between 14 and 16, as opposed to the 8 to 10 years old range indicated by Torrance's Slump. Similarly, Lau and Cheung's (2010) study measuring creativity using the Wallach-Kogan Creativity tests showed that students' scores *rose* from Grade 4 to 5, and then dropped from Grade 5 to 6. Conversely, G. J. Smith and Carlsson (1983) reported an occurrence of the slump at age 7 to 8, with creativity peaking at 10 to 11, and then declining again at 12 years old.

Causes of the Slump

The causes proposed for the Slump are numerous: socio-economic status, differences in life experiences, the existing educational system, industrialization, bilingualism, the onset of evaluative thinking, etc. Roswell and Chall (1992) highlight that the 4th grade is when students transition from 'learning to read' to 'reading to learn', or from Stage 2 to Stage 3 in Chall's (2011) 'Stages of Reading Development', and that this poses a primary difficulty for children causing them to slump in performance and motivation. In a study investigating how evaluative thinking affects children's degree of fluency and flexibility in creative thinking, Charles and Runco (2001) reported that "an increase in preference for appropriate ideas significantly predicted declines in high-quality ideas". Torrance (1967) himself provides a three-part rationale for the Slump based on the profound changes that take place in the child's development: social accommodation, peer approval, and the need for validation as the child comes into greater contact with society and her environment. This developmental social awareness leads a child to be more judgmental of her own work (Kirkpatrick, 1900) and to engage in more critical self-evaluation of competence (Ruble, 1987). Such self-appraisals with respect to social norms and standards often lead to self-regulation of behavior. Positive self-appraisals may then lead to greater involvement in creative behavior, and negative self-appraisals may result in self-doubt and possibly a decrease in or withdrawal from creative activity. This is illustrated by Henk and Melnick's (1995) study on the activity of reading, whereby

children who see themselves as poor readers “probably have not experienced much in the way of reading success”.

Interventions for the Slump

Interventions that have been proposed to counter or attenuate the effects of the Slump include mostly better teacher training sessions and workshops, the use of technology, and structural policy changes. Williams (1976) showed that after an intervention that provided teachers with weekly inservice training sessions on strategies to enhance school self-concept by paying attention to individual students’ needs and strengths, a slump was no longer observed in the 77 4th grade children’s posttest data. Sanacore and Palumbo (2008) laid out a list of 4 issues that teachers need to be aware of when framing their teaching practices for the 4th grade. Suhr et al. (2010) followed the effects of a one-on-one laptop program against a control group of students, and found that the laptop students significantly outperformed the non-laptop students after two years on certain components of the English Language Arts assessment rubric, notably literary response and analysis, and reading comprehension. In a report from the Sesame Workshop, Gee (2008), a noted learning scientist and video game expert, provides 6 policy recommendations to ameliorate the Fourth-grade Slump by capitalizing on the affordances of digital media. Nash (1974) tested the creativity level of 66 children who entered the special ‘Vanguard Program’ for the Gifted at an elementary school in Houston, Texas using the Torrance Tests of Creative Thinking and found that only 16 to 18% of the students showed decreases. He concluded that specialized programs and settings may mitigate the Slump. However, his study did not include a control group, thus had little basis for equivalent comparison. Although the Fourth-Grade Slump has been discovered more than forty-five years ago, articles in popular media such as in the Newsweek magazine (Bronson & Merryman, 2010; Springen, 2007) show that the phenomenon remains a worrying gap for educators today.

II. 2 The Child’s Development

Following Torrance’s intuition that the cause of the Fourth-Grade Slump may be developmental in nature, one can find various changes in the child’s growth during this period of 8 to 10 or 11 years old that may possibly lead to drops in performance and disengagement. We elaborate on two main aspects here, notably the intensification of social awareness and need for identity formation, and the transition to symbolic thinking. We note however that these factors most probably do not individually cause the Slump, but instead they function together and interact within a broader infrastructural and societal system to affect the child.

Social Awareness

Jean Piaget (Jean Piaget, 1973; J. Piaget & Inhelder, 1973) defined four stages of the child’s development: the sensorimotor stage, the preoperational stage, the concrete operational phase (COP), and the formal operational phase. The 4th grade period is located during the COP. A central facet of the child that develops during the COP is the bringing to consciousness or overt

attention that one is embedded in a social and cultural world, and it is critically important for one to contribute to that society to be a part of it. The ability to understand social roles and point-of-views, be it one's own or others', has sometimes been called the theory of mind (ToM) (Leslie, 1987). Such is the dilemma that the child faces in trying to reconcile society's expectations, the human need to belong, and her own abilities in various domains. In many ways, Erikson (1993/1950) captures this inner conflict in his eight-stages theory of psychosocial development by placing the basic virtue of 'competency' (and its associated psychosocial crisis of industry vs inferiority) during this period of development. The importance of the social aspect can also be seen in Vygotsky's (1978) sociocultural approach to cognitive development or also known as the social development theory. Vygotsky emphasizes the role of culture and a child's social environment in shaping her cognition, and the way that the child creates her own meaning. In a sense, for Vygotsky, the child absorbs meaning from the world around her (in terms of her strengths and weaknesses, what she is good at, etc.), and with time integrates this meaning into her own sense of self.

The mechanism by which social awareness may trigger the retraction from creative activity occurs may be illustrated by the feedback loop in Figure 2 below.

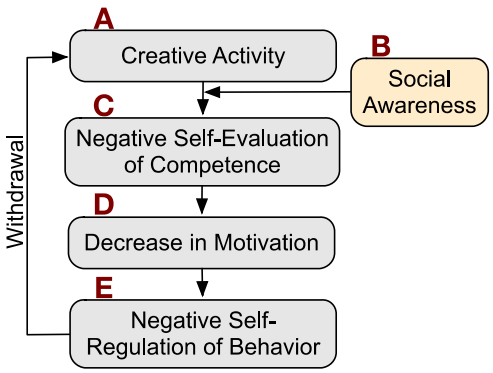

Figure 2. Demotivation cycle during the Slump

With the increase in social awareness during the period of the Slump (Box B), the child engaging in creative activity (Box A) evaluates her creations negatively, leading to negative self-evaluation (Box C). Cumulative experiences of negative self-evaluations lead to a decrease in the child's motivation to engage in the creative activity (Box D). Eventually the child regulates her behavior to completely withdraw from or avoid the activity (Box E). Such a feedback mechanism is likely to be characteristic of other common 'slumps' that even adults go through, such as during the choosing of a career or the learning acquisition of a new skill. In fact, another slump resembling the

Fourth-Grade Slump in later college years has come to be known as the 'Sophomore Slump' (Lee & Leonard, 2009; Schaller, 2010; Tobolowsky, 2008; Vaughn & Parry, 2013). This slump has been attributed to uncertainties experiences by students in the sophomore year of college as they encounter more intensive subject matter, leading to their being overwhelmed and to a decrease in performance, and even to retraction from engagement in a domain. The importance of motivation for creative performance and engagement has furthermore been discussed by T. M. Amabile (1983). In a controlled study with young adults, she found that (intrinsic) motivation is conducive to creativity in poetry writing whereas extrinsic motivation is not. Motivation is thus a core element of her social psychology of creativity, along with creativity-relevant skills and domain-relevant skills.

Symbolic Thought

Another key aspect of change that occurs during the period of the COP is the child's transitioning from concrete thinking to abstract thought. While the child still learns through pretend play of fixed scenarios in the preoperational stage, such as being a specific character in a situation or counting objects, in the COP, the child begins to understand that meaning can be construed at an abstracted level, such as making sense of a situation without necessarily being a character in the scene or counting without necessarily counting specific objects. This is echoed in Jerome Bruner's (1964) three modes of representation – the enactive, the iconic, and the symbolic. Bruner's theory states that up to the first year, children learn exclusively in the enactive before engaging in the iconic form of thought until around 7 years old when the child begins to transition to the symbolic (language/text) mode of thinking. However, unlike Piaget, Bruner proposed that all of these three modes of representation, which are basically ways that information and knowledge are encoded in memory, apply whenever new information is learned, even for adults.

Much of our educational system is structured around and grounded in such stages of development, with the 3rd to 4th grade being the turning point when the child is expected to perform at a more abstract or symbolic level. For instance, instruction is typically done with physical manipulatives (base-ten blocks, tangrams, color tiles, etc.) in mathematics up to grade 3, after which children are expected to transition to symbolic abstractions in grade 4. As mentioned, in language arts, children are required to transition from *learning to read* to *reading to learn* in the 3rd grade. Across all subject areas, children are expected to transition toward more expressive writing at this period. The problem arises if the child is not cognitively ready or prepared to engage in exercises at such level of abstraction. Her performance decreases, and this may lead to the demotivation downspiral described in Figure 2.

II.3 Interviews with Elementary School Teachers

Studies investigating the Fourth-Grade Slump vary significantly in terms of dependent variables, measures and inventories used, sample size, etc., making it hard to form a synthesized and completely coherent picture of the phenomenon. To gain insight on the Slump in a local context and in the present day, we conducted an exploratory foray into the issue of creative motivation

through the lens of academic motivational theories with a set of interviews with elementary school teachers. The goal of the study was to collect the perceptions and thoughts of teachers, who are arguably one of the most experienced groups of people in terms of interacting with and observing children. The interviews were carried out with 10 teachers, all females and presently teaching either 3rd or 4th grade in local elementary schools. The teachers spanned five different schools and taught a variety of subjects ranging from Language arts and Social studies to Math and Science. They had an average of 12.6 years of teaching experience across the grades, from pre-K to 7th grade, and an average of 2.2 children of their own. The interview lasted 40 minutes on average, and was conducted in a semi-structured format with questions covering mainly the following themes: demographics, creative activities in the classroom, manifestation of the Fourth-grade Slump, reasons for drop in motivation, motivational strategies used, and use and impact of media. Participation in the interview was purely voluntary with the promise of anonymity and confidentiality. All interviews were conducted at the site of the respective schools. The conversation was audio recorded and later transcribed. Following the interview, each teacher was asked to fill in a questionnaire with 6-point Likert-scale (e.g. *Strongly disagree* to *Strongly agree*; *Not important at all* to *Very important*) questions on their level of agreement with the existence of the Fourth-Grade Slump, the effect of media on creativity and their judgments on the importance of the different components of the MUSIC (defined below) motivation model for creative thinking and engagement.

The MUSIC Model of Academic Motivation

Proposed by Jones (Jones, 2009; Jones & Skaggs, 2012), the MUSIC model consists of five components that have been shown to affect students' engagement and eventually performance or level of achievement in academic settings. The components, eMpowerment, Usefulness, Success, Interest and Caring, have been derived from research and theories in psychology and education, such as self-efficacy, interest theory, expectancy-value theory and attachment theory. As described by its author, *empowerment* in the MUSIC model refers to the "amount of perceived control that students have over their learning". *Usefulness* refers to how much the student understands the relevancy and utility value of what he is learning with regards to her interests or the 'real-world'. *Success* concerns the extent to which the student believes that she can succeed in her course of study with adequate investment of effort. *Interest* refers to the amount and depth of interest, thus level of attention, that the student has in the course. And *Caring* involves the extent to which the student believes that the course instructor cares about her learning and well-being on a more personal level. The MUSIC model has been validated directly and indirectly by several studies including Jones and Wilkins (2013), Jones et al. (2012), Matusovich et al. (2011), and Jones & Skaggs (2012).

For our study, we adapted the definitions of the different components to make them more applicable to creative activity. In the post-questionnaire thus, the MUSIC model was described to the teachers as follows in Table 3:

Table 3. MUSIC model adapted for creative motivation study

Empowerment	How much control the child perceives she has in the creative activity
Usefulness	How much the child sees the creative activity to be useful immediately or later
Success	How much the child perceives that she can complete the creative activity successfully
Interest	How much the child enjoys the creative activity
Caring	How much the child thinks others care about the product of the creative activity

The teachers were asked based on their experiences with children, to evaluate the extent to which they agree that a slump occurs in the 3rd and 4th grades in several different ways: (i) in creative thinking itself; (ii) in imagination; (iii) in motivation to engage in creative activities (e.g. drawing, storytelling); and (iv) in motivation to engage in activities creatively (i.e. approaching the activity in a creative manner).

Data Analysis

About 6 hours of interviews were recorded in total. All interviews were transcribed and analyzed using a qualitative coding approach. An open coding process was first performed on the transcripts to uncover significant points made during each interview. These points were then grouped and categorized by topic covered. A selective coding process was then done by going through the significant points again and relating them to the MUSIC model. Finally, themes were formulated with regards to the significant points that were found to be relevant to the MUSIC model. All questionnaires were coded as well and entered into a spreadsheet for analysis. The Likert-scale answers were coded such that the most negative statement (e.g. Strongly disagree) is given a 1 and the most positive statement (e.g. Strongly agree) is given a 6. Given that the sample size is relatively small and only basic calculations were needed, no statistical software was used.

Findings

We will report results of the study under three sections relating to the existence of the fourth-grade slump and how it is seen manifested in school, the reasons for its occurrence as conjectured by the teachers, and the strategies used or recommended by the teachers to motivate students to engage in creative thinking and activity. In the following section, sample quotes from specific teachers are given as examples. Teachers are referred to using their ID codes (e.g., T1).

A. The Fourth-Grade Slump

The teachers were asked based on their experiences with children, to evaluate the extent to which they agree that a slump occurs in the 3rd and 4th grades in several different ways: in creative thinking itself, in imagination, in motivation to engage in creative activities (e.g. drawing,

storytelling), and in motivation to engage in activities creatively (i.e. approaching the activity in a creative manner). Generally the teachers most strongly agreed that a slump happens in the child's creative thinking abilities (average μ of 4.6). This was followed by a 4.4 average agreement of a slump in general motivation of the child to engage creatively. Agreement with a slump in motivation for creative activities (μ = 4.3) and in imagination (μ = 4.2) was lower but still above the median scale point. Figure 3 shows the average agreement ratings given by the teachers with different aspects of the slump.

The slump in creative thinking was commonly illustrated by the teachers in the form of a difficulty for the children to start creating, akin to a 'writer's block': *"And then there're others who when they edit sentences they do fine. But ask them to do something, create something on their own, and they're like uh uh I don't know where to start."* (T2), and in the propensity of the child to seek directions and guidance from the very start: *"I would just say that when I try to provide a creative activity, they automatically are 'ok do you want us to do this this and this?' and I'm like 'I'm not telling you what to do'. And then they're like 'but but do you want' cuz they're so used to just being given an order and kind of plugging in"* (T9).

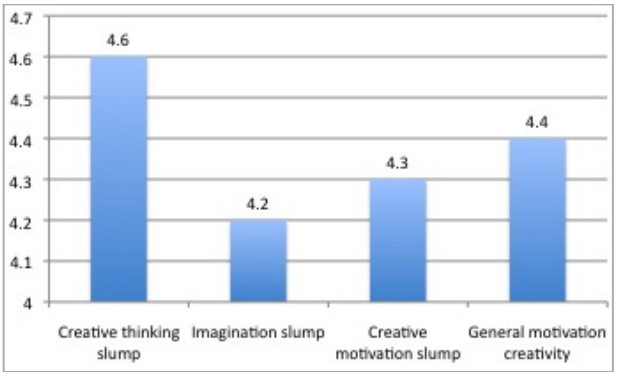

Figure 3. Slumps in 3rd to 4th grade

According to the teachers, the slump in motivation to engage in creative thinking and activities is characterized by the students taking an avoidance approach to such activities or a complete disengagement when being involved in the activities. T8 expressed this lack of desire to engage in the following way (^ indicates emphasis): *"And looking at the writing products that I've seen, that they're writing more, they seem to be quieter as far as...they're definitely, their heads are engaged in what they're doing and they're really...they're working hard on it. And the same thing in 5th grade. When I've been in there. And then in 3rd grade it seems like it just ^takes more to get them to that point. Not that they can't do it, we just have to motivate them more."* An instance of the manifestation of the slump is given by T5: *"I think it's the motivation, to engage in them. I really do, I just, I don't know why. It's like...I'll tell you why that I think that that's true, because we'll offer them like fun things to do in class, like hey you know they'll color something forever. Here's something*

that you can color and create, like I had these little habitats diagrams you know. They want to color…but they don't want to do it. They do not want to do it. They don't want to color. And I said I'm just like wow, it is interesting. I'm not sure what it is."

B. Reasons for the Slump

The main theme uncovered in the reasons and explanations provided by the teachers for the occurrence of the Fourth-grade Slump is the anxiety of evaluation or judgment. This can take three main forms: the pressure of formal testing in school, the fear of evaluation by others and society, and a more personal safeguard against what is right or wrong. T8 talks about the slump as the effect of the change in the type of assessment of students in higher grades: *"up until 2nd grade, kindergarten, 1st and 2nd, they're graded, ^graded, more on their, erm, just completing something, rather than their achievement on the product. Now in 3rd grade we're looking more at their achievements. We're looking...the quality, right."* The mere amount of testing and its associated rigors cause children to become risk-averse and used to being bounded by parameters: *"I think a lot of it is caused by the standardized testing and too much testing. Because everything now is about pick A B C or D. And get them to know this, and know this and know this, and drill and practice rather than having that time, I remember back in school where you get to explore, and you get to discover."*

On a social level, on one hand the child fears the reactions of others around her when she creates and so retracts from such creative activities, or judges her abilities to be inferior to her peers: *"Because of the reactions they've got from their peers, from their teachers, from their families...when they have tried something creative or they've been more creative with things."* (T7). On the other hand, according to the teachers, the children, particularly girls and those belonging to minority groups, become aware of societal expectations placed upon them and develop a desire to fit into the stereotypes and please others. T9 expresses her observation of the phenomenon especially in Math: *"I think at this age they start to get more into the peer thing and more into the boy-girl thing, and so they don't want to be the smart girl, they want to be kind of the fun so that the boys...and unfortunately it's got younger and younger, but we kind of see that so the girls start to kind of slumping off 'cause they don't want to be the smart girl. They want to be the fun, cute, giggly girls. So a lot of times you'll see at least in Math that the girls will start to slump on purpose, whether or not."*

Moreover, children disengage from creative activities during that period because on a more personal level as well, they want to be "safe". The nature of creativity is such that it requires a certain degree of comfort with uncertainty and open-endedness. For the child who is starting to realize her embeddedness into a highly structured cultural world, creativity is not always a sound way to ensure not only her acceptance into society but also the assurance of a suitable performance. T8 illustrates the child's dilemma: *"And ^my opinion of that was that it was safe for her, because it was right. And I think sometimes folks who are really smart, it's important for them*

to be right. And if you're being creative, you're not right. It's just, it can be subject to debate. I think she wanted to be right. I think she wanted to know that...that's what I meant by 'safe' as far as it was a safe thing for her just to make a list because you can't get that wrong. Whereas if you're being creative, that's subject to editing."

Other themes for why the slump happens include the sheer decrease in opportunities to actually engage in creative activities, the influx of content and material to be covered starting with 3rd grade, the independency or amount of responsibility that the child is expected to exhibit, the lack of value attached to good performance in school in general, and the selective valuation of certain domains as the child discovers her strengths and weaknesses. Other less commonly cited reasons were that the slump is inherently a developmental phenomenon, the lack of praise received, and the effect of either accumulated past failures or starting off with weak foundations.

C. Motivational Strategies for the Slump

The average scores assigned by the teachers to each of the MUSIC model factors in terms of how important each is for creative motivation are shown in Figure 4.

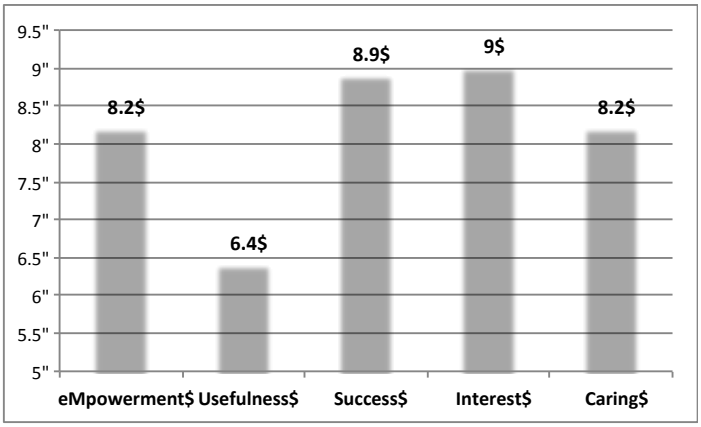

Figure 4. Perceived value of factors affecting creative motivation

Strategies perceived by the teachers to be effective in motivating students towards creative thought and activities were classified under the five components of the MUSIC model. Based on our coding process, the model seems to be adequate to cover most of the themes elicited from commonly mentioned strategies. Table 4 shows the various themes uncovered under each component. It is interesting to note that the number of themes reflect the relative importance of each MUSIC component for creative motivation as rated by the teachers in the questionnaire (see Figure 4). The themes under Success can be broadly grouped into three categories: the importance

of a *'creation culture'*, the provision of *guidance* and the prominence of *sharing*. T2 and T3 explain that when *"it's cool to create"*, students are incited to engage in creativity. One has to provide many opportunities and different avenues for children to find what they can succeed in. An environment that is more open-ended, where it is *"ok that I'm not this brilliant artist"* (T4), where failures are not condemned and going back to the drawing board is encouraged, and where such activities are met with enthusiasm, tend to be motivating for the child to create.

Table 4. Themes of creative motivation based on the MUSIC model

Adaptation of the MUSIC model to Creative Motivation					
Component	**Empowerment**	**Usefulness**	**Success**	**Interest**	**Caring**
Avg teacher rating	**8.2**	**6.4**	**8.9**	**9**	**8.2**
THEMES	Free choice	Emphasis of activity importance	Open-endedness	Connection to personal background and experiences	Personal encouragement
	Pro-activity		Creation culture	Fun element	Confidence-building through co-activity
	Sense of belonging		Self-efficacy (self-perceived competence)	Activity with movement	Relationship-building
	Relation to personal experience		Normalization of averageness	Use of technology	
			Modeling and guidance	○ Novelty	
			Praise of work	○ Stimulation of all senses	
			Enthusiasm by work	○ Intrinsic feeling of self-efficacy	
			Acknowledgement and recognition	○ Instant feedback of product	
			Collaboration and sharing of ideas, strategies, struggles, products	○ Transparency and simplicity of interaction	
			Demonstration and performance		
			Support for failure and retrials		
			Multiplicity and variety of types of opportunities		

Under the category of guidance, many teachers emphasized the need for modeling and providing students with examples either from their own creations or from past students. Modeling however has to be controlled to find a correct balance so as to provide enough examples to motivate, but not too many as to induce tunnel vision. T6 warns of the problematic character of modeling for creativity: *"Sometimes I'd give examples, I try not to give too much, too many examples 'cause when you give an example that's usually what you'll see, an exact replica of that, or something similar."* Acknowledging the creation of the child and recognizing it as adequate, together with cautiously phrased praise when suitable, is posed by the teachers as paramount to creative motivation.

The third category, sharing, entails mainly the idea of collaboration in terms of both groupwork and demonstration or performance. Not only ideas should be shared, but also struggles and difficulties faced in the creative process, and strategies for creating: *"There's a lot of discussion and collaborating, and sharing of ideas, sharing of pictures in this process. And over the years we've seen, it does help the other kids to then start using those same strategies of visualization." (T4).* Other quotes that illustrate the motivational power of sharing are: *"But they all want to share. I doesn't matter how small their piece is, they really want to share. And that's one way to encourage them. You get to share this if you write it, you know."* One notable theme under the component of Interest is the use of technology to motivate children to engage in creative activities: *"Anytime they can get on the computer or use the smartboard, anything related to technology, they love."; "I mean there's nobody who ever say I don't want to get on the computer. I don't want to use the smartboard." (T7).* Several reasons articulated by the teachers for this potential of technology include the mere novelty effect that it brings about, the stimulation of all senses from the visual to auditory and touch, in contrast to the media-poor channel through which standard paper-and-pencil exercises are given, the confidence that technology inculcates in children through design features such as instant feedback for actions performed, and the transparency of interaction between the child and the system.

In this chapter, we have provided some context of children's creative functioning at the age of 8 to 11 by reviewing studies on the Fourth-Grade Slump, literature on children's development, and by reporting our findings from a series of interviews that we conducted with elementary school teachers. The Fourth-Grade Slump specifies a decrease in creativity performance and creative engagement of children at the point of transition from childhood to adolescence. This chapter highlights that children during this period require support not only in terms of creativity skills (creative performance), but also in terms of motivation to engage and self-belief (self-efficacy).

CHAPTER III
CREATIVITY AND STORYTELLING

III.1 Theories of Creativity

The study of creativity is cluttered with a wide variety of perspectives and definitions of what creativity is and what it entails. A popularly accepted taxonomy divides creativity into 4Ps (Rhodes, 1961): the creative *Persons* (personality traits of creative people – the psychometrics approach to creativity), creative *Processes* (methods, operations, and techniques involved in creating – the creative cognition approach), creative *Products* (outcomes of creative efforts), and the creative *Press* (environments that support or hinder creativity). Another taxonomy is the four-C model of creativity (Kaufman & Beghetto, 2009), that includes *Mini-c* (personal realizations), *small-c* (everyday insights), *Pro-c* (advanced enough to be making a career of some creative domain), and *Big-C* (eminent contributions to a domain). This four-C taxonomy acknowledges important distinctions between, for example, creative writing in one's diary *vs.* creative literature with broader value. Many other models of creativity have been proposed in the literature. Some examples include Wallas's (1926) classic four-stages of creative thought, Osborn's (1953) CPS creativity framework, Finke et al.'s (1992) geneplore model of creative cognition, Amabile's (T. M. Amabile, 1983; Teresa M Amabile, 1996) componential model of creativity, Csikszentmihalyi's (1988) systems model of creativity, and Shneiderman's (1999) genex model. In this dissertation, I do not adhere to any of these specific creativity models, but make use of a looser model of creativity as entailing a core process of recombination of ideas. This is elaborated upon later in this section.

Research has shown that creativity is domain specific (Baer, 1998; Han & Marvin, 2002), that is, requisites that lead to scientific discoveries, artistic expressions, and creative athletic performances may be very different, and it is rare to find individuals whose creative contributions occur in multiple domains. This domain-specificity of creativity may be detrimental in the evaluation of Persons or Products. A Process approach to creativity, on the other hand, stresses the universality of creative operations and procedures – processes that different individuals, domains, and levels of value of products have in common (R.A. Finke et al., 1992; Steven M Smith & Ward, 2012). Inherent in the Process approach is the belief that processes of creativity can be learnt, and that children's creativity can be nurtured and practiced. Like tiger cubs engaging in pretend kill playing in preparation for when they can actually kill for food, children can be nurtured to practice the creative process while waiting for education to provide them with knowledge, skills, and expertise that can enable them to truly contribute significantly to society.

An interesting conception of creativity is the *structured imagination* theory, which states that novel, creative ideas stem from existing knowledge (Ward, 1994). This theory states that at all

levels, whether in eminent, professional, everyday, or personal creativity, imagination is based on the conceptual cognitive structures that are used, extended, and combined in the course of the Process approach of creative cognition. Concepts are flexibly constructed and tailored for different contexts, and they are combined and extended to generate new instances of those concepts in the structured imagination view. This is not to say however that creative cognition advocates one unitary "process" that can be called *the* creative process. Rather, there are many types and levels of recombinatory processes and operations that can collaborate in various ways to give rise to creative products: the combination and synthesis of ideas that may have emergent properties, generating numerous novel and unusual ideas as in divergent thinking and remote association, conceptual restructuring, insight, non-verbal processes such as intuition and incubation, and logical thinking, analogical reasoning and transfer, inference, and induction. In fact, apart from structured imagination, (re)combination as an umbrella term for the process of creativity has been advanced in many other theories, and appears to be a central process of creativity: M. Boden (1990) refers to 'combinatorial creativity', i.e. utilizing rules in a conceptual search space in new ways "to come up with new combinations". Fauconnier and Turner's (2002) concept of 'conceptual blending' holds the same idea of combining domains. Novitz's (1999) requirement for creative acts is the "intentional or chance recombination of such ideas, techniques, or objects – where this recombination is subsequently deliberately used". Vygotsky (Moran & John-Steiner, 2003) sees creative activity as being based on the "ability of our brain to combine elements", using the past to create the future.

III.2 A Model of Creative Storytelling

Based on our experiences during our studies with children creating stories (Chu, Quek, & Lin, 2011) and our review of the literature highlighting the importance of recombination, we conceptualize the creative process as shown in Figure 5. Raw material from which a child constructs a story concept can be of two forms: A. a stimulus (1a in Figure 5 top) that may be any perceivable element in the environment; or B. elements from memory experiences (1b). The child can recombine (2) these idea fragments to form whole ideas that may (or may not) be expressed or formalized (3) into the external world. Maruskin and Thrash (2010) have shown the importance of inspiration and motivation for expression. Most importantly however, the support of thinking through the reuptake of external representations of ideas is illustrated by the dotted arrow labeled 'Feedback' where the external form (a written sentence, or part of some other outcome) itself provides new material to further fuel the recombination process as it becomes part of the perceivable environment of the child. L. S. Vygotsky (1978) conceives of this mediation of thinking through perception as an 'outside-in' process. From our model of the creative storytelling process, we can conceive of 'mental products' as ideas produced (before the green dotted line of motivation), and of 'external products' as ideas produced in concrete, physical and visible form through a medium (after the green dotted line of motivation). During the creative process, mental and external

products feed upon each other in tight cycles such that the two may be said to become coupled, making creativity very much an embodied process.

This model may be construed in the light of storytelling done through the means of conventional methods, such as writing, as shown in Figure 5 (middle). The adapted model helps to explain why writing by itself provides little support for the child's creative storytelling process. Specifically, methods such as writing do not help the child to exploit external representations for thinking. Echoing theories of distributed cognition (Hollan, Hutchins, & Kirsh, 2000), Kirsh (2013) makes a poignant case that human cognition relies tremendously on external representations to anchor and catalyze thought and ideas. In fact, he states that if our interaction with external representations is not critical, then "Why not just sit still and 'think'?". Writing relies on the process of abstracting and representing free-flowing ideas into the external product in the symbolic form of language. As described in Section II.2, children in the age range of 8 to 11 are transitioning to abstract thinking, thus they may not yet be fluent in the expression of ideas in symbolic form (green zigzag arrow). Further, the child has little motivation to engage in actualizing her ideas into written text (broken red line). A child does not often willingly review her writings once she has written it, thus eliminating the benefits of bringing perception into the loop of thinking (wavy feedback arrow).

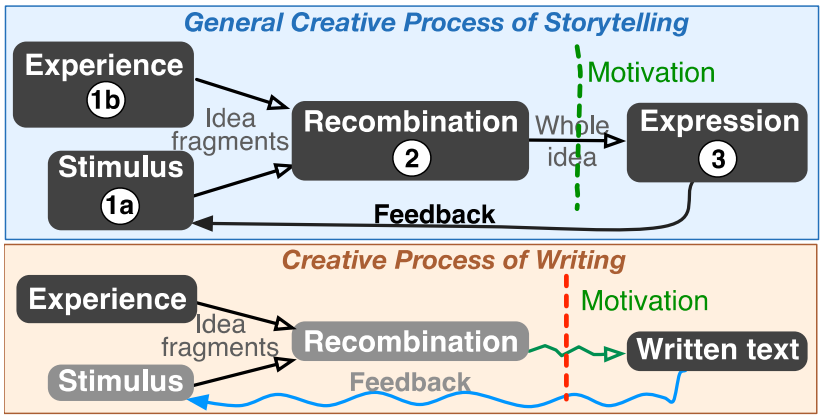

Figure 5. Mediated creative storytelling process

III.3 Creative Self-Efficacy

Our model of creativity illustrates that both the cognitive (idea generation, idea abstraction) and the affective (motivation to engage) interact to affect the child's involvement in the storytelling

activity. A core aspect of this interaction is encapsulated in the concept of 'creative self-efficacy'. Self-efficacy has been defined as "people's beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives" (Bandura, 1977). The construct has often been equated with self-confidence or self-esteem. Alfred Bandura, the originator of the self-efficacy concept, states that "it is partly on the basis of judgments of personal efficacy that people choose what to do, how much effort to invest in activities and how long to persevere in the face of obstacles and failure experiences" (Albert Bandura, 1989). Perceived self-efficacy even serves to influence performance by triggering self-regulatory processes such that "a person with the same knowledge and skills may perform poorly, adequately, or extraordinarily depending on fluctuations in self-efficacy thinking" (Bandura, 1977).

Self-efficacy is paramount for the creative individual. To be creative involves an "expression of the self" (Morgan & Averill, 1992), which requires the individual to possess an emotional capacity to believe that she can succeed (Spendlove, 2008). Self-efficacy has been related to creativity through the term 'creative self-efficacy', the creativity-focused sense of efficacy defined as the "belief that one has the ability to produce creative outcomes" (Tierney & Farmer, 2002). A generally-accepted definition of a creative outcome is a product that is judged to be domain-specific, novel, and useful (Teresa M Amabile, 1996). Thus an individual may have many creative ideas, but decides not to pursue their actualization into concrete products because she lacks the confidence that she is able to produce something worthwhile.

One's self-efficacy judgments are formed from four main sources of information (A. Bandura, 1989): *performance mastery* (how much one attributes to one's direct effort); *vicarious experience* (social comparisons done with the performance of others on the same task); *verbal persuasion* (acknowledgements and feedback from others); and *physiological state* (affective and emotional arousal). Performance mastery is said to be the most powerful determinant for one's self-efficacy (Bandura, 1993). To the extent that we can maximize each of the four determinants in a creative activity, we can posit that one's creative self-efficacy will be supported, leading to increased motivation to re-engage in the creative process. Bandura's (1989) four grounds for self-efficacy formation may help to explain the Fourth-Grade Slump, as the child's struggles to express her ideas may leave her with a sense of decreased self-efficacy of being capable of creating:

- She is not able to complete the task smoothly (compromised *performance mastery*).
- She sees that the quality of her writing cannot compare with written pieces that are valued by society (*vicarious experience*).
- Few people compliment a child on her written story, unless she is really good at it (lack of *verbal persuasion*).
- Her overall experience of writing leads to a distressed experience (negative *affective arousal*).

Approaches used by teachers (see Section III.4 below) help somewhat to ameliorate this state of affair, but none of the approaches address creative self-efficacy precisely.

III.4 Creative Storytelling in Education

Creativity and Learning

Creativity is not seen as one of the primary pillars of our present educational system. Learning is seen as the key outcome of what schools are meant to achieve for children. However, we take the position in this dissertation that learning is not totally distinct from creativity, similar to Fasko (2001). A creative thinker requires knowledge, and a learner needs to be creative to learn. The model of the creative process that we presented in Figure 5 reflects how creativity is intricately and inseparably linked with learning. By the recombinatory process of creativity, one assembles or constructs new concepts from previously learned knowledge. This acquisition of knowledge is the core aspect of all learning. The educational paradigms of constructivism (Ackermann, 2001; Wadsworth, 1996) and constructionism (Papert, 1987) maintain that to be truly learnt, knowledge has to be constructed and integrated with one's body of existing knowledge, as opposed to for instance, mere reproduction or repetition of knowledge. This same process of deconstruction and reconstruction is part of the creative process. The child breaks down newly perceived knowledge or experiences into bits before synthesizing selected bits into an overall picture. Hence, 'being creative in one's learning' has many overlapping cognitive processes with 'being knowledgeable in one's creativity'. The knowledge one has constructed may yield creative products, but participation in creative activity is also said to develop strength in one's knowledge.

Cannatella (2004) states: "creative practice can assist the clarification of ideas, advancement in thought, and concentration in learning", thus strengthening not only what one learns but how one learns. Similarly, Beth A Hennessey and Amabile (1987), p. 10) posit that creativity requires a mixture of "factual knowledge, technical skills, and special talents [which] can be seen as a set of cognitive pathways one can take to solve a given problem". Amabile's (1983) componential model of creativity brings together creativity-relevant skills (i.e., recombinatory processes of thinking), domain-relevant expertise (i.e. knowledge and experience), and motivation. It is unfortunate thus that creativity is not always taken seriously in education. An international study titled "Barriers to creativity in education" by Adobe (2013) surveying 2000 educators and 2000 parents reports that the "education system itself is a barrier to developing the creativity that drives innovation". The report cites three key steps that are necessary to promote and foster creativity in education: 1) "Provide tools and training to teach creativity"; 2) "Make creativity integral to the curriculum"; and 3) "Reduce mandates that hinder creativity".

Creative Storytelling in the Classroom

Storytelling is one of the common devices used in the elementary school classroom both as a creative exercise, and as a step towards fulfilling the requirement of the curriculum. In the Common Core Standards (CCSs) (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2014b), 4th- and 5th-grade students are expected to be able

to write for three purposes: A) Persuasive writing that articulate an argument; B) Informative writing that presents facts and information; and C) Narrative writing of real or imagined events.

Students are required to demonstrate knowledge and the ability to use and explain literary elements, such as story and poetic structures in a variety of genres, and literary nonfiction, historical, scientific, and technical texts, including biographies, autobiographies and books about history, social studies, science, and the arts (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2014b; National Governors Association Center for Best Practices & Officers, 2014). At all grades, students are expected to use various strategies to organize and present their ideas and information according to the purpose of assignments and their audience. The Texas Essential Knowledge and Skills (TEKS) for English Language Arts and Reading (Texas Education Agency (TEA), 2010) states that students should select "a genre appropriate for conveying the intended meaning to an audience", determining appropriate topics through a range of strategies (e.g., discussion, background reading, personal interests, interviews). Across the board, the CCSs emphasize skills and processes used across all areas of learning: "Across the English language arts and mathematics standards, skills critical to each content area are emphasized. In particular, problem-solving, collaboration, communication, and critical-thinking skills are interwoven into the standards" (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

But beyond the curriculum fulfillment aspect of storytelling, this creative process is an age-old activity that is basic for humans to make sense of the world. Stories or narratives structure our lives, experiences and even identity (Brooks, 1984). According to Bruner's (J. Bruner, 1991; Jerome S Bruner, 1990) theory of 'narrative intelligence', we understand intentional action through the lens of narrative structures. Children are immersed in stories: fairytales, make-up stories, pretend play, … Gajdamaschko (2005) posits that stories are the proper 'cognitive tool' that satisfies all the requirements for the development of imagination. Narratives are "crystallized in culture", unified in terms of "imagination and thinking, imagination and emotions", influential of the child's behavior, and accepted by the child as part of her cultural development.

However, as we mentioned in Section III.2 above, creative storytelling is not transparent to many children. Breakdowns can occur at any point of the process, and It poses much difficulty especially for children who are English Language Learners (ELLs). In the classroom, expectations for ELL students include the development of "enough English vocabulary and command of English language structures to address grade-appropriate writing tasks" (Texas Education Agency (TEA), 2007), which represent challenging or even insurmountable challenges for them, leading to the children slumping in performance and motivation to engage. Such challenges may include not only difficulties with the mechanics of writing (grammar, sentence formation, vocabulary, etc.), or with the lack of knowledge, content or ideas to express, but also with the process of translating ideas into the final format, in essence moving through stages 1 to 3 in our model of the creative process

in Figure 5. This gap between the jumbled ideas that one wishes to express and putting the ideas in a form that can be formally expressed is thought of to be part of the 'prewriting' phase of writing. Prewriting is one of the most important stages of writing during which the author makes ideas 'writing-ready', deciding on and evaluating the story topic, the chain of events, and details that support the topic (Meyer, 1995). Such details may be understood as part of the story's 'coherence' (A. Nicolopoulou, 2008) that addresses aspects such as narrative order, thematic centering, causal links, etc.

Support Materials for Creative Storytelling

In our interviews with teachers described in Chapter 2 Section II.3, materials that teachers mentioned using to help children make sense of their creative storytelling process include graphic organizers, slideshow presentations, storyboards, story cards, 'interactive notebooks' and digital online tools. Graphic organizers are visual structures, typically displayed as a series of boxes labeled with sections of a typical narrative. Various layouts are used, ranging from hierarchical tree-like formats, star patterns, or layouts mapped to a biological metaphor (e.g., a butterfly, a human being, a snowman, a tree – the head of the butterfly or person represents the story's 'introduction' box, the body represents he story's 'main plot' or 'climax' box, etc.). Other graphic organizers help the child to dissect story elements such as the 'who, what, where, when and why' of the plot. Research into graphic organizers have been mixed, finding both benefits or null effects associated with their use (Meyer, 1995). Slideshow presentations entail having the students prepare their narrative arguments using standard presentation software such as Microsoft PowerPoint, and then presenting their 'story' to the class. Storyboards are drawn sequences of story scenes in a comic book-like format. Story cards include commercial sets of cards that represent various characters, places, objects, such as the 'Storyworld kit' by Matthews and Matthews (2010). Children can either purposefully or randomly choose a series of cards, and then create a story wrapped around the cards' illustration sequences. Interactive notebooks are diary-like individualized notebooks that each student keeps to jot down their thoughts and ideas. Thoughts can be expressed using text, drawings, magazine cutout pictures, annotations, etc. The amount of structure and type of components required in an interactive notebook vary by teacher.

A number of teachers also reported making use of online tools to support the storytelling experience. Especially as the curriculum increasingly advocates the use of technology for teaching (e.g., one of the Common Core English Language Arts anchor standards for college and career readiness for writing (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2014a) recommends to "use technology, including the Internet, to produce and publish writing and to interact and collaborate with others"), and as the new generation of teachers become more accustomed to technology, tools such as Little Bird Tales, StoryBird and Comic Master are gradually becoming more popular in the classroom. Little Bird Tales (LittleBirdTales, 2015) enables the child to upload her own artwork or photo and to record voice

narration associated with each picture to create a digital story. Storybird (2014) is a visual storytelling tool that allows the child to combine curated artwork with text to tell stories that can be presented locally on the screen or added to the website's library. Comic Master (Web2teachingtools.com, 2009) allows the child to create multi-page stories laid out in a comic book format quickly with preset backgrounds, characters and props, and with the ability to input customized text. There is little doubt that these tools induce motivation and excitement in the child to create, as opposed to traditional writing-based approaches. Multimedia learning theory (Mayer, 2001) indicates that multiplying the forms of media (text, pictures, animation, etc.) help to improve learning and creativity. However, no scholarly research has been conducted to understand how these digital tools actually help to scaffold creative expression in the children.

CHAPTER IV
SUPPORTING THE CHILD'S CREATIVITY

IV.1 Overarching Research Question

Our foremost concern in this dissertation is the support of children's creativity. We found that this concern is particularly critical during the 3rd to 5th grade period, when children undergo rapid growth and substantial cognitive and affective changes. Numerous factors may contribute to the slump in performance and engagement in creative functioning, but we hypothesize that one of the most significant factors is the child's acute self-evaluation based on the perceived quality of her output or creative products, not only based on others' judgment but also on her own perceptions. As the child enters into the transition phase of concrete to abstract thought development during a period when requirements and expectations at school and at home become more adult-like, her self-evaluation is compromised if she is unable to produce satisfactory content that is up to her standards. We posit that greater scaffolding to the creative process is needed for the 8 to 11-year old child to facilitate and support (1) creative performance in terms of the quality of output, and (2) creative self-efficacy in terms of one's self-belief in one's capacity to produce creative outcomes.

The guiding question that provides the general direction for our research is as follows:

How may digital technology augment the 8- to 11-year old child's creative performance and creative self-efficacy?

We address this overarching question through the four phases of exploration, design, evaluation and integration. A wide variety of prior technological systems whose effects are positioned within that scope can be found. We present a review of existing work in the following section.

IV.2 Creative Storytelling Support Systems

In the human-computer interaction (HCI) literature, a diverse number of systems have been developed to support children in creative storytelling. We conducted a review of these systems using the following method:

- A search was done in the ACM Digital Library, the IEEE Explore Digital Library and the Springer database using the search phrase 'creativity storytelling children'. 561 search results were returned from the ACM library, 4 papers were found in the IEEE library, and 5 from the Springer database.
- The search results from ACM were refined by including papers only within the 10 years of 2002 to 2012. 380 results were obtained.

- The search results from ACM were further refined by conference proceedings. Papers from the following conferences were considered for review: CHI (International Conference on Human Factors in Computing Systems), TEI (International Conference on Tangible, Embedded and Embodied Computing), C&C (Creativity and Cognition), IDC (Interaction Design and Children), MobileHCI (International Conference on Human-Computer Interaction with Mobile Devices and Services). The search results were narrowed to 133 papers.
- These papers and the IEEE papers were reviewed, and papers that met with one or more of the following criteria were excluded: papers that dealt with theoretical frameworks or reviews; papers that were conceptual in nature; papers that proposed systems whose focus was not storytelling (e.g. programming, social interaction for children); papers whose target audience were special populations (e.g. visually impaired children); papers that were workshop abstracts or doctoral consorta (all full, short or work-in-progress papers were considered).
- 34 papers were found to be relevant for our purpose. The target audience of the storytelling systems proposed in these papers was classified as being either 'Category 1' – Pre school/Kindergarten, 'Category 2' – Elementary (6 to 11 years old), 'Category 3' – Middle School (12 to 14 years old), and 'Category 4' – Older children and adults.

We were mostly interested in the papers addressing Category 2, but within the broader design space, four dominant paradigms of interaction were found. These are listed in Table 5: (i) Graphical user interfaces (GUIs); (ii) Sketching; (iii) Text; and (iv) Performance. Systems making use of GUIs typically require the user to use a keyboard and a mouse for interface actions such as navigation, selection, etc. Sketching interfaces, also known as pen-based interfaces rely on some form of drawing, and are sometimes accompanied by speech interaction. Systems based on text input typically include natural language processing that guides the selection of appropriate animation clips. Systems relying on some sort of outward performance from the user typically require the user to use gestures, direct or indirect bodily movements, etc. Table 5 shows the systems reviewed that we coded with their associated interaction paradigm and tools, the nature of story output generated, the target audience, and the point-of-view taken by the user in creating the story. Only some of these systems focus on and have been tested with children as target users.

Table 5. Existing storytelling support systems

#	System Name	Paradigm	Interaction Tools	Output	Audience	Point-of-View
1	**Improvisational puppets** (Hayes-Roth & Van Gent, 1997)	Text	Mouse, Keyboard	2D	Children, Adults	Allocentric
2	**KidPad** (Druin, Stewart, Proft, Bederson, & Hollan, 1997)	GUI	Mouse, Keyboard	2D	Children	Allocentric
3	**POGO** (Decortis & Rizzo, 2002)	Performance	Physical objects, Custom tools	2D	Children	Mixed
4	**CBC4Kids' Storybuilder** (Alissa Antle, 2003)	GUI	Mouse, Keyboard	2D	Children	Allocentric
5	**Animaatiokone** (Hämäläinen, Lindholm, Nykänen, & Höysniemi, 2004)	Performance	Mouse, Clay figurines	3D	General public	Allocentric
6	**Pen-to-Mime** (Oshita, 2004)	Performance	Pen	3D	Adults	Egocentric
7	**Spatial keyframing** (Igarashi, Moscovich, & Hughes, 2005)	Performance	Mouse	3D	Novices	Allocentric
8	**Vuelta** (Hourcade, Perry, & Moore, 2007)	GUI	Mouse, Keyboard	2D	Children	Allocentric
9	**Video Puppetry** (Barnes et al., 2008)	Performance	Paper puppets	2D	All users	Allocentric
10	**Handimation** (Svensson, Björk, & Åkesson, 2008)	Performance	Wiimotes	3D	Animators	Egocentric
11	**K-Sketch** (Davis, Colwell, & Landay, 2008)	Sketching	Pen	2D	Novice animators	Allocentric
12	**Second Life** (Pereira et al., 2009)	GUI	Mouse, Keyboard	3D	Children	Allocentric
13	**Performance-driven motion choreographing** (Liang, Li, Zhang, Zhang, & Geng, 2009)	Performance	Accelerometers	3D	Adults	Egocentric
14	**Animated storytelling system** (Sumi, 2008, 2009; Sumi & Nagata, 2006)	Text	Keyboard	2D	Novices	Allocentric

Table 5. Continued,						
#	System Name	Paradigm	Interaction Tools	Output	Audience	Point-of-View
15	**Pen and speech-based storytelling system** (Danli Wang, Li, Zhang, & Dai, 2008; D. Wang, Zhang, Li, Dai, & Lin, 2007)	GUI	Pen, Speech	3D	Children	Allocentric
16	**Wayang Authoring** (Widjajanto, Lund, & Schelhowe, 2008, 2009)	Performance	Mouse, Keyboard	2D	Children	Allocentric
17	**Animation from natural language texts** (Oshita, 2010)	Text	Keyboard	3D	Animators, Novices	Allocentric
18	**TellTable** (Cao, Lindley, Helmes, & Sellen, 2010)	Performance	Photo camera, Multi-touch table	2D	Children	Allocentric
19	**ToonTastic** (Russell, 2010)	Performance	Multi-pen interactive display	2D	Children	Allocentric
20	**Prochinima** (Åkerman & Puikkonen, 2011)	Performance	Mobile phone, Video camera	2D	Children	Mixed
21	**ShadowStory** (Lu et al., 2011)	Performance	Wireless handheld sensors	2D	Children	Allocentric
22	**PuppetAnimator** (Shi, Suo, Ma, & Shi, 2011)	Performance	Mouse	2D	Novices	Allocentric
23	**Shape Your Body** (Leite & Orvalho, 2012)	Performance	Body	3D	Adults	Egocentric

Focusing on the systems that allow for the authoring of multimedia stories away from the desktop, as opposed to the systems that are text-centered or tied to the keyboard/tablet, we categorized further the systems in the 'performance' paradigm or what we would call the more 'embodied' systems in Table 5. Figure 6 shows the resulting framework (numbers reference # in Table 5). Three types of performance can be distinguished: (i) *Direct manipulation* – the child manipulates story elements onscreen through the mouse pointer or finger touch interaction; (ii) *Puppeteering* – the child controls story characters through the manipulation of external physical objects; and (iii) *Enactive* – the child performs the role of story characters. The user's gestures and movements are tracked in some way and mapped onto an animated character or non-human entity.

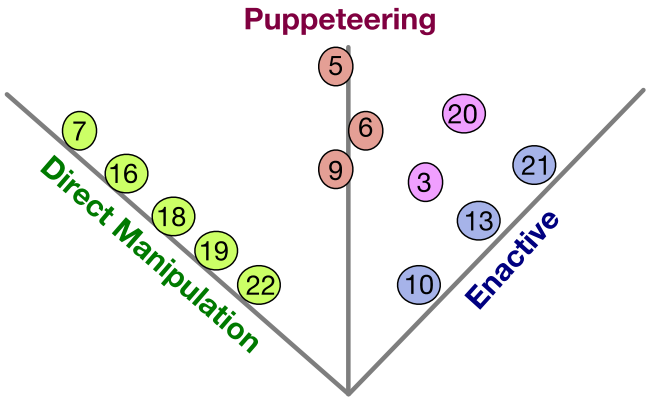

Figure 6. Classification of embodied storytelling support systems

A. Direct Manipulation Category Examples

In 'Toontastic' (Russell, 2010) children can draw or choose characters from a preset library, and place each on a separate 'layer', on a touchscreen tablet. Children can move, rotate, and scale these characters while the screen is being captured. 'Wayang authoring' (Widjajanto et al., 2008, 2009) is a direct manipulation interface that enables children to author stories in the form of shadow puppetry, a traditional Indonesian storytelling art. The child composes a story using a web-based graphical user interface by clicking and dragging objects on a 'stage'. The system records the direction and speed of the dragging movement as 'the story being told'. The authors reported that "the visual appearance and the implemented work flow were first uncommon but easy to handle for most of the children". However, only informal testing of the system was reported.

B. Puppeteering Category Examples

'Video puppetry' (Barnes et al., 2008) allows children to tell stories through puppeteering with cut-out-style animations. After drawing and cutting out the story elements using paper and scissors, the user moves the paper-based elements in front of a camera. The software processes the input frames from the camera by detecting the 'object' drawn and tracking it as the user moves the cut-out element around, and removes the user's hands from the video. Although the system was not specifically designed for children, it was showcased at several public events where it was used by children. The authors reported that "the system is easy to learn and use. All users were able to control the onscreen puppets with minimal instruction because the interface is so transparent."

C. Enactive Category Examples

We did not find any *enactive* interfaces that were designed specifically for children to author stories. 'Handimation' (Svensson et al., 2008) maps the movement of a 3D virtual character to a user's movements by requiring the user to use three wiimotes (one in each hand, and one attached

on the top of the head), but the interface follows a music sequencer metaphor and is rather complex to use. The system was developed to support animators in their work. In 'Performance-driven motion choreographing' (Liang et al., 2009), the focus is to support the rapid prototyping of scenarios such as fight and dance choreography, sports training, game avatar control, etc. The user is able to choreograph motions using 3-degrees of freedom accelerometers placed on pre-specified positions on the user's limbs. The user's motions are then recognized using a preset database of motions using a Hidden Markov Model. The core contribution of Liang et al. (2009) however is the technical approach proposed. No user study is reported in their work.

The 'ShadowStory' (Lu et al., 2011) system was designed to emulate the Chinese shadow puppetry experience. Children create digital puppets using a stylus on a drawing-like interface on a tablet PC. They then drag created story characters and props onto a 'stage'. Each character or prop on the stage is automatically assigned to a pair of wiimotes. The 'stage' interface is projected onto a larger projection screen viewable by an audience. The children can then perform their story by moving the wiimotes, mapped to the story characters and props, behind the projection screen. Lu et al. (2011) reported a pilot study of the system with 14 Chinese children aged 7 to 9, who created stories using ShadowStory and gave public performances of their stories to their whole class. Their findings included qualitative results in terms of the creativity of the stories created, collaboration, intimacy with traditional culture, and the combination of the physical and digital world. With the wiimotes in ShadowStory, the children also had to rotate their wrist to manipulate the story characters and props. Yet, the authors reported episodes of children's enactments during their storytelling: *"many children tried to create more direct mappings between the character's position/action and those of themselves. For example, one girl waved her own hands when the character she controlled was doing so. One boy was controlling a character to fly in the sky, and while doing so he stood on a chair so that he was also physically above other performers."*

IV.3 Creative Self-Efficacy Support Systems

Research in the support of creative self-efficacy in human-computer interaction (HCI), especially for children, appears to be lacking. The range of effects that researchers have looked at with respect to creativity support tools can be seen in the assessment measures used. These fall generally into three categories: *performance-based*, such as evaluating the number of ideas generated and the extent of divergent thinking (A. Kerne, Smith, Koh, Choi, & . 2008); *self-report-based*, through the use of psychometric scales pertaining to constructs like flow, immersion and exploration (Cherry & Latulipe, 2014); or *socially-based*, of which the consensual assessment technique (T. M. Amabile, 1982) is a prime example, measuring general product creativity. Self-efficacy is ill-fitted to any of these categories. A key area within HCI that has looked at the support of self-efficacy through technological systems is behavioral change technologies. These have investigated system effects on self-efficacy in relation to technology acceptance by older adults, programming efficiency for designers and novice programmers, the motivation of physical activity

(exergames) and the promotion of eco-friendliness behaviors. All in all, little self-efficacy research in HCI can be found dealing with either creativity or with children.

CHAPTER V
PHASE I: EXPLORATION *

V.1 Exploration Research Question

In order to begin exploring our overarching question of how digital technology may augment children's creativity, we asked whether a change in the medium of creation has the potential to affect the child's storytelling process, and if so by which mechanism the mediation occurs. Our review of existing storytelling systems in Section IV.2 distinguished between systems centered mostly around text and multimedia-based systems. Our exploration thus focused on how children's creative process is mediated when using text as opposed to using media, particularly animation to tell stories. The research questions for this Phase I Exploration were as follows:

1. How does storytelling with animation qualitatively change children's creative process?
2. How do children perceive storytelling with animation?
3. Do children produce more creative stories with animation than with a text-based medium?

The following sections of this chapter describes the background of prior research on media effects, and then presents our study with children investigating the research questions listed above.

V.2 Investigating Media Effects

The study of media effects is not new, especially in disciplines like Communication or Media studies. Research has been carried out on the impact of different types of media on the child's cognitive processes as early as in the 1950s. The literature is replete with studies of media effects on mental functions such as learning, comprehension, recall or memory, and attention. However, the study of media effects on creativity has received relatively less attention. Among studies that have been conducted, there has not been a consensus. On one hand, P. Greenfield, Farrar, and Beagles-Roos (1986) found medium effects in favor of radio over the television (TV), and Watkins and Coulombe (1981) found differences between print, radio and TV in terms of inferential elements. Valkenburg and Beentjes (1997) also more recently found that a TV stimulus produced more novel stories for children aged 8 years and older than a radio stimulus. On the other hand, both M.A. Runco and Pezdek (1984) and Rubenstein (2000) did not obtain any effects

* Parts of this chapter are reprinted with permission from "Studying Medium Effects on Children's Creative Processes" by Chu, S., Quek, F. and Lin, X., 2011. *In Creativity & Cognition '11.* Pp. 3-12: Atlanta, GA.

comparing radio and TV, and print and TV respectively. Despite the contradictory results, McLuhan's (1994) proposition that "the medium is the message" maintains that the medium can have an important impact on the content, processes and the environment.

Why Medium Matters

Based on neuroscience research, S. Greenfield (2008) highlighted a dichotomy between "people of the book" and "people of the screen". Other theorists have suggested that there are complementary roles for our verbal/symbolic and visual systems. Baddeley and Hitch (1974) proposed that we have both a visio-spatial sketchpad and phonological loop in working memory. Paivio (1986) advanced a "dual coding theory" by which "memory and cognition [are] served by two separate symbolic systems, one specialized for dealing with verbal information and the other for nonverbal information" (Malaga, 1999). Mayer (2001) thus argues that using both visual and verbal channels improves our creative problem solving abilities. In fact, multimedia learning systems are built based on this very argument. It is worth noting that similarly, the media richness theory proposes that a communication medium is 'richer' when it transmits immediate feedback and a multiplicity of cues (Daft & Lengel, 1986). Nevertheless, among the various modes of representations, Shepard (1978) claims the primacy of the visual. In the same way that media naturalness theory (Kock, 2004) adopts an evolutionary perspective to posit face-to-face communication as the most 'natural' medium, spatiality and visual images according to Sheppard have been "incorporated into our perceptual machinery by eons of evolution in a 3-dimensional world". Imagery therefore empowers us to obtain ideas and thoughts that are not "fully preserved by language" (Malaga, 1999).

Media as Tools for Creativity

We have shown the significance of studying creativity in relation to media, but it is necessary to point out three essential differences between previous media effects studies and our exploration research. First, prior studies such as those mentioned earlier consider media as modes of communication. Thus their experiments manipulated the medium in which stories were presented while keeping neutral the medium in which the subjects were assessed. In our study, we adopt the perspective of media as tools provided by culture and enabling mediated activity. In that sense our understanding of media here is closer to Vygotsky's (1987) concept of 'tools for thinking'. For Vygotsky, tools have properties that can change behaviors and thoughts. It would not be surprising therefore that as tools of cultural production, media possess the ability to influence the nature of our higher psychological processes, including our creativity, in their use. Second, our study looks at how the intrinsic form of the medium mediates creativity. A medium can be said to consist of three components: a physical platform or hardware, a set of formal features, and content (Subrahmanyam & Greenfield, 2009). Even though the influence of content on creativity cannot be denied, "medium content is a fickle thing" (Brown, 1988) and easily enough be controlled by the user. We are instead interested in the medium's formal features, or the way that the representation

of content using the differing symbolic makeup of verbal language, icons or visual signs, as well as the rules and conventions governing the interaction of the symbols, exercise influence on children's creative activity. A review of the literature shows few prior studies that exactly investigate the effects of media as tools on creativity. One strand of research of greater relevance consists of studies performed during the popularization of personal computers. Cochran-Smith (Cochran-Smith, 1991) summarizes work inquiring about the impact of using a word processor on the writing process as opposed to the use of pen and paper. Some of the qualitative findings of those studies reported the rise of "speculative thought", the tendency towards "impermanent writing", and the positive effect of "discouraging premature closure of divergent ideas" during the writing process.

The third point on which our study deviates from the previous studies mentioned is our focus on process rather than outcome. Studies of media effects mostly evaluate creativity in terms of the creative products, that is the stories generated by the children. Creativity has been conventionally studied using four different approaches: by looking at the product created, the process of creating, the person or the creator, or the environment of creation (Rubenstein, 2000). The emphasis of our study is on the creative process that takes place as the outcome is being produced. Although the 'objective' creativity of the work products is important as the basis for evaluation by others, studying creativity developmentally enables us to tease out the effects of the medium on children's behavior as a process. Moreover, we look at creativity as 'situationally induced' (P. Greenfield et al., 1986), that is creativity motivated by current conditions and environmental factors, instead of creativity as an individual trait as measured by standardized tests. However to prove whether practicing situated creativity over an extended period of time will or can result in better creative individual abilities is out of the scope of this study. In a similar line of thought, we investigate creativity in the average child in an everyday context, as opposed to others who have looked at 'specialists in creativity', such as gifted children or artists who either have developed, stable creative processes or defined creative output – e.g., (Colangelo & Davis, 2002; Getzels & Jackson, 1962; Weisberg & Springer, 1961).

V.3 Study Design

Pre-Interview

Third and fourth graders were recruited from the after-school program of a local elementary school as participants. The main medium of study was the animated medium or animation, but we concurrently studied the digital print medium as well for control and comparison purposes. The print medium provides a contrasting mode of mainly textual information representation with regards to the mostly visual nature of animation. Results from a pre-interview lasting around half an hour conducted with a group of fourteen children at the school also provided us good confidence in the choice of the control medium. The print (textual) medium and the animated medium were seen to be a significantly different pair ($p < 0.005$) in a survey of their perceived familiarity with various media including storybooks, cartoons, movies, comics and the internet. Familiarity has been

described as consisting of five main factors: prior experience, repeated exposure, level of processing, study duration and forgetting rate (Zhang & Ghorbani, 2004). We based our questions about familiarity with the different media on these five factors, and produced a scale with a reliable alpha coefficient of 0.77. The full questionnaire used can be found in Appendix C.

Main Study

Ten children from 3rd or 4th grade, 5 girls and 5 boys, took part in the main study. Eight of them participated in the pre-interviews and two of them joined in only for the main study. The bulk of the study consisted of asking the children to create stories using the two media. They made use of the 'Frames' software to create the animated stories. Frames (Tech4Learning, 2011) is a digital storytelling software that can be downloaded for free as a fully-featured evaluation version on the web. The children created the textual story with the *'Microsoft PowerPoint'* software, presented as a set of storybook slide templates to them (Figure 1).

Frames makes use of a frame-by-frame approach to allow one to create animations (see Figure 7). Stories can be organized as a series of still frames (like a storyboard with sound). Authors can specify the duration that each frame stays active when the animation is played, and so, can create the illusion of motion by varying the placement of objects in consecutive frames. Objects can be obtained either from a library or can be created using drawing tools. They can be manipulated through rotation, flipping or resizing. Frames has been tested with children in several schools (Tech4Learning, 2011) and is easy to use even for younger children. By controlling the frame transitions, children can then create the effect of 'stop-motion-animation' or a slideshow story.

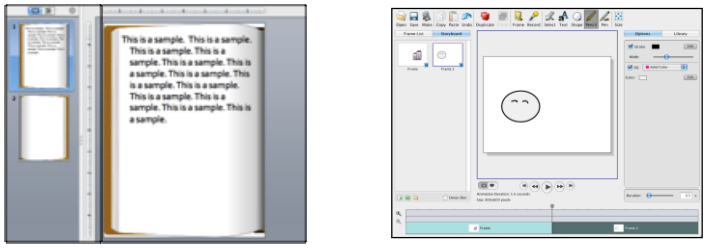

Figure 7. Screenshots of Powerpoint with storybook template (Left) and Frames animation software (Right)

The study was carried out in two sessions over two different days to prevent fatigue of the children from creating two stories in one session. To enable us to study the creative process, they worked in groups of two or three as social interaction motivates externalization of thoughts into speech. The children were grouped subjectively by the site administrator. In the first session, two

pairs created animated stories and two pairs produced Powerpoint 'storybooks'. In the second session, two of the participants were not able to take part in the study, resulting in two groups of three children, one using the animation software and the other the Powerpoint software.

Each group worked on a separate computer, and had a voice recorder placed nearby to capture the conversation during the story creation process. The children's task was to continue and provide an ending to a given stimulus story beginning. Tasks that have been used in previous storytelling creativity studies can be classified as drawings, questions about a story, the use of standardized creativity tests such as the Torrance's (1967) tests of divergent thinking, and story completions (Valkenburg & Beentjes, 1997), which we used. We wrote two stimulus story beginnings that we ensured satisfied three criteria: that they were appropriate for the developmental age of the children, both in terms of language and content, that they were not close to experiences that only some of the children might has gone through before, and that they were more action-oriented than emotionally-driven. The stories had similar themes and were both around half a page in length with standard formatting, while still being different. The first story beginning related the story of living soap bars who have been placed in the cupboard by a family. One day the protagonist, a blue soap bar, decided to leave the cupboard to see the outside world. His cousin, a green soap bar, wanted to go with him. The second stimulus story introduced a set of Red, Blue, Yellow and Green living colored pencils belonging to a girl named Amy. They live in a box on Amy's desk. One day, they decided to visit the outer world. The full story beginnings used can be found in Appendix D.

The step-by-step procedures of the study were as follows:

- The children were grouped and each given a sticker with an ID code to paste on their shirt.
- They were separated into two groups according to the stimulus stories that they had to follow.
- Two researchers read out the stimulus stories to each group.
- The children were then divided into their working pairs or groups of three. Those creating animations were sent to a different room than those creating the storybooks.
- Two researchers, one in each room, explained how to use the software (Powerpoint for the storybook group and Frames for the animation group) to the children. The children were given a print-out of the stimulus story that they had to follow, and asked to continue and end the story.
- One researcher remained in each room as an observer and took down notes of behaviors. No formal time limit was imposed for the authoring sessions, but the amount of time that the children had to create the stories was determined by the arrival of their parents. Under these circumstances, the children had about 1.5hrs for the task.
- Individual post-interviews were conducted on the next day with each child separately. The children were asked about any problems that they might have had with the software, and to retell their own story.

Study Model

Figure 8 illustrates our study model. Demographics and familiarity with media were variables that we collected for the purpose of the pre-study. The possible confounds were controlled as described above: content familiarity through the use of the same stimulus stories for all the children, and usability of software through the use of a tested, off-the-shelf software. In the post-interviews, all the children also indicated that they had no problems using the software and did not find it hard to create the animations. We next describe the lower part of the model: methods used and the data analysis done.

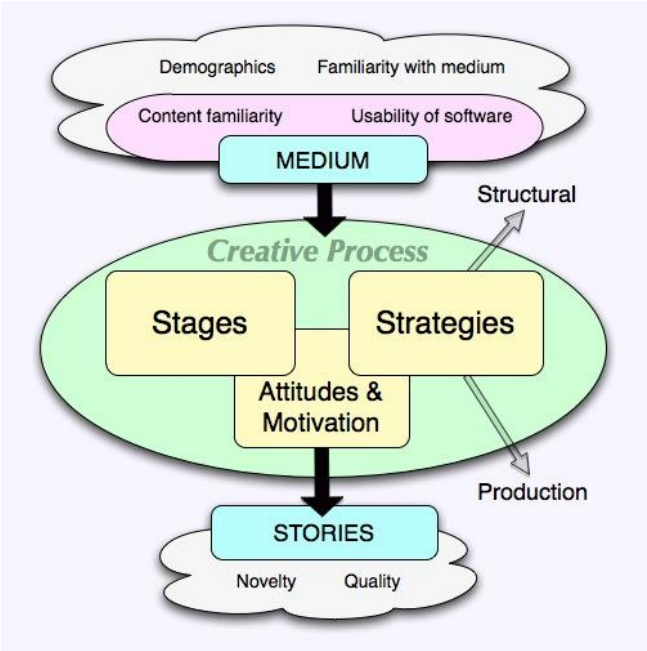

Figure 8. Phase I: Study model

V.4 Data Analysis Methods and Metrics

As we mentioned above, evaluating outcomes was not a main focus of this study. We wanted to analyze the 'way in which' the authoring took place in-situ. A theoretically-driven discourse analysis was used to analyze the data collected to identify qualitative trends in the children's creative process. The coding process was conducted thus:

All the audio clips recorded during the story creation sessions were transcribed with associated speaker turn numbers, emphasis points and short event descriptions (e.g. playing the animation). A reference chain analysis as described in (David McNeill et al., 2008) was performed by four coders. Each was first allotted a transcript to analyze according to the following coding scheme of speech at three levels: *object*, where the reference is to a task-related entity; *meta*, which includes references to the talk being carried out (this includes speech referencing the process of story construction and not the stories being constructed themselves); and *para*, which references things and persons in the environment and includes discourse about the individual's perspective and opinions. The four coders then conferred and resolved any serious discrepancies in the different understandings of the coding scheme. We found that an *object* code in our case could refer either to talk about the Story or the Tool. The transcripts were then redistributed among the coders, and coded again with new understanding of the coding scheme. After the reference chain analysis, an open coding was done on the transcripts to reveal categories and themes. Examples included 'distribution of roles', 'asking for help', 'setting up next scene', or 'searching the library'. All the instances of each code and theme were then grouped and analyzed for patterns using Coughlan & Johnson's (Coughlan & Johnson, 2009) two perspectives of creative interaction as a guide.

The first perspective, *structural interaction* entails the practices and the structuring of the creative process. In this respect we looked at the different stages that the children went through to complete the task. The speech acts coded as *Para* and *Meta* helped in identifying patterns. The second, *productive interaction* is concerned with "low-level interactions", such as the generation, externalization and evaluation of ideas while working towards the final outcome. We thus looked at the different strategies that the children employed to generate ideas for their stories by employing Guilford's (1967) concept of convergent and divergent thinking but given our interest in the process, we analyzed the concepts in a more qualitative manner. Divergent thinking has been defined as "producing a variety of responses in which the product is not completely determined by the information given to the respondent" (Mark A. Runco & Pritzker, 1999). Several divergent thinking tests have been developed (e.g. Torrance's Tests of Creative Thinking, Guilford's Alternative Uses Task). In our coding process, divergence was taken to be a proposition of a story idea that departs from previously presented material, either in the stimulus story or by other group members. It was however not taken to be equivalent to disagreements. If only a disagreement was manifested without a suggestion for a change, it was not counted as an instance of divergent thinking.

Convergent thinking refers to the process of following "a particular set of logical steps to arrive at one solution, which in some cases is the 'correct' solution (Mark A. Runco & Pritzker, 1999), and has often been measured using the Mednick's Remote Associates Test. For our study, an instance of convergence entailed a proposition of a story idea that draws from, builds, follows or draws from what was presented before by the stimulus story or by another child. Apart from

divergent and convergent thinking, we also coded a third element that we labeled as 'seeding'. The emergence of a story idea was categorized as seeding when it consisted of a proposition that did not draw from what has been presented before in any form. It should be noted that all story ideas were considered in the analysis, including ideas that were suggested but did not eventually make it into the final story. Furthermore, no assessment was done as to the originality of the story ideas during the coding process. A convergent idea could be as original or more original than a divergent idea, but if it drew from material presented in the past, it was still coded as convergence. The coding was done mainly in terms of how an idea shaped, directed or influenced the path of the creation of the final story product.

A further analysis was carried out for the children's retelling of their stories in the post-interviews. There were three storybooks and three animations produced. Although the stories were short, each story was first reduced to a 'narrative digest' (L. M. Register & T. B. Henley, 1992) before being used for analysis so that they all had comparative value. Procedures to create a 'narrative digest' included reviewing the story and writing down the main events that happened in the story as a list of sequential story propositions. The retelling of the story by the child was then compared to the story's 'narrative digest' and checked for coverage of the propositions.

Finally, we used Amabile's (1982) consensual assessment technique for the evaluation of the actual stories. Three teachers with experience dealing with children of the 8 to 10 year old age group were asked to be the judges. Teachers were chosen because as pointed out by Boden (2004), it is not possible for one to "decide whether or not an act is genuinely creative" without being familiar with the conceptual space of the creator. The teachers were asked to judge the stories with the following instructions: they were asked to first go through all the six stories without any judging. They then had to preview each story again one by one and fill in an evaluation form for each. The ratings scale was exactly as Amabile's and included the dimensions of creativity, novelty, coherence, continuation and completion. Following Valkenburg and Beentjes (1997), we grouped the first two dimensions into a story Novelty component, and the last three into a story Quality component.

V.5 Study Findings

Structural Interaction: Stages of Creation

The creative process in the storybook and the animation sessions differed substantially. The development of the storybook happened in a cycle consisting of four main steps: generating ideas, typing it into the *Powerpoint* storybook, working on aesthetics, and correcting language (Figure 2). Idea generation saw greater argumentation before a story idea was actually materialized in the form of text and typed in, as compared to the animation sessions where story ideas were mostly acted out immediately. Previewing story (in terms of reading aloud) and assessment of the story mostly occurred towards the end of the creation process. Work distribution in the storybook session was done by turns. It was typically settled that one child would be the 'typist' and the other

the 'idea generator'. Throughout the session then, the 'idea generator', despite having the logically more important role in the creative process, would often claim their turn to be the ‘typist’ after some intervals. The following extracts illustrate the typical role distribution procedure that took place across the storybook sessions:

"How about this Lisa? I type and you tell me what to type"
"So you (^) make up the text."
"No…Lisa…help meee. You got to tell me what to write."
"Ok can I just type from there from now on?"

In the animation sessions, the creative process took place mainly as alternating sequences of Idea generation, Previewing the story (playing the animation), Assessment and Fixing (using tool functions, e.g. undo, timing, placement) (Figure 3). During the process of generating ideas, the children were more inclined to openly state what they were thinking of doing. They seemed to clearly have pre-formed ideas of what was going to happen next in their story, and offered their ‘plans’ both when asked and even without prompting. For example, one of the child saying “on this one (referring to a frame) he needs to say ‘Bye’” shows that she already had a picture of the story development in mind while creating the previous frame.

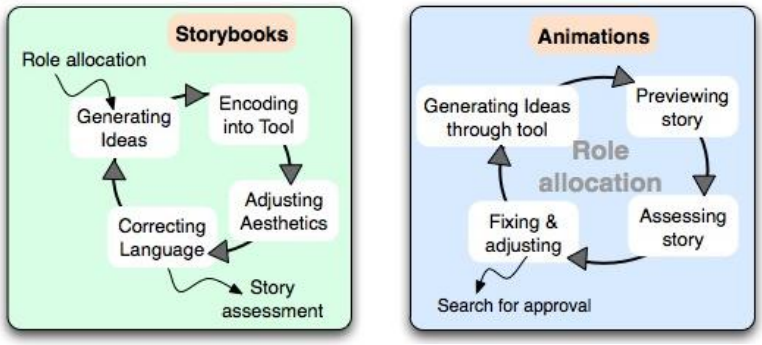

Figure 9. Stages of creative process for Storybooks (Left) and Animations (Right)

Children also started to preview their story much earlier in the process and much more frequently in the animation sessions, leading to what we call ‘micro-assessments’. Rather than a concrete assessment phase at the end of the session, assessment was done more as a step-by-step process of short evaluations for each subtask, e.g. image placement, object appearance,

sounds. The micro-assessments created more opportunities to generate consensus throughout the creation process. As compared to the storybook sessions, negotiation of roles in the animation sessions was similarly more integrated in the process. We identified four main strategies that the children adopted to distribute work: by frame (each child does one frame), by task (e.g. choosing the color, placing the images) or by skill (e.g. drawing, making sounds). For instance, even though it was not his 'turn' to work on the particular frame, a child interjected:

"Let me (^) do it, you're terrible (car honking sound)"

This flexibility in role negotiation and work distribution enabled all of the group members to stay active and interested throughout the sessions. It was also observed that children contested roles much more often than during the storybook sessions. An additional 'stage' was seen in the animation sessions in terms of the search for approval. Children were eager to 'show off' what they have created, and were clearly confident that they did a good job. They repeatedly asked the researcher, who stayed as an observer and to help with any software-related problems, or other teams to watch their story, as *"it's really good"*. Two of the children also asked their parents to see their stories as they were leaving.

Production of Interaction: Strategies of Creation

Five main themes were uncovered in the analysis of the children's creative process using the animated medium through the coding of recurrent instances and patterns.

A. Micro-Activities

The animation medium resulted in the story being told using micro-activities of creating different elements, e.g. sounds, objects. Even though they spent longer amounts of time on certain micro-activities (e.g. one group recorded a character script line four times to get it right in terms of loudness, clarity, speed, etc.), it was clear that the children still had a macro-view of the story as a whole. In contrast, in the storybook sessions the story was generated through the use of prompting questions. Questions such as *"What happens next?", "What do they do?" ,"What are we going to write about?"* served as breakpoint that constantly appeared throughout the session and that pushed for a series of ideas built around a central topic each time. It seemed that the story was developed by the children in an amorphous manner as they go along, fashioned 'by-the-seat-of-their-pants' at each breakpoint.

B. Activity-Driven Integrated Story Generation

Story creation occurred in terms of specification of actions within the interface and without. They responded to the multiple cues and modes of stimuli enabled by the animation tool to make sense of the story, for instance through *placement of elements*, the *choice of objects* to include, *characters' speech and sound effects*.

<u>*Object Placement:*</u> By placing and moving objects in the set-up of each story frame, the children molded the development of the story. For example, to tell the story that the main character is going out while the rest of the family is staying behind, the child verbalized her actions in the following

way: *"That guy needs to be way up. Those guys need to be right there."* Action-based story creation was hence often accompanied by extensive gesturing and pointing at the screen. Space and time became a kind of 'medium' where the children's imagination was materialized.

Choice of Objects: Searching for material to use in the story was done in two ways: the children either used existing images in the software library or drew their own objects. This search for objects, whether through library browsing or by deciding what to draw, became a focal point that led the children to make decisions on what to include in their story. It can be argued that the provision of ready-made 'sources of ideas' in the library is limiting to the child's imagination. For example, one of the groups saw the categories of items 'Animals' while browsing the library and decided to include a dog in their story. Hence, the categories may be said to 'limit' the possibilities the children considered. Contrariwise, library materials also served as epistemic prompts to scaffold individual and group creative activity. This is similar to the use of physical objects as inspirational devices to catalyst creative design (Heimdal & Rosenqvist, 2010; Jacucci & Wagner, 2007). In the same group of children, we observed a feedback loop whereby the library informed and modulated the creativity of the children. In that one group's story, the dog was made to save the falling green crayon.

Characters' Speech: The auditory mode of representation was found to be a key part of story construction. This, in itself, is unsurprising since it is difficult to carry the symbolic element of any narrative arc in animation alone. What was remarkable is that throughout the story creation process, the children did not explicitly (in speech) or directly (using straightforward words) discuss the overall arc of the story. In many instances across the animation sessions the children communicated story development through the process of creating sounds, from determining what to record, practicing the speech or sound effect to be recorded, recording the sound, to deciding where to place the sound:

> *"Ok wait, I wanna do a sound to that. He might be saying like "woah this suitcase is so heavy"*

> *A: Wait let me practice. (dog sounds) Like that? (dog sounds) which one?*
> *B: Big dog voice*

In this way, the animation storytellers seem to be thinking through the tool. This is different from the storybook children who wrote 'on the fly' (without an overall narrative sketch), but did so in spurts where they formulated what to do next, and then proceeded to encode it by typing into the 'storybook'. The children even acted out sounds made by characters in the storybook sessions, but this remained as part of the idea generation process we identified earlier. The children had no way to include the sounds directly into the storybook, and the fundamental authoring loop of *Idea generation – Encoding with tool – Aesthetics – Correction* remained intact. The extract below of a child explaining to her partner that the story's main characters heard a singing voice in the storybook session is a clear example:

> *"So they're hearing this: Do you want to plaaayy" (singing)*

C. Qualitative Focus

Development of the story manifested itself with a focus on precise, qualitative details through the shaping of aesthetics (e.g. color, speed, size, thickness). This motivated the children to think of how the different objects in their story world look like qualitatively, for instance, discussing whether the book in the story should be rectangular or square, determining book size and color, or the type of dog. Yet, manipulating aesthetic details at times did cause the process to be longer. One group spent a significant amount of time determining what was to be shown on the book cover, even though the book was not a major element in their story. They went from depictions of Jack and Jill, to the Three Little Pigs, with suggestions about the Three Musketeers and simple scribbles. Nevertheless, comparatively, spending time adjusting aesthetics in the creation of the storybook story was time lost on manipulating the tool (e.g. font size and spaces), whereas adjusting aesthetics in the creation of the animation was meaningful to the story itself, acting as means to induce the children to define or take decisions on certain story details.

Moreover, the focus on qualitative details made for much shorter stories with the animated medium, but richer in texture. If the stories were to be converted in text based on the details that the children paid attention to in their creative process using animation, they would be much more vivid stories than the storybook stories they wrote. Skilled adult writers have the necessary fluency (in the common sense of the term) to portray a story with expressive imagery using the written language. At 4th grade, children do not possess the sophistication in the written text yet, but the animated medium provides them with a 'language' that enables them to create similarly rich stories.

D. Consistent Imagination

The visual nature of the animation medium seemed to have the capability of serving as a stimulus for retention and to broaden the imagination of the child with respect to the story world. In the interviews conducted after the sessions, there was a large difference in the fidelity with which the children who did the storybooks could retell their story as compared to those who did the animations. The first group could retell their story with an accuracy of 41.8% (based on the number of propositions covered in the retelling over the total number of propositions in the 'narrative digest' of the story), whereas the second group did so with an accuracy of 63.3%. In fact, two of the children could not remember any of the propositions at all when asked to recount their storybook stories, while two others recounted their animation stories with a full coverage of all the propositions.

E. Serendipitous Creativity

The activity-based nature of the creation process with the animation medium led to idea generation by accident at various times, a strategy that was not present in the storybook authoring. This finding was also observed by Eales (2005) when she studied the ad hoc creative process of a professional artist using digital software to produce her works of art. In the creative process of the artist, the computer "often introduces unexpected or accidental effects and elements, generally helping to create the compositional problem". While one group using the animation software was

trying to draw a cupboard, they accidentally created a brown shape that they then imagined to be a shelf. The following conversation shows this serendipitous creativity:

> *A: Oh...how did that (^) happen?*
> *B: Ooh that's good actually*
> *A. That's good yea…it's like a shelf*
> *B: Shadow. The shelf on it.*
> *A: Yea we've got a shadow with the shelf. We can move the suitcase up there so he can be reaching down there*

F. Story Generation

Using the coding process based on the concepts of divergence and convergence as explained above, we found that more seeding (difference of 22.13%) occurred in the storybook sessions than in the animation ones, indicating that somewhat more ideas were put forward during the creation of the storybooks. However using the animated medium, the degree of both divergence (difference of 14.8%) and convergence (difference of 7.32%) of ideas was greater (Figure 10). These results may be explained by the five themes that we have described above. For example, low seeding may have been caused by the constraints imposed by the software, such as the search for objects in the library. The activity-driven property of the creative process may have on the other hand encouraged greater divergence and convergence by providing more discussion and decision points.

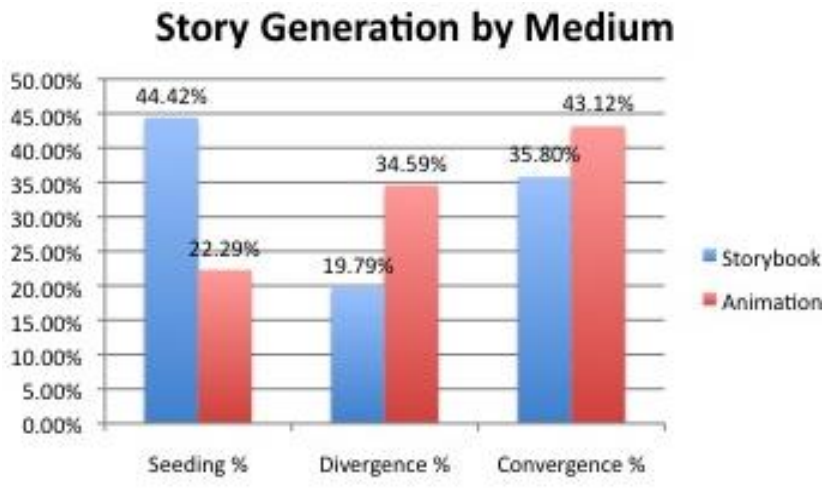

Figure 10. Seeding, divergence and convergence by medium of creation

Attitudes and Perceptions

B. A. Hennessey (2007) describes motivation as one of the key factors in creative behavior that needs attention. In fact, it is of even greater importance if we are to sustain creativity over an extended period of time throughout the Fourth-Grade Slump. Amabile's (1982) "principle of internal

motivation for creativity" states that internal motivation like satisfaction and interest leads to the creative process, but external stimuli such as expectations and the offering of rewards hinder it. We thus need to look at children's reactions to the use of animation for creative activity. A number of observations provide support for us to posit that story authoring using animation was more motivating for the children. The storybook sessions, which lasted on average 28 minutes (153 speaker turns), were much shorter than the animation sessions, which took an average of 48 minutes (417 speaker turns). The children became bored and restless quickly when making the storybooks, as we observed and as illustrated by the extract below from one of the group's conversation:

"That's all we have to do. We just have to write a middle and an end."

"Hurry let's write the story so we can get outside"

Children in the animation sessions conversely showed excitement and enthusiasm, gesturing, acting out, and were eager to present their story to others. Two children in fact explicitly remarked to their group during the sessions:

A: This is fun
B: I know

A: Kyra isn't this fun?
B: Yea…

The groups doing the animated stories wanted to keep going even when they were being picked up at the end of their after-school period. Several students requested that the researchers return another day to let them finish their stories.

Creative Products

The average rating given by the three teachers on Novelty (consisting of the dimensions of creativity and novelty) was slightly higher for the animated stories (μ = 3.72) than for the storybooks (μ = 3.56). For the Quality component (continuity, coherence, completion), the teachers rated the storybooks (μ = 4.44) higher than the animation stories (μ = 3.96). However, it should be emphasized that children were given the same amount of time to create the stories in both the animation and storybook sessions, and typically the animated medium by nature requires a longer commitment of time to create. We reiterate here our point that our focus in this study was about the process of creativity rather than the outcome. We believe that it is difficult to draw conclusions, although interesting, from mere assessments of finished products.

The creative process is complex. We recognize that other factors such as group dynamics and gender may have had an effect on the processes and strategies during the authoring sessions. It is however out of the scope of this study to analyze the role of social influences in the mediated creative process.

V.6 Summary of Phase I Exploration

The study that we conducted to explore how the mediation effects of the animated medium of creation can be summarized as having produced the following understanding:

1. How does storytelling with animation qualitatively change children's creative process?
   - Using the animation medium, children create stories using *micro-activities* (e.g. creating sounds/objects one at a time) while still maintaining a macro-view of the story as a whole. In contrast, the storybook story was generated through the use of prompting questions that pushed a series of ideas to advance the story amorphously.
   - Using the animated medium, story creation occurred in terms of action specifications both within the interface and without. We observed how the children use *body enactment* to express, catalyze and enrich ideas in their animated stories. For instance, describing a dog as the character in her story, a child would say: "It barks like this: Woof, woof!" and enacts the 'big dog' bark. The use of enactment was characteristic of a 'flow of creativity', a state whereby the child was unhindered by technical limitations or need for formalization of ideas (e.g., in textual form).
   - *Playful exploration*, that seemed to enable better use of serendipitous ideas, was prominent in the animation authoring sessions, as compared to a more 'formal' brainstorming phase in the textual story authoring process.
2. How do children perceive storytelling with animation?
   - High *motivation*, excitement and engagement were evident as the children pressed for others to see their animations.
3. Do children produce more creative stories with animation?
   - Animated story development manifested itself with a focus on precise, qualitative details through the shaping of aesthetics (e.g. color, size, thickness). This made for stories that are *richer in texture*.
   - The children using the animated medium exhibited *'broader imagination'* of their story world beyond what they actually expressed in the animated product. They retold the stories they created with much higher fidelity, and were able to orally expand on their story world.

V.7 The Concept of Micro-Enactment

The particularities of children making use of *micro-activities* and *body enactment* as strategies of story creation were harnessed as an approach to supporting the child's creativity during storytelling, called *micro-enactment*. The concept of *micro-enactment* can be defined as *the use of embodied enactment (body-based or through the use of physical objects) to create story fragments (e.g. a scene, an action, a dialogue, etc.) that support the larger view of a story.* Several others have observed that enactment is an integral part of children's storytelling process. S. Wright (2007) described how children engage in meaning-making through embodiment and narration in a

study with 108 five- to eight-year-old children. In her study, children were asked to draw 'what the future will be like' and then tell their story to the interviewer. She notes the children's prominent use of "dramatization, expressive sound effects, gesture and movement" to "bring their stories to life". Theune, Linssen, and Alofs (2013) recounted that, during the use of their touch table-based storytelling system, *"the children did speak in character to express story elements that were not available in the system, such as certain character emotions (Oooh, I'm scared!) and goals (Especially for you, Red! when baking a cake). In-character communication also frequently involved miming character actions such as shuffling, diving and eating, and expressing the characters' emotions through sounds and facial expressions."* In testing the 'K-Sketch' application for general purpose 2D animation scenarios, Davis et al. (2008) reported that "*Animator 3 taught animation classes for children and said that our demonstration-based approach matched very closely with children's intuition. Her students frequently "act out" the actions of characters in front of the camera."* Similarly, with regard to the Prochinima system where children can project animations on any surfaces and record them with a camera, Åkerman and Puikkonen (2011) stated that *"The third remarkable thing was the amount of acting. The pre-tests showed that this was a valid option, but still the main tests included more live acting than we thought. Moreover, the acting happened very naturally. It seemed to be easy for them to take the role of an actor and interact with the projection."*

V.8 Children's Pretend Play as Correlate

The informal counterpart of our concept of micro-enactment can be conceived as pretend play that children engage in routinely and enthusiastically. In pretend play, children's ideas are more freely expressed through the use of their bodies and voices to act out ideas. Pretend play (sometimes also called make-believe, imaginative play, or story enactment) has been shown to be beneficial not only more generally as a 'zone of proximal development' (L. S. Vygotsky, 1978) for the development of cognitive skills such as problem-solving, but also more specifically for the budding literacy and storytelling skills. Comparing the recall of narrative structures after 4- and 5-year-old children engaged in conditions where they either pretend play enacted stories or only listened to stories, S.-Y. Kim (1999) found that over short time periods, pretend play can facilitate narrative recall and expression.

Many different theories have been advanced for the benefits of pretend play to storytelling (Wendy K. Mages, 2006). These include the *contextualization hypothesis* (Ageliki Nicolopoulou, Blum-Kulka, & Snow, 2002; Peterson & McCabe, 1994): Enactment/pretend play enables the child to formulate her ideas within a contextualized instance before moving to the decontextualized language required in expressive writing; the *imagery hypothesis* (D. Singer & Singer, 1990; Wagner & Barnett, 1998): Enactment/pretend play facilitates the creation of 'mental pictures', "children who play at make-believe may be attempting to construct sights, sounds, smells, textures, and tastes as part of their games and in this way may actually be practicing and sharpening their capacity for

imagery"; and the *explicit language hypothesis* (Pellegrini, 1985): The directed nature of the situation during pretend play helps children to understand that their communication needs to be explicit and specific.

According to Lillard (1993), the necessary and sufficient components for pretend play to take place include: *1) A pretender* (i.e., the child) ; *2) A reality* – the real world in which we are constantly immersed (i.e., the bounded space within which the pretend play takes place); *3) A mental representation that is different from reality* (i.e., the idea of a story character, or of a non-visually present story object); *4) A layering of the representation over the reality, such that they exist within the same space and time* (i.e., the child imagining herself as the story character, the child projecting on a visually-present object); *5) Awareness of the pretender of components 2, 3, 4*. These components are integrated for use in pretend play across three subparts:

Character Play

The child takes on the role of someone who she is not. Pretend play by children is a key contributor to the development of what cognitive psychologists call the 'theory of mind', the human ability to "explain people's behavior in terms of their thoughts, feelings, beliefs, and desires" (Zunshine, 2006). Being able to associate and interpret observed behavior with underlying mental states is essential for character playing. Theory of mind has also been related to perspective-taking.

Object Substitution

The child imagines an object to be something else (e.g., a stick becomes a horse). Much imaginary object substitution involves 'projection', defined by Kirsh (2009) as "augmenting the observed thing, of projecting onto it".

Fantasy Worlds

The child imagines a surrounding environment that is not present. The creation of mental imagery that specifies an ambient 'world' is akin to what we call the ability for 'broader imagination.

V.9 From Pretend Play to Drama Interventions

The hypothesized benefits of pretend play have led to various attempts to use drama education to support the child's development. Creative or educational drama can be defined as "an improvisational, nonexhibitional, process-centered form of drama in which participants are guided by a leader to imagine, enact, and reflect upon human experiences" (McCaslin & Schonmann, 2006). This stands as contrary to theatre, which is "audience and product centered" (Kratochvil, 2006). Many studies have touted the positive effects of drama interventions on social, physical, emotional, cognitive and language development. For instance, Kosidoy (1989) performed a study on social skills, comparing the use of creative drama with a group of 17 1st to 6th grade children participating in a 10-week program, with a control group who did not undergo any intervention. The children in the drama program self-reported as being more confident in conflict situations than the control group. Fizzano (1999) studied 6 classes of 3rd graders split into 3 conditions (2 classes undergoing traditional reading, 2 teacher-directed drama, 2 student-led drama of selected

folktales). Both drama groups performed better on a reading comprehension test, and showed greater complexity in oral language. Investigating creative drama as a prewriting strategy of short story writing, Cormack (2003) tracked 2 grade 6/7 classes for a period of 10 weeks. Drama students received progressively better composition scores (ideas, detail, audience awareness, sentence structure, language style, plot, setting, character, and narration/dialogue) than a control group, and showed and greater enthusiasm about prewriting. Last but not least, P. R. Wright (2006) administered an in-school role play-based drama program in rural villages with 123 children, mean age of 11.5. His results showed improvements in the children's role-taking ability, vocabulary and self-concept at the end of the program.

Amidst such positive evidence however, many review, meta-analysis and survey articles have cautioned against drawing too strong conclusions from the plethora of optimistic drama studies. In a quantitative meta-analysis of 16 studies, Kardash and Wright (1987) provided a more nuanced picture, finding extremely small effect sizes for reading achievement, and large effect sizes for roletaking abilities. However, their analysis showed that the effect sizes varied tremendously based on factors such as the type of measurements used, sample sizes, and experimental designs. Wagner (1988) reviewed "methodologically sound" studies on the effects of drama interventions on language arts (oral language development, reading, and writing), and concluded that quantitative studies generally show positive effects, except for a few studies. However, the author deplored the lack of qualitative research on the topic to contribute to our understanding of how the effects actually take place. Kratochvil (2006) did a review of meta-analyses collating research on the use of educational drama to support English language learners, and concluded that although the field's research generally shows positive connections between drama and literacy, "the research is narrow and inconsistent; too inconsistent for decision makers to institute policy changes or to implement changes in teaching practice and strategies".

Jindal-Snape and Vettraino (2007) reviewed papers from the year 1990 to 2005 on drama techniques to support social-emotional development of people with special needs, and found only 8 relevant studies. The findings indicate a potential for positive effects, but Jindal-Snape and Vettraino cautioned that "the authors have not provided enough evidence to substantiate their claims". Similarly, Şengün's and İskenderoğlua's (2010) content analysis of 17 articles on the use of creative drama in mathematics education showed that studies generally result in positive effects on student achievement, attitude and creativity. But the authors concluded that "there were not enough creative drama studies in mathematics education". Conversely, Conard and Asher (2010) conducted a meta-analysis that included 13 experimental or quasi-experimental studies using creative drama as teaching strategy, and found no effect on the self-concept of elementary school children under a variety of conditions.

Apart from Conard's and Asher's meta-analysis, other individual studies have found little to no significant effect from drama interventions. For instance, Freeman's studies (Freeman, 2000;

Freeman, Sullivan, & Fulton, 2003) that subjected 237 3rd to 4th grade students to either a treatment group using creative drama, or to a control group engaging in standard music activities, over 18 weeks found that effects of creative drama were not significant for self-concept, behavior, or social skills. Some positive gains were identified, but no significant results were obtained. W. K. Mages (2008) studied the effects of a theater-in-education curriculum program on the language, Theory of Mind, and imaginative development of 155 preschool children. No significant differences overall were obtained between the intervention and the control group. Measures were taken at two points in time: on the first measurement, native English speakers outperformed English Language Learners. By the second measurement however, no difference between the two groups was detected.

Although there appears to be much evidence that drama positively affects various aspects of the child's development, the literature is highly mixed and conflicted. A possible reason for negative results may be that unlike pretend play, which occurs within the boundaries of rules that children themselves make and private spheres that they themselves choose, drama places the focus on overt performance, leading indubitably to greater self-consciousness, and thus compromising the hoped-for benefits of the embodied process for some children. While the possible positive effects of drama interventions support our proposed approach of micro-enactment to support children's creativity, the conflicted results open up an opportunity to improve upon such methods.

CHAPTER VI
PHASE II: DESIGN *

VI.1 Design Research Questions

Phase II of our research seeks to translate the findings of the Phase I Exploration into a testable system that may be used to test the approach that we advocate. From our 'medium effects' study in Phase I, we defined the concept of micro-enactment as overt story gestures that the child performs to support her thinking of a story idea. Our warrant for the concept is grounded in theories of children's pretend play. Phase II Design asked the following research questions:

1. What physical and digital design affordances are required to frame the concept of micro-enactment?
2. How may the concept of micro-enactment be faithfully embodied in a testable system?

The following sections describe the (theoretical) concept of micro-enactment, and how it is translated into the design concept of performative authoring, present two studies that we conducted to elicit design affordances, and describe a design methodology that we developed to guide the design of research prototypes. This chapter wraps up by describing the DiME system that was developed for this research, and reports on a pilot and usability study that was conducted to test the system.

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"Finding-NEVO: Toward Radical Design in HCI." by Chu, S., Quek, F., Wang, Y. and Hartson, R., 2013. In *Proceedings of INTERACT '13.* Cape Town: South Africa. Copyright 2015 from IFIP-Springer LNCS;
"Ready...Action! A Performative Authoring System for Children to Create Animated Stories" by Chu, S., Quek, F. and Sridharamurthy, K., 2014. In *the 11th Advances in Computer Entertainment Technology Conference (ACE '14).* Madeira, Portugal. Copyright 2015 from Springer; and
"Exploring Performative Authoring as a Story Creation Approach for Children" by Chu, S. and Quek, F., 2014. In *International Conference on Interactive Digital Storytelling (ICIDS '14).* Singapore, Singapore. Copyright 2015 from Springer.

VI.2 The Design Concept of Performative Authoring

Micro-enactment has as its naturally-occurring phenomenon the concept of pretend play. We therefore used theories of pretend play to evolve micro-enactment into a design concept. As we described in Section V.8, pretend play consists of 5 main parts: a pretender, a reality, a mental representation that is different from reality, a layering of the representation over reality, and awareness of the pretender. In pretend play thus, the child has to simultaneously engage with the *physical reality* in which she is acting, and her own *mental representation*. However to make use of pretend play to author digital stories, an additional layer of representations is required: the *digital representation* of the story being created. The layering of these elements is at the core of our design approach of performative authoring. Figure 11 illustrates this conceptually. In a sense, performative authoring harnesses the power of pretend play, and aims to support it through digital technologies by augmenting its strengths and potentially countering its weaknesses – a *digitally-augmented enactment-based* approach to storytelling.

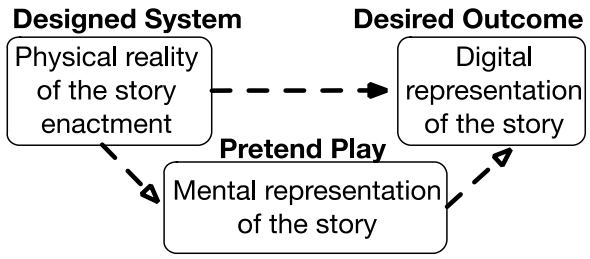

Figure 11. Conceptual diagram of performative authoring

The end goal of performative authoring is to produce stories in a digital form, which can be text-based, graphics-based, animation, or multimodal in nature. The environmental structures extant during performative authoring are critical, as they shape the reality of the child while she engages in the creation of stories. Within this setup, performative authoring asks the child to overtly enact her imagination of character roles and to imagine object props and surrounding worlds. Practically therefore, a system based on performative authoring needs to consist at the minimum of:

- **i.** A setup that enables a child to create a digital story through pretend play/enactment;
- **ii.** Structures that support a child's imagination or mental representations as she enacts;
- **iii.** A way for the child to view and edit her digital story.

Based on the background and theoretical foundations that we set out in the previous chapters, we posit that the performative approach may facilitate children's creative storytelling process by three potential mechanisms:

- *Performative authoring makes use of embodied processes that, like in pretend play, facilitate the composition of ideas into coherent story pieces, allowing the child to move her ideas closer to a writing-ready form.*

Many different theories have been advanced to explain the benefits of pretend play to storytelling (Wendy K. Mages, 2006). These include the *contextualization hypothesis* (Ageliki Nicolopoulou et al., 2002; Peterson & McCabe, 1994): Enactment enables the child to formulate her ideas within a contextualized instance before moving to the decontextualized language required in expressive writing; the *imagery hypothesis* (D. Singer & Singer, 1990; Wagner & Barnett, 1998): Enactment facilitates the creation of 'mental pictures', "children who play at make-believe may be attempting to construct sights, sounds, smells, textures, and tastes as part of their games and in this way may actually be practicing and sharpening their capacity for imagery"; and the *explicit language hypothesis* (Pellegrini, 1985): The directed nature of the situation during enactment helps children to understand that their communication needs to be explicit and specific. Performative authoring would allow a child not only to bring to life her imagined scenes through enactments, but also to build on her own enactments (reflected through a virtual avatar) to broaden her imagination of the scenes and of her story. The child is able to focus on actualizing her ideas instead of on the rules and peculiarities of language. She is able to characterize her ideas with subtleties and nuances that she is able to imagine but may not have the competence to express yet, adding richness and texture to her story (e.g. complex gestures of wings flapping vs writing "the bird is flying").

- *Performative authoring produces concrete, external representations of ideas in the form of animated cartoon stories, a form that the child is interested to engage in and is motivated to use for storytelling.*

Non-technological approaches such as pretend play and drama performance lack the immediate feedback that is essential to our thinking and sensemaking. There is no obvious or concrete product that can be immediately reviewed stemming from either pretend play or drama. A play may be recorded for the child to review afterwards, but the asynchronicity in feedback reduces the effectiveness and usefulness of review. Echoing theories of distributed cognition (Hollan et al., 2000), Kirsh (Kirsh, 2013) makes a poignant case that human cognition relies tremendously on external representations to anchor and catalyze thought and ideas. In fact, he states that if our interaction with external representations is not critical, then "Why not just sit still and 'think'?". With performative authoring, the embodied nature of idea generation facilitates recombination of ideas into whole units, and given children's keen interest in media (Ofcom, 2012), children are motivated to not only actualize their ideas but also review their animated cartoon videos. These cartoon videos

may even function as the intermediate 'writing-ready' form of the story writing process, that is so fundamental in the school curriculum. Children can reference their cartoons as they produce their formal written text, while focusing on the mechanics of language. This is illustrated in Figure 12 using our model of the creative process described in Section III.2.

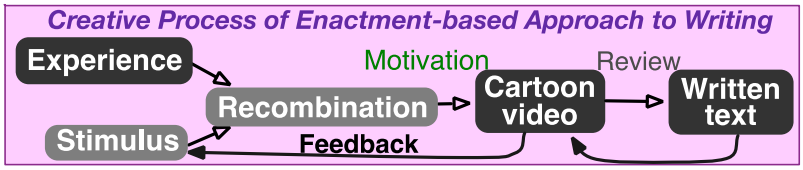

Figure 12. Performative authoring approach to creative storytelling

- *Performative authoring inspires greater self-efficacy in the child to be able to create a valuable story.*

We described the four main determinants of self-efficacy (A. Bandura, 1989) in Section III.3: performance mastery; vicarious experience; verbal persuasion; and physiological state. Using this framework, children may feel more self-efficacious using performative authoring since using body enactment, they are able to complete the storytelling task smoothly (*optimized performance mastery*). Since they can produce story animations more fluently, the stories that they produce may be of greater quality, and they may thus recognize that the quality of their stories is better (*optimized vicarious experience*). They may receive greater compliments on their stories (*optimized verbal persuasion*). Their overall experience of storytelling leads to a fun experience (*positive affective arousal*).

A system embodying the performative authoring specifications that we set out above could be designed in a myriad of ways. Romero et al. (2007) advanced the idea for a very similar system, which uses embodied authoring of animation scenes for teaching computational concepts (e.g., abstraction and modules). They proposed a system design whereby the user, wearing paper markers, records movements via a webcam on a 'magic mirror'. Although they provide neither empirical evidence for their concept, nor a concrete system, their system concept provides added support to the idea of performative authoring. In the next section, we describe two studies that provided guidance for system features specifications.

VI.3 Designing Physical Objects for Enacted Storytelling

The Child's Creativity and Physicality

In HCI, many have advanced the importance of physicality, tangibility and/or embodiment for systems geared towards education, insight formation and problem solving. Psycholinguistic studies have also shown that body gesturing leads to better speech recall (Cook, Yip, & Goldin-Meadow, 2010). With respect to children, much research in tangible interaction can be found on pen-based and touch interaction, and the effects of particular designed systems on learning in particular. Few recent works have sought to understand the effects of physicality and embodiment on the creativity of children, let alone imagination that is the basis of creativity.

Among the relevant ones that address physicality, embodiment and imagination in some way, A. N. Antle, Droumeva, and Ha (2009) compared 7 to 10 year-old children solving jigsaw puzzles in three conditions: a traditional cardboard puzzle, a mouse-based graphical user interface (GUI) puzzle and a tangible user interface (TUI) tabletop puzzle. They concluded that "direct handling of objects supports children to mentally solve the task through iterations of exploratory and direct placement actions" by observing interaction patterns and measuring time to completion. With the goal of informing the design of tangible environments that support 'reasoned imagination', A. N. Antle, Corness, et al. (2009) generated a list of design knowledge (e.g. "most conceptual systems are understood through several embodied metaphors") from three design projects. The distinction of their work is that they looked at imagination in a sense that is closer to reasoning or to a user's understanding of a designer's intended schema.

Literature that more directly relates to the investigation of the effects of physicality on imagination is mostly dated and typically deal with toddlers aged 2 to 5 years old, with theoretical underpinnings such as Piaget's (1962) theory of symbolic play, Vygotsky's (2004) theory of the child's imagination, El'Konin's (1966) work on pretend play, and De Saussure's semiotic theory of signs. In a study on how the structure of play objects affects imaginative play in 3½ to 5 year-olds, for example, McLoyd (1983) found that high structure objects significantly generated more pretend play themes. High structure objects are miniature version of objects whose "identity and functions … most preschoolers are aware of" (e.g. dolls, trucks). Low-structure objects were objects that were "less specific and unique" at least for preschoolers (e.g. boxes, pipes).

In a controlled experiment, Elder and Pederson (1978) compared how children aged 2½, 3, and 3½ performed the same action with objects grouped as Similar or Dissimilar to particular objects, or with no object at all. The children's pretend performances were scored for recognizability of the action sequence using the substitute object. Their results showed that while 2½-year-old children performed significantly less well in the Dissimilar condition as compared to the Similar condition, the 3-year olds performed equally well across all conditions. Pederson, Rook-Green, and Elder (1981) conducted another experiment similar to Elder & Pederson's with children of the same age group performing the same actions with substitute objects differing in form and function

classified as ‘ambiguous’, ‘unlikely to elicit a response’, and ‘highly likely to elicit a response’. They found again that physical similarity of the object guided actions for younger children. Studying the behaviors of 5-year old children with interactive toys (an interactive duck toy was used), Smirnova (2011) concluded that the ‘openness of the image’, “its capacity to accept various experiences and emotions and to perform various actions in the child’s hands” can turn an object into an effective ‘play tool’. A common theme in this and other (e.g. (Kritt, 2001; Sutton‐Smith, 1992) studies is that objects can function as tools for psychological development with immediate effects on children’s behaviors. Furthermore an object can support a child’s imagination effectively when it can help the child to move “from action in response to objects present in the perceptual field to action generated and controlled by ideas” (Pederson et al., 1981).

We are interested to probe whether the differing physicality of objects continues to guide imaginative behavior later in childhood, specifically for our target age of 8 to 10 years old. Imaginative play in which the child acts out roles and speaks aloud has been shown to decline at ages 6 or 7, as the child increasingly internalizes such play into “private mental activity”. Nevertheless, pretend play does continue to occur in 8 to 9-year olds, becoming evident especially in group play (D. G. Singer & Singer, 2005). Even in adolescent children and adults, physical objects/toys can elicit imaginative enactment (a form of pretend play). We highlight here that we look at ‘broader imagination’, which may or may not be facilitated by the object, instead of simply imaginary object substitution as previous studies have done. L.S. Vygotsky (2004) suggests that cognitive mechanisms learnt in childhood are constantly used and built upon in adulthood. It is highly likely that in later childhood, we make use of physical affordances of objects to support imagination instead of being hindered by them.

Physicality and Enacted Storytelling Study

A. Study Design

We conducted a study to investigate the effects of the following on the child’s imagination in the context of storytelling, with a focus on the first: (i) Objects of varying specificity, that we refer to as *object types*; (ii) The use of objects as compared to just the body without objects, that we refer to as *enactment conditions*; and (iii) The type of stimulus used as story prompt, that we refer to as *visual conditions.*

We conducted a semi-experimental 2 (Visual condition) × 2 (Enactment condition) × 3 (Object type) × 3 (Object) mixed design study (illustrated in Figure 13). Participants were allocated to one of two visual conditions (between-subjects factor): *graphical slides* (child watches a slideshow illustrating the stimulus story graphically) or *narrative video telling* (child watches a video of a narrator telling the stimulus story). The audio tracks are identical for both conditions. Two enactment conditions were tested as another between-subjects factor: *body-based* (the child acts without using any object) or *object-based* (the child acts with physical objects). Within the object-based condition, the type of object used was manipulated at three levels as a within-subjects factor

based on different degree of fidelity to the object referent: *Cultural*, *Physical* and *Arbitrary* object. The cultural objects had visual resemblance and the same manipulative affordances as their real-life referents. The physical objects had the same manipulative affordances but decreased visual resemblance. The arbitrary objects had little visual resemblance and minimum manipulative affordances. The children were asked to enact with three objects (within-subjects factor) in the context of a story: a *frying pan, pickaxe* and *lantern*. For maximum customizability, the objects, shown in Figure 14, were handmade.

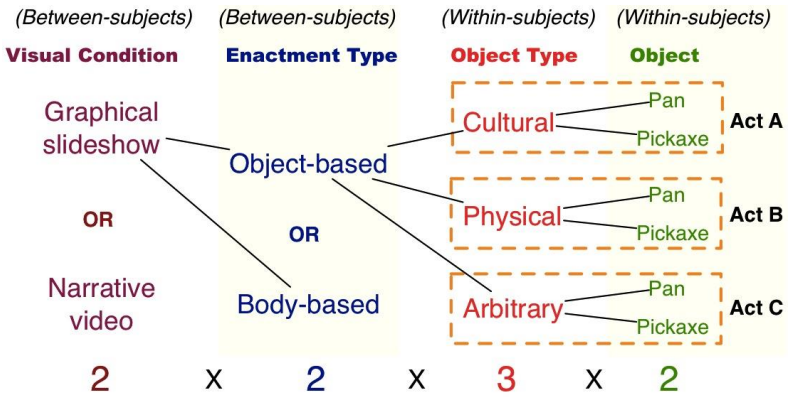

Figure 13. Phase IIa: Study design

Figure 14. Physical object affordances

To allow for the within-subjects design of objects and object types, we constructed the stimulus story to have three acts (one act for each object type. e.g., if Act 1 is designed as being for cultural objects, all objects (frying pan, pickaxe and lantern) of cultural object type would be

used in that act. Act 2 would be for physical or arbitrary objects, and the final object type would be for Act 3). The order of object types was randomized. The story tells about three dwarves setting out into the caves to collect mushrooms to help their city that will soon be attacked by an ancient enemy. Three actions of the dwarves (cooking, digging and using the lantern) were repeated in each act. Care was taken in the authoring of the story to make the story context of the actions as similar as possible across the three acts without being too repetitive.

To convey the story to the children in the slideshow condition, graphical illustrations for scenes in the story were created in cartoon style using Photoshop CS3. The story narration for children in the narrative video condition was recorded by an external performer reading the story script. Samples from the stimulus materials are shown in Figure 15. The three story acts were each around 5 to 7 minutes in length in both slideshow and narrative video formats.

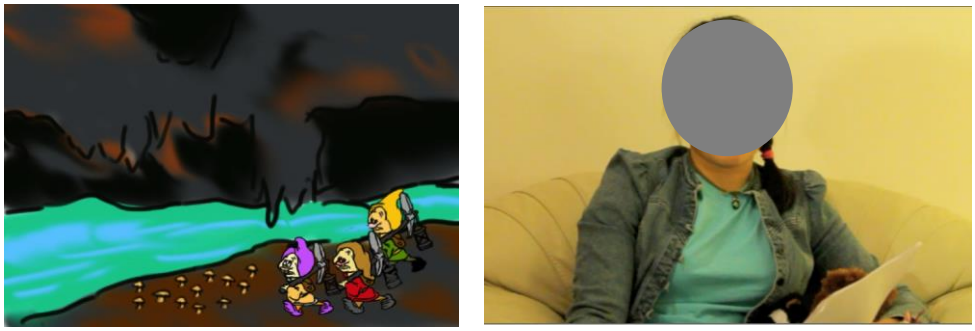

Figure 15. (Left) Sample story slide. (Right) Screenshot from narrative video.

At the point of the story when the dwarves performed the cooking, digging and lantern actions in each act, the story was stopped and an 'enactment prompt' slide was shown, asking the child to enact the story event that immediately preceded it with questions in the form of '[Dwarf's name] is frying/digging up/swinging the [target object]. Can you act out how he/she is using the frying pan/pickaxe/lantern?'

B. Study Description

The study was held at an elementary school with 12 children from a 4th grade class over 4 days. Two additional children were recruited separately for the study, making a total of 14 participants (8 girls and 6 boys), all aged nine except for one aged 10. A packet consisting of a con- sent form, an information sheet and a personality questionnaire (the Big-Five Inventory-10 scale [35]) was sent to the parents via the teacher a week before the study started. The teacher was also asked to complete a questionnaire to assess (on 7-point Likert scales) the engagement,

realism and imaginativeness of the typical performance of each of the child participants in day-to-day class activities.

For the study, the children were paired randomly by the teacher. Two rooms near the classroom were set up with a laptop, a large 55" display, loudspeakers, floor mats, two video cameras and a voice recorder. Additionally, in each room two boxes were drawn on the floor to act as the 'enactment areas', with a camera on tripod facing each box so that two children standing in the boxes would face away from each other (see Figure 16 below).

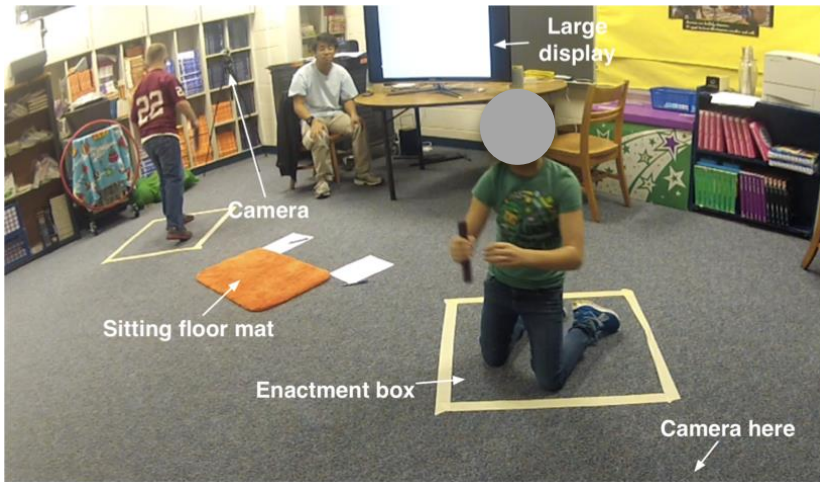

Figure 16. Physicality study room setup

On the first day of the study, an experimenter distributed a questionnaire to all the participants asking, on 7-point Likert scales, about their enjoyment of storytelling, their confidence to tell and to act out stories, and their frequency of telling stories. They were guided to fill the questionnaire as a group. Subsequently, one pair of children at a time was sent to each 'experiment room'. A trained experimenter in each room carried out the study, while a third experimenter acted as the 'runner' to fetch the children and ensure objects and materials were in place throughout. At the beginning of the study, the two children were briefed about the study and told that they will be listening to a story and acting out (or pretend play) parts of it with different objects. They were told that it was like filming their own movie. The study then proceeded as shown in Figure 17.

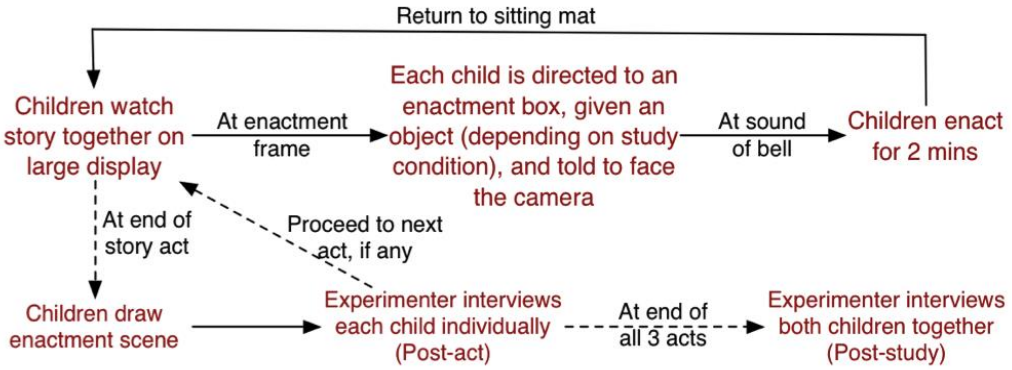

Figure 17. Physicality study procedures

For the enactments, the children were allowed to enact in any way they want and to use the objects as they desired. For the drawings, the children were asked to choose one of the scenes they just acted out and to draw it on a sheet of blank A4 paper. The post-act interview was semi-structured and asked the child the following questions: How did you use this object in the story? (if relevant); What were you thinking while you were acting out the [action]?; Did you think about [detail mentioned] just now or back then while acting? Follow-up questions based on their previous responses probed for indications of the depth and detail of their imagination. Enactments were video recorded and interviews were both video and audio recorded.

Although we were interested to see the effects of a non- graphical visual stimulus and a body-only enactment condition, our main focus was to study children using objects in story enactment. We therefore allocated the majority of the participants to the slideshow, object-based condition, and assigned a number of randomly selected children to the other variant conditions. Three of the children were allocated to a narrative video, object-based condition; four to a slideshow, body-based condition; and, one to a narrative video, body-based condition. For children in the object- based conditions, the order of the object type (cultural, physical, arbitrary) was randomly chosen.

Data Analysis

A. MAIA – Evaluating Children's Imagination during Story Enactment

We could not find a method for analyzing imagination from gestures that was suitable for our purpose in the literature. Loke, Larssen, Robertson, and Edwards (2007), Andrienko et al. (2011) and the Laban Movement Analysis framework for instance provide some indication as to how to analyze movement qualitatively but does not relate it to imagination in any way. Nemirovsky, Kelton, and Rhodehamel (2011) relate gestures to imagination using a method of analysis from psycholinguistics called microethnography, a "collection of techniques that focus on moment-to-moment bodily and situated activity". The enactments of our child participants however did not

include co-produced speech per se. We therefore devised a method of enactment analysis to elucidate the child's in-situ imagination called MAIA – Methodology for Assessing Imagination in Action.

The videos of the enactments were processed as described below. The collected video stream was cut up to isolate each enactment of each child. A child had nine enactment videos in total (3 objects: [pan, pickaxe, lantern] $\times$ 3 object types: [cultural, physical, arbitrary]) across the three acts. Two coders analyzed each enactment video separately identifying micro-actions and their timings and recording these in a spreadsheet. Micro-actions represent the objective actions that the child performs in the enactment and consist of any distinguishable action such as an overhead swing of the pickaxe, a flipping action, or a swing of the lantern with the pan. Disagreements were then resolved in discussion and a consolidated 'action description' of the enactment was produced. For each enactment, the micro-actions coded in the consolidated action description were collated to produce a 'repertoire of micro-actions' for that particular enactment. Acronyms such as Flipping (F) or Put in Pan (PiP) were used to represent the micro-actions.

The two coders then did an interpretive coding pass over the video combining the micro-actions into 'story vignettes', and conferring when disagreements occurred. The vignettes for each enactment were also collated into a 'repertoire of vignettes'. Vignettes represent the semantic interpretation of the set of micro-actions in the enactment: the story that the child is trying to tell. Attention was paid to body postures, facial expressions, gaze, pace, etc. when interpreting micro-actions into vignettes. Acronyms were also used for the vignettes, such as Fanning Fire (FNV) and Misflip & Catch (MFCV). A sample of part of the consolidated coding sheet is shown in Figure 18.

High-level Micro-Action description	Micro-Action Repertoire	Vignettes
Child's activity seems more rigorous than for Act 2 but same actions (HS and F). Eye gaze is hardly engaged throughout. Actions also seem more arbitrary, and not 'cooking-like' at certain points. Child switches pan from hand to hand. Whole thing is pretty homogeneous (7-72)	1. Horizontal Shaking Side to side (HSS); 2. Horizontal Shaking Linear (HSL); 3. Flipping (F)	**Summary: BCV** BCV Throughout with 2 kinds of HS: HSS & HSL. Begins with HSS and unlike Act 2, HS seem more dominant than Fs. (7-72)
Child is in kneeling position throughout but with a more relaxed feeling than in Act 1. At the beginning of the enactment, he glances over at the female subject across the room using the cultural object. She was 'adding condiments' to her pan (PiP). He seems to follow her action. Throughout the enactment, he adds condiments, shakes the pan (small motion side to side) (HSS) and repeats the cycle. He generally looks at the pan and the cooking activity he is doing. At about 1:30 he seems to get bored and disengages. At 1.56, he seems to do a single flip (F) after glancing at the girl again (she was doing large flips).	1. Put in Pan (PiP); 2. Horizontal Shaking Side to side (HSS) 3. Flipping (F)	**Summary: BCV, AIV** Child does BCV constantly with a lot of AIV. He does mostly SoF, adding a few subtle HSS at times and a single F toward the end. He adds ingredients throughout from both sides.

Figure 18. Sample of data analysis spreadsheet

We used the interviews and drawings as supporting data to elucidate the child's imagination during the enactments. All interviews relating thoughts of the child during the

enactment were transcribed with timecodes using InqScribe, and inserted into the spreadsheet along with the micro-actions repertoire and the vignettes repertoire. The two coders then read and coded the transcripts separately and then together, for four dimensions: the child's stated goal in the enactment (goal); the child's operationalization of the goal (schema); extra details that the child imagined (extended); and how consistent the child was during the interview in terms of intent, action and recall with regard to the enactment (consistency).

The drawings were coded by the two coders separately at first, and then in conjunction whenever disagreements arose, for three dimensions: the character, if any, in terms of his/her suggested action (character); the scene or environment and any other elements in it (scene); and how consistent the child was in his/her drawing with regard to the enactment and the interview (consistency). We highlight here that not all enactments had an associated drawing as the child was asked to draw only one of the two enactments he/she did during the previous act. The enactment videos were referenced again throughout the coding process whenever needed. Finally, each of the two coders gave an 'overall broader imagination score' (referred to as imagination score hereafter) for each enactment based on a gestalt view built from all of the child's enactment's micro-actions and vignettes, interview analysis and drawing observations (see Figure 19). Unmatched scores (only 10%) between the two coders were discussed and resolved into a score that both agreed was adequately representative. A sample of part of this analysis is shown in Figure 20.

The imagination scores, personality scores from the parents and the baseline performance scores from the teacher were entered into SPSS for statistical data analysis. A repeated measures two-way ANOVA was run with object type (3 levels) and object (2 levels) as within-subjects variables and visual condition as between-subjects factor. The openness scores from the personality questionnaire, the imaginativeness scores from the teacher questionnaire, and gender were used as covariates. Further, two between-subjects one-way ANOVAs were run with imagination scores as dependent variable and enactment condition as factor for the first, and visual condition as factor for the second, both with the same covariates.

Clustered barcharts were generated in a spreadsheet to illustrate the number of micro-actions and number of vignettes per object condition. This allowed us to analyze the enactments in greater detail. Other clustered barcharts were generated in SPSS for the imagination scores per child for each object separately. This allowed us to identify patterns in the ordering of the object types across participants. Personality scores from the BFI-10 were standardized and computed (according to Rammstedt and John (2007)) for each child on five dimensions: Agreeableness, Extraversion, Conscientiousness, Neuroticism and Openness. Scores from the teacher questionnaire were averaged into three dimensions: General engagement, Work realism, and Baseline imaginativeness.

B. Evaluating Storytelling Quality

After transcription of all interview recordings, each episode from both the stimulus story and the children's story tellings were converted into a list of core idea units, similar to a 'narrative digest' (L.M. Register & T.B. Henley, 1992). The narrative digest of each child's story telling was then compared to the digest of the stimulus story. The stimulus story was used as an objective baseline to enable comparisons across participants. Comparisons were made in terms of narrative coherence and richness.

Following the definition in A. Nicolopoulou (2008), narrative coherence was understood as the need for "both the parts of the story and the story as a whole [to] hang together in a convincing and satisfying way". It concerns assessing the centering of a story as well as the sequence of events narrated. Similar to Berman (1988) who devised a coding scheme for assessing the narrative structure of children's stories based on measurements such as the number of references to plot advancing events, the number of references to plot summations and the types of connectivity markers, we identified the different types of connectors in each child's story telling and totaled them up to obtain a coherence score. Words that significantly described causal (cause and effect), temporal (event sequence) and relationship (clear identification of character relationships or referents) linkages occurring between events were marked as connectors.

For richness, prior literature has proposed to assess story retellings through 'holistic grading', which functions on the premise that "the whole of any piece of writing is greater than the sum of its parts", and that one thus has to take into account the "total impression" of the text (Irwin & Mitchell, 1983). However, we found that this procedure did not fit our purpose. We wanted a more objective and consistent method that enables us to evaluate how much the child has fleshed out the narrative with relevant contextual information, in other words, the amount of details included in the telling. Borrowing from news narratives, which are often evaluated based on the 5Ws and 1H principle (Gupta, 2003), our analysis comprised of identifying how many idea units addressing the who, what, where, when, why and how are contained in the child's narrative digest of each episode. The outcome of this procedure (summing up the total number of idea units detailing the 5Ws+H per episode) was a score embodying the richness of the child's story telling. All codings were done by two independent coders who conferred upon disagreements.

The Coherence and Richness scores were normalized by the number of idea units in each episode of the stimulus story, subject to a maximum number of units per episode (to minimize penalty due to memory and time constraints for episodes of the story with too many idea units). An overall Story Quality (SQ) score was then generated by summing up the Coherence and Richness scores.

Study Findings

A. Participants

Descriptive statistics of the participants showed that our sample was very diverse with a wide range of personality characteristics, strenthening our external validity: the openness dimension from the parent's questionnaire had a SD of 1.68, the teacher's imaginativeness score had a SD of .94, the child's enjoyment of storytelling had a SD of 2.62. Imagination scores had an average SD of 1.60 across all object types.

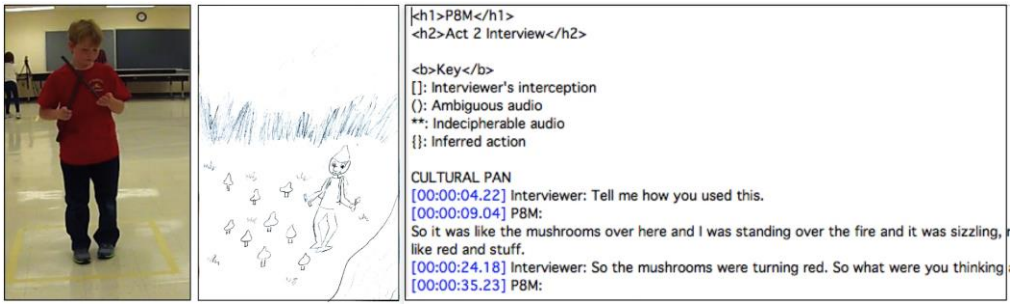

Figure 19. Sample of data sources: (Left) Enactment video. (Middle) Drawing. (Right) Interview transcription

Enactment Thoughts from Interview	Interview Coding	Drawing Coding	Imagination Score
[00:03:25.16] Interviewer: How about the third one? [00:03:27.14] P12F: The third one like trying to get rocks away with an axe. [00:03:34.17] Interviewer: How were you doing that? [00:03:36.27] P12F: You were like hammering down and then you would move it away. [00:03:43.28] Interviewer: You mean the rocks? What kind of rocks were you hitting? [00:03:45.18] P12F: Just old..debris pretty much. [00:03:53.20] Interviewer: What color were they? Did you think about.. [00:03:56.18] P12F: Black. [00:04:00.12] Interviewer: What were you thinking about? [00:04:07.22] P12F: The rocks and trying to get them away [00:04:13.12] Interviewer: And who were you acting as, when you were doing.. [00:04:16.12] P12F:	**Goal:** Get rocks away with axe **Schema**: Hammer down, Move rocks away **Extended:** Object of hit, Color of rocks, Acting as Berin **Consistency with Enactment:** Intent, Action, Recall - Yes (basically the same actions)	**General**: Two dwarves, one male holding a pickaxe and one female holding a lantern **Scene:** Scribblings represenging rocks around and two lines to signify a pathway **Consistency with Interview/enactment:** Not quite - Drawing does not show much action but shows more of surroundings imagined	6

Figure 20. Interview and drawing analysis

B. Enactments

Enactments were coded in terms of micro-actions (MAs), representing the diversity of the child's story operationalization, and vignettes, representing the complexity of the child's story construction. There were a total of 52 unique MAs and 20 unique vignettes across all participants and across all object types of the frying pan object, 47 MAs and 50 vignettes for the pickaxe object, and 48 MAs and 28 vignettes for the lantern. We classified the MAs into three types of actions: *Object actions*, encompassing any action that simulate the use of the frying pan (e.g. flipping, shaking, tossing), the pickaxe (e.g. chopping, stabbing) or the lantern (e.g. swinging, sweeping, flicking); *Body actions*, signifying actions that involve the use of one or more parts of the body (e.g. peeling, sprinkling, smelling of pan, kicking, wiping forehead, clearing with hand for pickaxe, simulating running); *Facial actions*, including expressions or other actions that involve parts of the face (e.g. chewing, making surprised look, making sound effects). Figure 21 shows the percentage distribution of the different types of actions within each of the body- and object-based conditions. Figure 21 also shows the proportion of the vignettes by complexity, where simple vignettes contain ony one MA per vignette and complex vignettes contain two or more MAs. This indicates the consistency and extension of the story pieces being enacted. Trendlines (dotted blue and red lines) have been overlaid on top of the charts to make the patterns clear.

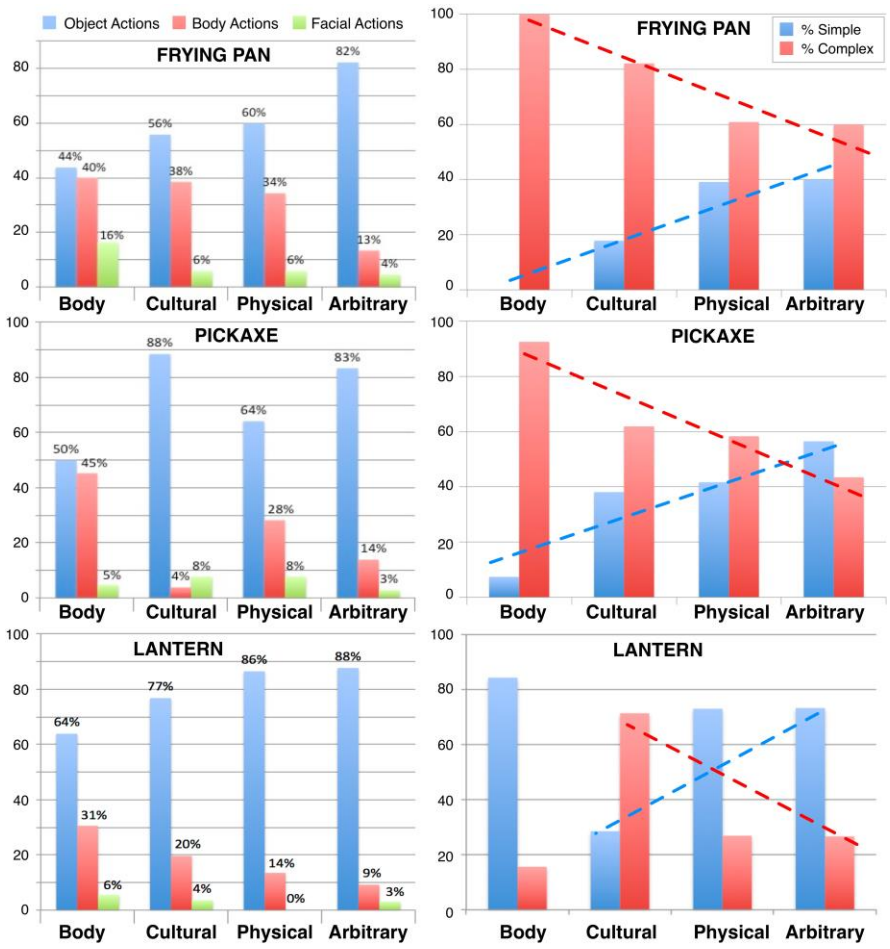

Figure 21. Distributions of micro-actions (Left) & vignettes (Right)

C. Object Types

We compared the use of objects of three differing set of characteristics in story enactment on the child's imagination. The two-way repeated measures analysis of variance test on scores of imagination yielded a significant interaction effect of *Object* × *Object type,* $F_{(4, 20)} = 3.23$, $p < .05$, partial $\eta^2 = .392$ (see Figure 22). The anomaly of the 'cultural frying pan' may be explained if the data is separated by gender. This is shown in Figure 23 (actual OBIS scores) and Table 6 (OBIS score patterns). The high OBIS score for the 'cultural frying pan' was mainly caused by females. The 'frying pan' object aside thus, a pattern can be identified for each gender: Arbitrary – Physical – Cultural for males, and Physical – Arbitrary – Cultural for females. The picture however is even more complicated than this. Our following analysis studied the OBIS scores with respect to the pattern of object types for each individual child.

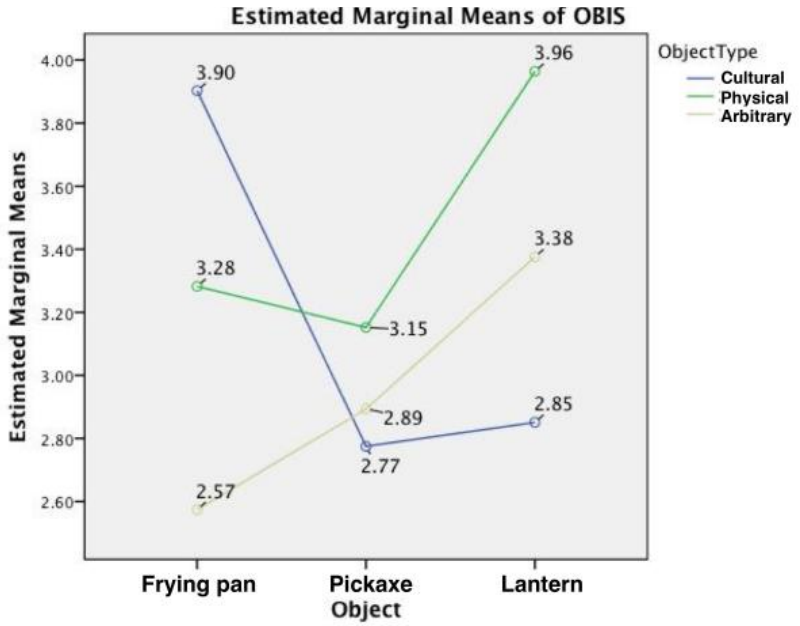

Figure 22. OBIS scores by object type and object

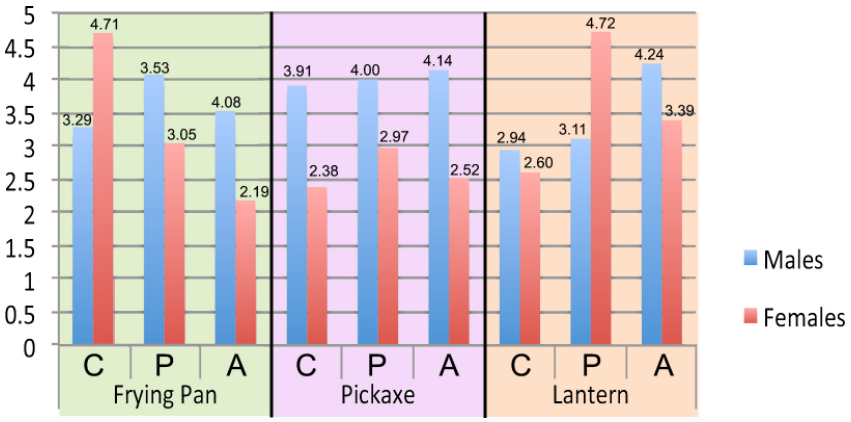

Figure 23. OBIS scores by object type, object and gender

Table 6. Pattern of object types supporting OBIS by gender

Four main groups can be distinguished from the object type order: one set of children, labeled I in Figure 24, had higher imagination scores for the arbitrary objects, and consistently followed by a higher score for the physical objects and then the cultural objects. A slight variation of this first group, labeled II, had similarly high scores for the arbitrary objects, but followed by the cultural then the physical objects. Conversely, a third group labeled III performed best with the cultural objects, followed by the arbitrary and then the physical objects. Group IV is a variation of group III whereby the orders of arbitrary and physical objects flipped. Only one child had the highest scores with the physical objects. Thus, two main groups of tendencies (Figure 25) can be distinguished: one where the arbitrary objects take prominence, the other where the cultural objects support imagination best.

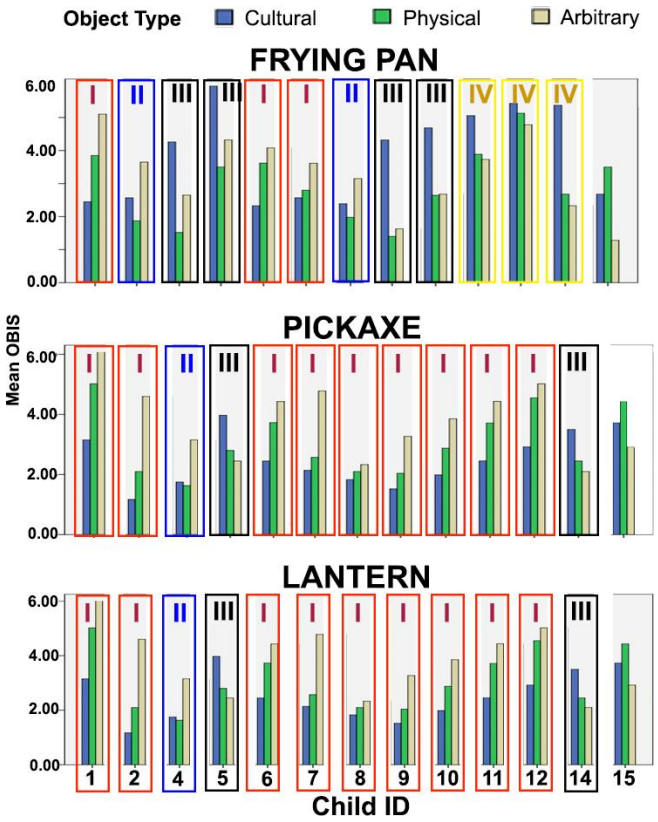

Figure 24. Barcharts of imagination scores per child

Figure 25. Object type patterns

Group	Pattern
I	A-P-C
II	A-C-P
III	C-A-P
IV	C-P-A

D. Enactment Conditions

We compared the condition of story enacting with objects with that of enacting without (with only the body). The one-way univariate analysis of variance test of enactment conditions on scores of imagination yielded a significant difference, $F_{(1, 10.24)}$, $p < .005$, $\eta = .165$, such that scores for the body-based condition ($M = 5.93$) were higher than for the object-based condition ($M = 3.63$). Effects of the personality covariates were non-significant.

E. Visual Conditions

We compared the use of graphical story illustrations (in slideshow format) with that of a video of a human storyteller as stimulus. There was no significant difference between the two visual conditions on scores of imagination (graphical condition, M = 3.40; narrative video condition, M = 3.32). However, a very interesting observation can be made when imagination scores are classified on visual conditions by object types. As shown in Figure 26, the scores for the slideshow condition *increases* from the cultural to the physical and to the arbitrary object. For the video condition conversely, the scores *decreases* from the cultural to the physical and to the arbitrary object.

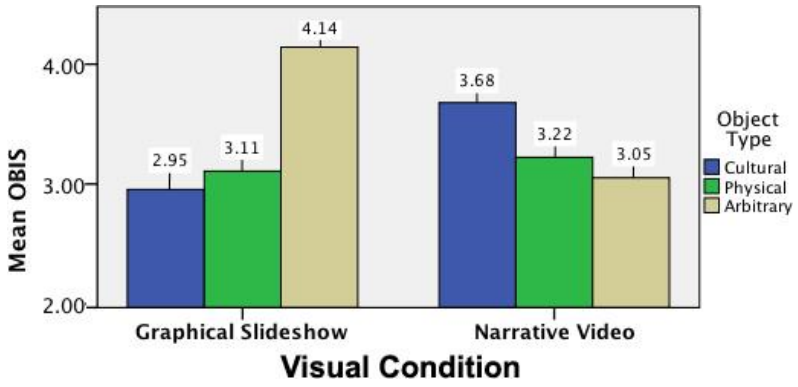

Figure 26. Imagination scores per visual condition

F. Children's Narratives

Stadler and Ward (2005) describe the levels of narrative development as progressing from 1) basic labeling to 2) listing, 3) connecting, 4) sequencing and finally 5) narrating. They explored these levels with children aged up to only about 5.5. In our study, we found that although the fourth-grade children (mostly aged 9) were able to tell comprehensible and reasonably attractive stories, most of their tellings remained at the second to fourth levels of Stadler's and Ward's (2005) narrative development scheme. The most common type of connectors seen when coding for coherence was the 'and' connector. In those cases, it was often not evident whether the child meant for the relationship to be temporal, causal or simply sequential. Best guesses were made in cases where it was possible, other- wise they were not coded. This level of narrative may be classified as the listing level of narration whereby one recounts a "topic-centered list of perceptual attributes or character actions" and uses basic conjunctions to connect the items logically. There were also some evidence of more developed narratives at the level of sequencing with causal connectors

(examples found included to, because, so, so that, but), and temporal connectors (examples found were then, when, after that, while, soon, first of all, first, a few seconds later).

G. Episode Type, Story Quality and Enactment Quality

The story quality and enactment quality scores for all episodes of all participants (35 episodes × 12 participants, resulting in 420 cases) were entered into SPSS. Outlier cases were excluded after descriptive analyses were run, and the final total number of cases was at 412. A one-way between-subjects Analysis of Variance (ANOVA) test was run to see the effect of episode type (the independent variable indicating whether an episode was enacted or non-enacted) on story quality (the dependent variable). It showed a significant difference in means be- tween enacted and non-enacted episodes, $F(1, 204) = 6.245$; $p < .05$. As shown in Figure 27 (Left), enacted episodes resulted in higher SQ (standardized $\mu = .61$) than non-enacted episodes (std $\mu = .33$). Further, a correlation test was run to investigate the relationship between enactment quality and story quality, and the two were found to be correlated, Pearson $R = .317$; $p < .05$, although not too highly. Our further analysis explained why. The dataset was split into three files based on the enactment quality scores to obtain a set of low EQ cases, one of medium EQ, and one of high EQ. The ANOVA test of episode type by story quality was repeated with each of these three sets. Figure 27 (Right) shows story quality scores by enactment quality scores grouped into three bins. These ANOVAs testing how much high imagination, medium imagination, low imagination enactments contributed to the difference between SQ scores in enacted and non-enacted episodes showed an interesting pattern. Cases with high EQ resulted in a highly significant difference in SQ scores between enacted and non-enacted episodes, $F(1, 147) = 7.374$; $p = .007$). Cases with medium EQ showed a moderate significant difference, $F(1, 155) = 5.020$; $p = .026$), and cases with low EQ did not result in a significant difference, $F(1, 158) = .052$; $p = .819$). It appears that level of imagination during enactment functioned as a mediator of the positive effect of enactment on storytelling.

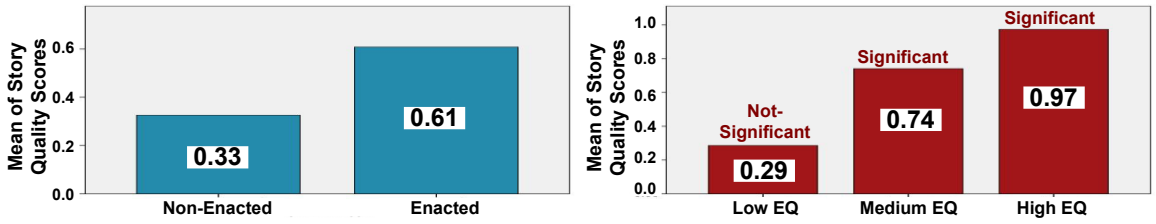

Figure 27. (Left) Episode type × Story quality scores; (Right) Enactment quality × Story quality

Summary of Study Findings

The key study findings can be summarized as follows:

- The more specific an object, the fewer the number of object-oriented actions, and the higher the number of complex story vignettes.
- Depending on the child, broader imagination is best supported by objects with either the greatest semantic range or with the greatest structure.
- Enacting with an object may lead to a focus on object-oriented actions at the expense of action diversity in story enactments.
- Enacting without objects may lead to greater broader imagination given the appropriate personality profiles.
- Graphical visual stimuli may compensate for less specific objects to support broader imagination in the child.
- Physical enactments result in better storytelling, only if the enactments are performed such that they cross a certain threshold of imagination.

Our results showed a complex picture. From our analysis of the distribution of the different types of micro-actions (MAs) (Figure 21), we observed that there is a clear trend of an *increasing number of object actions and a decreasing number of body actions as the object type becomes more abstract*. The trend repeats for all of the different objects, except for the cultural pickaxe. Based on observations and our interviews with the children, we posit that the cultural pickaxe produced a greater number of object actions and much fewer body actions because of its construction. The pickaxe head was made of a foam material that incited the children to use the object as a 'play object' (e.g., swinging the pickaxe in the air to hear the 'swish' sound) instead of as a task-oriented storytelling support. We suggest that the arbitrary object produces the least number of MAs because it creates an uneasy situation whereby constraints are placed by the presence of an object to be used, but the object does not provide any specific affordances to trigger broader imagination. In contrast, for the physical pan for example, the flat circular head prompted the action of adding condiments in the pan in the child. The body condition, which did not have any object constraints, produced a more equal spread of types of actions, hinting at greater diversity in imagining.

The number and type of vignettes (in Figure 21 (Right)) shows the ability of the child to string together MAs to construct mini-stories throughout their enactment. We observed a trend of *decreasing number of vignettes as the object type becomes less specific* across the pan and pickaxe objects. The trend follows through for the lantern, except for the body condition. It may thus be that the cultural objects support more coherent actions that are less driven by the perceptual cues of the object but more by generated ideas. The specificity of the object frees up cognitive resources for the child to imagine at a higher level (in terms of story bits instead of base actions). What is surprising however is that the body condition generated the highest number of complex

vignettes in the pan and pickaxe cases, but the highest number of simple vignettes in the lantern case. There may be two possible reasons for this: it may have been caused by the incidentally high personality scores of the children in the body condition, or by the fact that the lantern is an object with a bucket-like handle whereas both the pan and the pickaxe afford more knife-grip-like handles. We therefore are unable to draw any firm conclusions with regard to that result.

The significant interaction effect of *Object × Object type* suggests that the object type makes a difference in the broader imagination of the child. The imagination scores strengthened our analysis of the enactments by taking into account the consistency of the child's imagination through the drawings and post-interviews. *Broader imagination differs significantly across object types, when differences among objects are taken into account.* There were two distinct groups of children in terms of object type patterns: *one driven by the physical affordances of the object* (III and IV in Figure 24) and *one led by the semantic dimension of the object* (I and II). This is in line with Norman's (1999) concept that an object can possess both 'real' and 'perceived' affordances at the same time. Real affordances are brought about by the constraints of the physical, tangible object (what is true), whereas perceived affordances are what the user sees as possible with the object. Our finding however is not entirely consistent with the results of McLoyd (1983), Elder and Pederson (1978) and Pederson et al. (1981), who found that more specific objects help young children to imagine better in terms of object substitution and pretend play. This suggests that perception and imagination increase in sophistication as children grow older, allowing them to adapt to circumstances or to adopt particular tendencies. For instance, we observed that the patterns were very consistent within child. It may be that the real or the perceived affordance takes precedence depending on the object and context of use.

With regard to our exploratory investigation of the varying enactment and visual conditions, it seems that children in the body-based condition had far greater broader imagination than those in the object-based condition. Further, it appears that *object type and visual condition may compensate for each other in terms of broader imagination support*. The graphical slideshow can be said to have provided somewhat more specific details to the children, and thus the arbitrary object was sufficient for them to imagine. The narrative video however provided no visual stimuli related to the story at all, and so the cultural object played a much more important role to support the child's imagination. This may be explained by several communication theories such as the media richness theory, and supports Mayer's (2001) cognitive theory for learning with multimedia. Our analysis regarding quality of storytelling showed that simply enacting seems to contribute little to the child's storytelling, as the non-significance of the low enactment quality cases indicate. In other words, the quality of the story is positively related to the level of imagination during the enactment. This indicates the importance of designing the enactment-based interface (physical and digital) of a storytelling has to be designed to support imaginative enactment, as far as possible.

VI.4 Designing Digital Objects for Enacted Storytelling

External Representations and the Child's Creativity

In contrast to theories of design fixation (S. M. Smith, Linsey, & Kerne, 2011), theories of embodied cognition have suggested that external representations such as visual images are helpful for people to think. D. McNeill (1992) proposed that external objects can be appropriated as 'material carriers' to represent thought objects, in essence bringing the person's perceptual and spatial abilities to participate in her thinking process. This suggests the positive participation of perception in the creative process. Empirical evidence has been presented to that effect showing that features of the physical environment can mediate creative performance (McCoy & Evans, 2002). In line with fixation theories however, Neblett, Finke, and Ginsburg (1989) found that the presence of physical objects of particular shapes made available for perception and manipulation was functionally equivalent to simply visualizing or projecting the shapes in one's mind, resulting in no difference in outcomes. R. E. Anderson and Helstrup (1993) saw that physical synthesis could generate more patterns, but the patterns were not necessarily more creative. In this sense, the presentation of perceived structures may not translate to benefits.

Given the conflicting theories, it is difficult to determine whether the provision of visual contextual structures may support or hinder the child's story creation process. Bipolar explanations for possible outcomes include: the *'design fixation'/'stimulus' hypothesis*, whereby the perceived structures either have an overpowering effect on cognition or triggers the creation of new lines of association among the child's memory structures; the **'lack of raw** *materials'/'structures influx' hypothesis,* whereby the child either does not have sufficient experiences from which to draw or has a large store of memory structures that creates an influx of connections to be actualized in the creative act; the *'offloading'/'automatic retrieval' hypothesis*, whereby the external representations either help the child to reduce cognitive load therefore facilitating her retrieval of memory structures or cause the 'automatic' retrieval of schema (memory structures) associated with the task preventing the child to readily recombine other farther structures; and the *'cognitive dissonance' hypothesis* (R. A. Finke, 1990) stating that people may show poorer performance in creativity when imagined and perceived stimuli are mismatched/misaligned.

Contextual Digital Background Study

We ran a study in the form of a digital storytelling workshop in a studio space for children aged 8 to 11 (3 boys and 3 girls) whose parents voluntarily signed them up. Story backgrounds shown on a large display (see Figure 28 top right) were chosen as the form of contextual visual structures to be provided. This configuration is a common feature in many interactive systems for children. An interactive digital story authoring system was developed to help in the conduct of the study. The system has two modes: 1. Story listening, and 2. Story creation. In the story listening mode, the system plays a video of a story reader narrating a story (Figure 28 top left). In the story creation mode, the system allows the child to tell a story using enactment with a generic tangible

object. The use of the tangible object enables the child to interact with an analogous digital version of the object on the screen, e.g., moving a tangible toy lantern in the 'enactment box' will correspondingly move a digital 3D model of a lantern onscreen. In this story creation mode, either a background image or a blank screen can be displayed together with the digital object model on the screen.

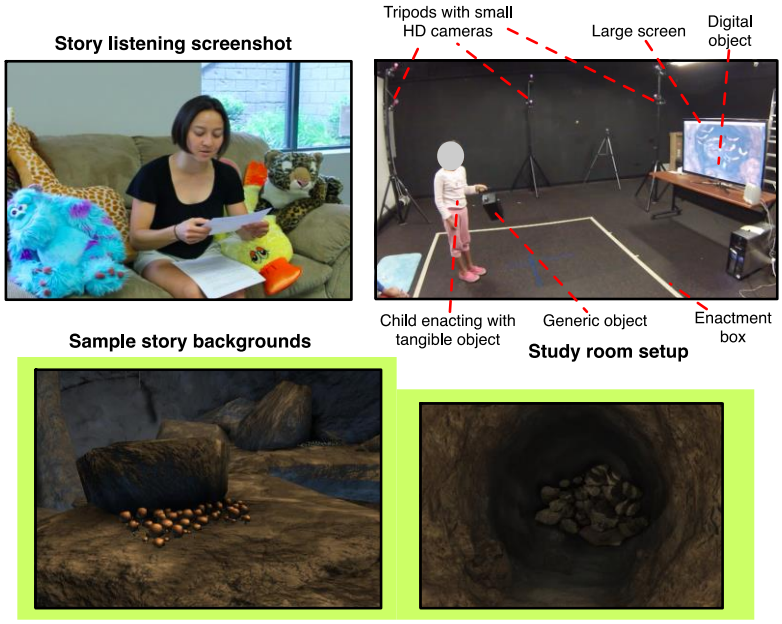

Figure 28. Contextual background system-related pictures

The study was carried out as illustrated in Figure 29: using the digital storytelling system, the child participant first watched the narration of a novel story of three dwarves going into a cave to find resources for their town. The story consisted of two parts, each part consisting of three segments or episodes. The three episodes in each story part were crafted to tell the same events (i.e. dwarves cooking, dwarves digging, dwarves shooing away enemies). The story was paused after each episode and the system was switched to creation mode. The child was asked to continue the story using enactment. All children engaged in two kinds of study sessions: enactment with a background image and with a blank screen. If a background image was displayed during enactment episodes of Story Part 1 for a participant, a blank screen was displayed for story creation in Part 2. In total the study took 1.5 hours, with each story listening episode lasting around 3 minutes and

each story creation session lasting about 2 – 3 minutes. The children indicated to the researcher when they were done enacting their story part. All enactment sessions were video recorded.

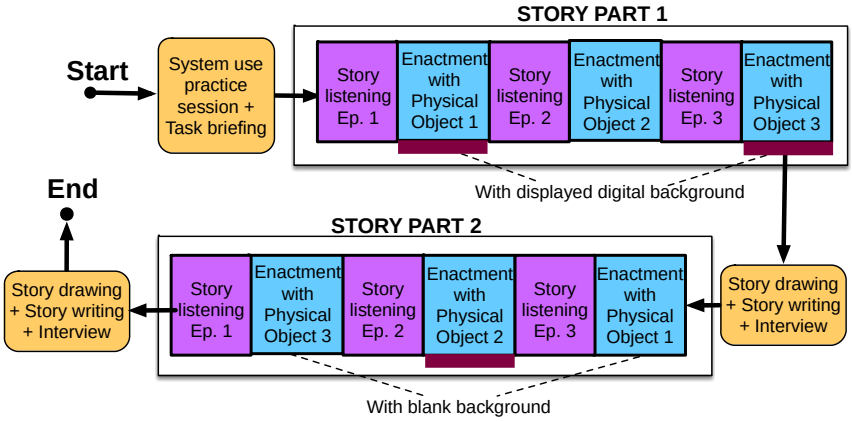

Figure 29. Contextual background study design

Data Analysis

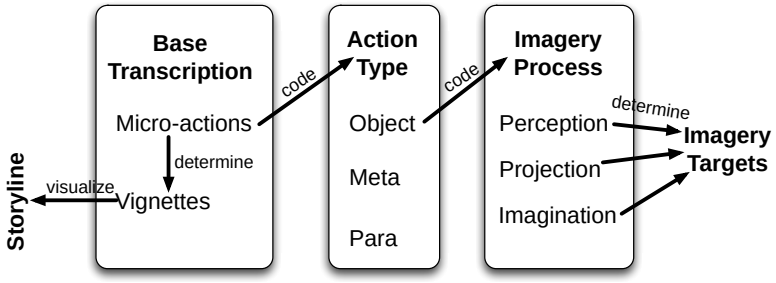

Figure 30. Data analysis approach

The overall analysis approach of the enactment videos is shown in Figure 30:

(1) Using the Inqscribe software (Inquirium LLC, 2013), the base transcription was done based on the MAIA approach that we used in the 'physicality' study in Section VI.3, in which the videos are transcribed first at the level of *micro-actions* (atomic actions including the use of voice), and second at the level of *vignettes*, meaningful groups of micro-actions telling a story piece;

(2) Each micro-action is coded using a variant of McNeill's (2008) reference chain analysis scheme into three levels: *object*- (referencing the story that the child is telling, e.g., rocking the frying pan to enact a cooking action), *meta*- (referencing the process of telling the story, e.g., pausing in mid-action to think about the next step in the story being told), and *para*- (referencing objects and persons in the immediate environment unrelated to either the story being told or the process of telling the story);

(3) 'Object-level' actions that indicated simulated interactions with some sort of story environment element were coded into three categories based on Kirsh's (2009) spectrum. Kirsh classifies the use of external structures participating in cognitive processes depending on its level of dependence on what may be readily perceived in the environment. In *Perception*, the mental imagery is anchored completely in perceived external structures. In *Projection*, imagined structures retrieved from memory are anchored on external structures, similarly to one wearing 'augmented reality' glasses. In *Imagination,* mental imagery is wholly retrieved from memory, and is independent from any perceived external structure. The utility of Kirsh's model is that it provides us with a way to analyze and understand the mechanism by which the child imagines and creates her enacted story.

Study Findings

We describe and discuss below themes uncovered in our analysis in terms of the process of story creation and the stories produced. The findings are summarized in Table 7.

Table 7. Summary of contextual background study findings

With Background	Without Background
Translation + Augmentation of digital stimuli	Augmentation of any environmental stimuli
Projection from environmental structures	Projection from memory
Continuous engagement	Reduced story focus
Greater motivation	More structured storyline
More typical storyline	More elaborate storyline

A. PROCESS: Transformed Imagination

There were differences in terms of the types of objects that the child's imagination targeted depending on the background condition. In the case with the digital background, the child would appropriate the perceived digital structures, e.g., mushrooms on the cave banks (refer to Figure 28), move them elsewhere on the screen or out into the world onto a different anchor, e.g., the tangible object. This transformation of perceived structures were not limited to translation or movement only, but also included augmentation of the state of the structures, e.g., the mushrooms being chopped up and cooked instead of raw. However, in the sessions without the contextual backgrounds, the child augmented any perceived structure in the environment (the tangible object, the blank screen, the floor, etc.) with structures retrieved from memory. Processes of appropriation, translation and augmentation were not needed.

B. PROCESS: Story Focus

We found that the child had a harder time getting started and staying on task in storytelling without the perceived stimulus of the digital background. To a large extent, sessions without digital backgrounds were punctuated with more periods of play or non-story relevant actions than sessions with digital backgrounds. 'Meta-level' and 'Para-level' micro-actions were significantly more prevalent. The child would often drift in and out of the story mode (e.g., to examine the tangible objects or to play with the technology) instead of having an unbroken block of storytelling activity. This is detrimental given that enactment has been identified as episodes of 'flow of creativity' as we have seen in our Phase I Exploration study, and has formed the rationale for many children's storytelling systems.

C. PROCESS: Motivation, Interest and Excitement

Apart from the excitement of the children by the interactive capabilities of the storytelling system with regards to the tracking of the tangible objects, we observed that the provision of the digital backgrounds consistently caused greater interest in the child to engage in story creation. The fewer number of micro-actions until the first story-relevant micro-action on average for many of the children, as well as comments during the post-interviews, provide evidence of the motivational effect of the digital structures.

D. PRODUCT: Affordance-Based Imagination

The types of actions that the child performed in the digital background sessions were usually more typical of the situation presented in the story episode than in the no-digital background sessions. For instance, the first event of the child's story tended to consist of an action that plays off the key contextual digital element (e.g., scoop up mushrooms) when digital structures were present, whereas with no digital structures the first story event was often one that sets some form of context or background to the child's story (e.g., declaring "I'm hungry", planning to get more food). The overall storyline as well was usually more typical of the schema of the story situation (e.g., gather food, cook food, eat food). More imagined actions and objects outside of the typical

schema of the story narration were seen in the no-digital background condition (e.g., spotting ants, getting burnt, walking in a tired manner). We call the child's imagination in the with-digital background sessions 'affordance-based' as the ideas that the child retrieved to include in the story were more often than not associated with what the perceived digital structures directly provided.

E. PRODUCT: Structured Narrative

The stories told in the sessions without digital backgrounds were observed to generally follow more of the narrative structure with a beginning, middle and end than those from the with-digital background sessions. The no-digital background storylines tended to start with speech uttered by the story character, the child's own narration, or character action that sets the context of the story (e.g., "I'm a miner", the character walking to the mines, the character being hungry). Although a clear climax was not always immediately evident, the child typically provided a closure or wrap up of some sort to the story (e.g., the character assessing the food cooked as "yummy", the character walking out of the scene to the next). With digital backgrounds present, the storylines were more focused on interaction with the elements perceived instead of producing an actual story that is normally defined by the narrative arc.

Summary of Study Findings

Our findings indicate that there are clear tradeoffs. On the one hand, contextual background structures act as prompts for task and story engagement for some children. On the other hand, they may harm the quality of the stories or creative products that a typical child can produce. Amabile's (1983) componential model highlights the importance of motivation, creativity-relevant skills and content knowledge for creativity. Given the Fourth-Grade Slump phenomenon that we described in Chapter II, motivation is a key component that should be considered for our 8- to 10-year-old target age group. Compromises may have to be made in design decisions when considering the level of perceived support to provide in an interface. For example, if contextual digital representations are excluded in the design of a system so as to maximize support for the child's creativity-relevant skills and content knowledge, one may want to incorporate a separate feature designed to increase the motivation of the child to be involved in the creative activity.

The stories constructed by our participants in the with-digital-background were less elaborate and exhibited poorer structure in the form of a less apparent narrative arc. The reason for this may be Kirsh's (2009) observation that projecting mental imagery onto perceptual structures incurs a 'cost' for the viewer to deconstruct the background structure and to transform its elements. In the no-background-image case, the child does not have to overcome this 'cost' in order to employ prior experience both in content and understanding of narrative structure.

VI.5 Design Methodology

In order to test the performative authoring approach to supporting children's creativity in storytelling, we needed to embody the approach in a testable system. We carried out two studies, one relating to the effects of varied physical enactment props, and the other relating to the presence

or absence of contextual digital backgrounds during story enactment, to inform the design of such a testable storytelling system for children. Apart from the implications for design that these two studies brought to light for our performative authoring storytelling system, many other design decisions were required to be made to bring the system to a successful and sufficient implementation.

To fully develop a performative authoring system, we made use of the *Finding-NEVO* 'design-oriented research' methodology that we developed to guide the design of research prototypes in HCI. Ideally, the testable system developed should faithfully embody the seed idea and the conceptual rationale for the testing of the conceptual rationale to be valid. However, many factors may intrude (and more often than not, they do) into the development of a testable system from a seed idea such that this scientific process becomes muddled. We call these factors that threaten fidelity to the original conceptual rationale 'creeps'. Examples of creeps include convenience creep, experience creep, feature creep, and user input creep. *Convenience creep* involves our tendency to resort to the most convenient way for implementation and design using tools and frameworks at hand*. Experience creep* is when prior experience with existing systems by designers, developers, and study participants moves the design to resemble existing solutions. *Feature creep* is the urge to include more functions to a design than necessary. And last but not least, *user input creep* is when the design is blindly adapted to follow the user's feedback and comments.

Our design research in this dissertation can be classified as being *Design-oriented Research* under Fallman's framework (Fallman, 2003, 2005, 2007). He distinguishes two types of research in HCI: *Design-oriented Research* (*DoR*) and *Research-oriented Design* (*RoD*), In DoR [2], design and technology implementations serve to test and validate particular research concepts. The focus is on the research concept to be investigated, a position most closely aligned to the natural and social sciences strand of HCI. Conversely, RoD focuses on the use of research to help in design practice, or solving problems and real-world obstacles, and is often used in product development. The focus is on the design of the artifact or technology, a position most closely aligned with the engineering, design and arts strands of HCI. In DoR, maintaining scientific validity in the design of the research prototype is key, i.e., the need to avoid the creeps.

The Finding-NEVO model, shown in Figure 31, proposes an approach to precisely avoid the creeps. The research process begins with a *conceptual rationale* from which a *seed idea* (box A) is generated. A set of *idea-defining characteristics* is produced (B) that identify the core features that the seed idea should possess, without which it would not be tied to the original concept. Exhaustive articulation of these characteristics is not necessary. Rather, the characteristics should be limited only to critically-identifying aspects of the idea with respect to the conceptual rationale. In fact, over-specification of idea-defining characteristics may even have the undesirable side effect of over-constraining creativity in the design process. The model addresses this by recognizing the

need for an informal *Team Understanding and Consensus* (B). Together, the Idea-Defining Characteristics and the Team Understanding and Consensus embody the seed idea, which then guides the Gatekeeping process. The *Gatekeeping* process (D) is used to vet individual design ideas in advance of development. These *design ideas* (C) may be the product of methods such as brainstorming and ideation, with respect to a particular design issue (which may be identified through methods like ethnographic studies, design principles, experience or intuition).

For our research, to be able to investigate whether pretend play may function as an appropriate means of creativity support for children, our seed idea was thus to develop the DiME story authoring system for children to embody the concept of performative authoring. The idea-defining characteristics were defined to be as follows: The child should be able to

(i) make use of embodied enactment (with or without physical objects) to express a story idea;
(ii) view their enactment in real-time through an animated avatar (and through the simulation of the object being manipulated);
(iii) review the digital enactment (through the animated avatar) whenever they want to;
(iv) integrate the digital enactment with other (media-based or text-based) story ideas; and
(v) structure the multimodal story ideas into a coherent storyline.

Examples of key design decisions subjected to gatekeeping are shown in Table 8. The rationale for decisions included consideration for the abilities of children in our target age range, technical possibility and feasibility, time constraints, study findings from prior literature, etc.

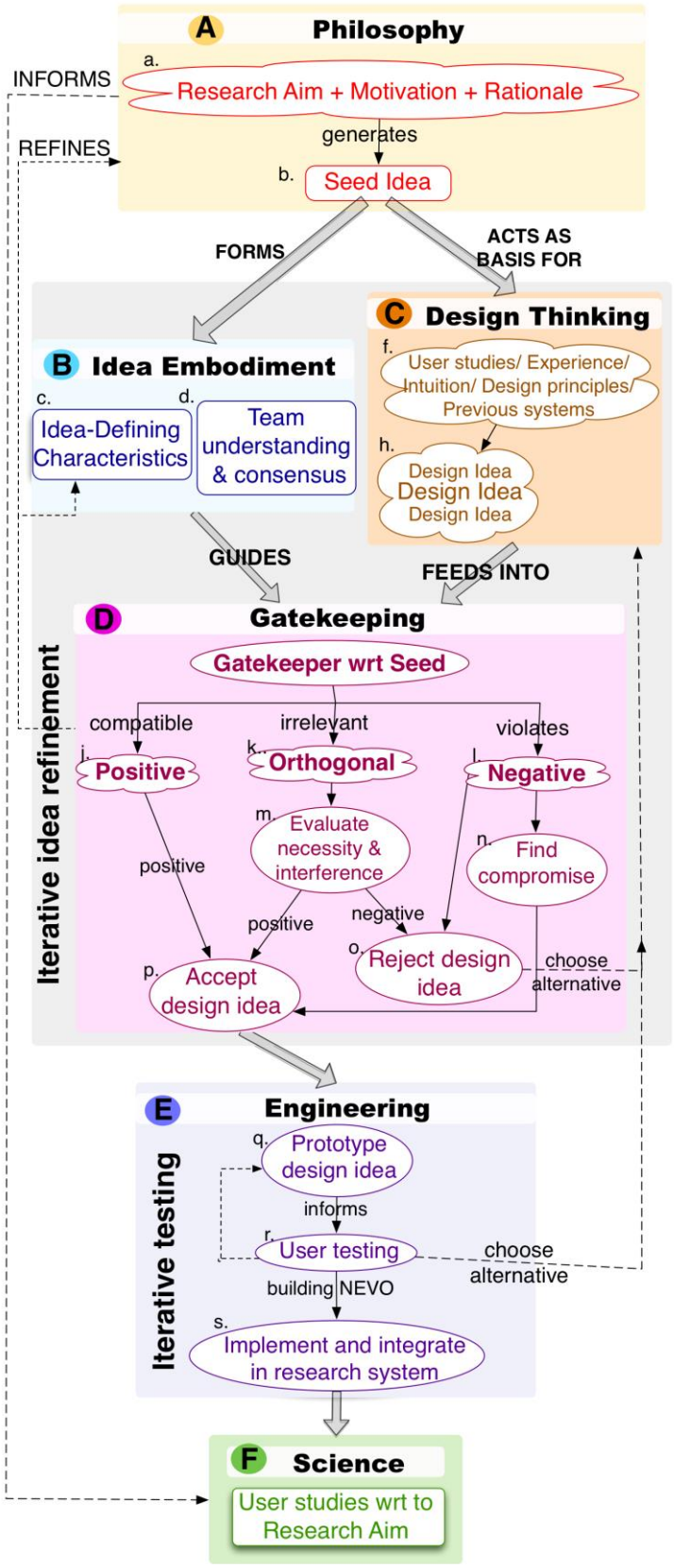

Figure 31. Finding-NEVO model

***Table 8. Examples of key design decisions in* DiME *using* Finding-NEVO**

Component	Design Idea	Gatekeeping	Rationale
Input method	Tablet-based handwriting for text input	Rejected	Lack of ease-of-use for children
	Motion capture-based movement tracking	Accepted	More accurate than other tracking methods
Authoring format	Filmstrip frames metaphor	Accepted	Usual representation for animated movies
	Guided narrative structure	Rejected	Orthogonal and unnecessary
	Actor-director setup	Accepted	Foster idea discussion
User interface	Cut-out style mixed 2D-3D cartoon graphics	Accepted	Technical feasibility and spurs child's interest in media
	Real-time feedback + Post-review	Accepted	Necessary
	Audio feedback for GUI elements	Rejected	Orthogonal and time constraint
	Blank background	Accepted	Prior work – given contextual backgrounds contrive children's imagination
	Generic physical objects	Accepted	Prior work – objects with generic affordances generally support the child's imagination best

VI.6 DiME: A Digital Micro-Enactment Storytelling System

DiME was developed to embody performative authoring as a design concept that is grounded in micro-enactment[†]. Beyond simple drama thus, the digital augmentations that DiME provide are mainly two-fold: (1) *Feedback:* The child can review her enacted story product in real-time and immediately after; and (2) *Output type:* The child sees an animated cartoon that she is controlling, instead of her own self, in the story. These two distinctions are highlighted in Table 9, which compares storytelling through the performative authoring approach to the recording of a drama, and to a live drama piece.

[†] For a video that describes the concept and the system, see https://www.youtube.com/watch?v=H6mE5jA68Wc.

Table 9. Distinctions in approaches to storytelling

Dimension	Enactment-based animated story authoring	Video-based enactment	Theater/ Drama
Feedback	Real-time	Delayed/ Real-time	Social evaluations
Output	Cartoon animation	Video of self	Performance for others

Below, we describe below the intricacies of the system design and development, as well as how it may be used by children to create animated stories.

Story Enactment in DiME

A child performs story enactments in an 'acting area' (see Figure 32) that features a motion tracking system that employs the *Motive motion capture software* and 8 'Flex 13' cameras from OptiTrack (Natural Point Inc, 2015). Typically children create stories in pairs with one playing the role of the *director* and the other in the role of the *actor*. As the actor moves in the tracked space, a cartoon character (Figure 34A) is animated in real-time on a large screen display that is positioned so that during enactment, only the director can see the real-time animation (labeled in Figure 34B).

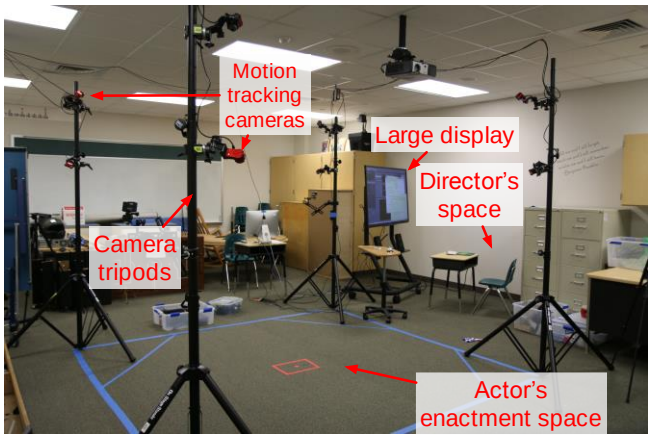

Figure 32. DiME setup at a school

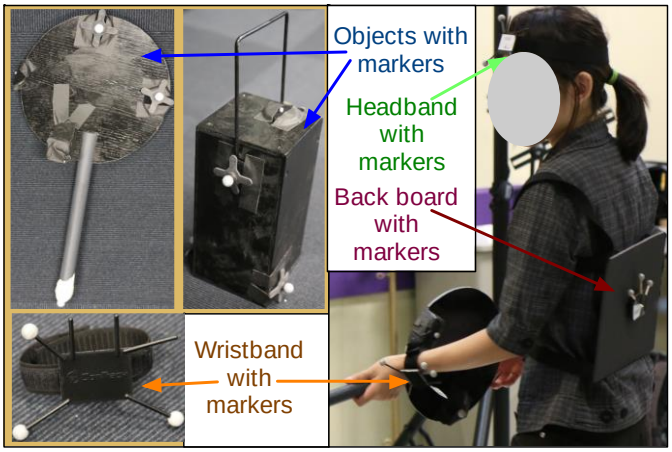

Figure 33. Markers worn by child

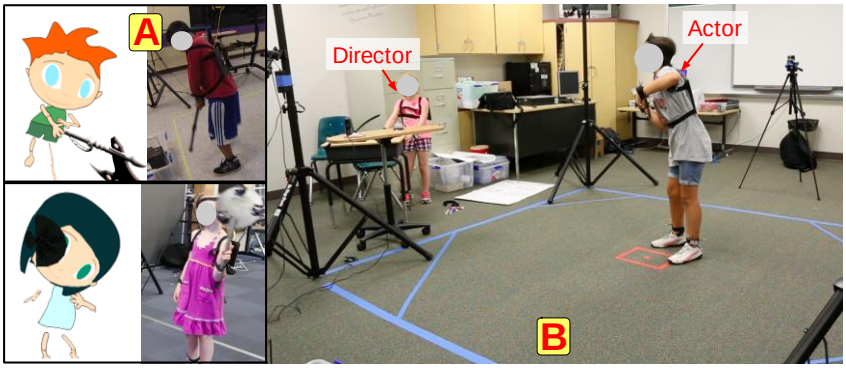

Figure 34. A. Enactment-Animation mapping; B. A pair of children enacting their story

The actor wears a set of tracking markers on her wrists, ankles, head, and torso (Figure 33) and can optionally hold a physical prop that is mapped by DiME into a graphical prop that animates with the cartoon character on the large screen. The physical props are generic physical objects such as sticks, balls, and boxes adorned with tracking markers torso (Figure 33). When DiME's enactment system is active, the tracking and animation are constantly running so that the children are free to play with the system and rehearse their story enactments. When they are ready, the director can activate the recording system to produce an animated scene. During recording, both the director and actor can speak or make sound effects that are captured by the system's microphone to be part of the animation. This allows the director to provide scene narrations or to 'voice act' with the *actor*. The children can then review the scene, redo the scene, or proceed to their next story scene.

DiME System Design and Interface

Figure 35A outlines the three major components of the DiME architecture:

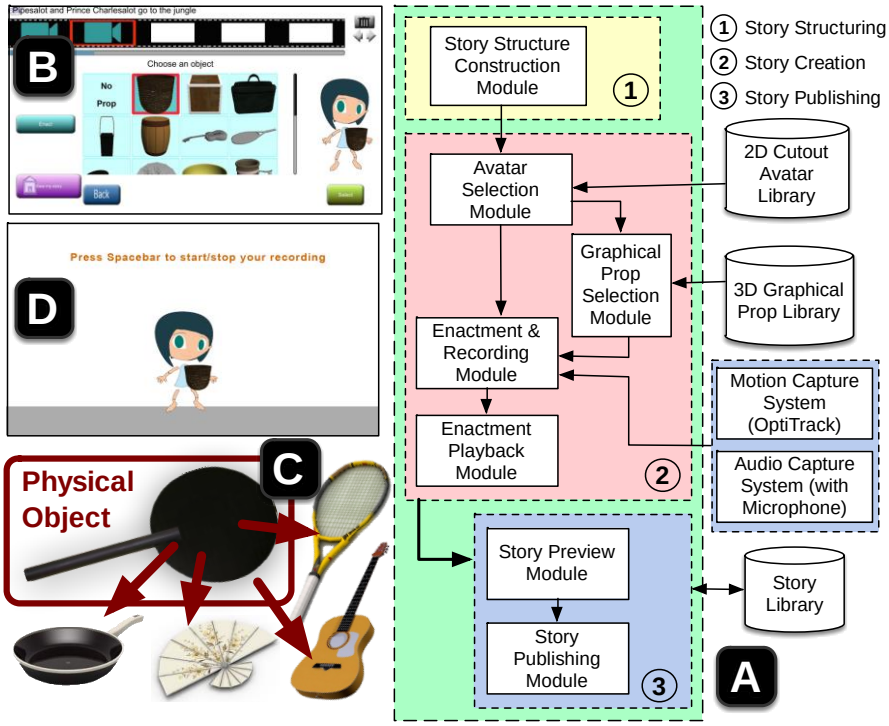

Figure 35. A. DiME system architecture; B & D: Screenshots; C. Physical -Virtual props mapping

A. Story Structuring (A-1)

The child creates a story as a series of 'story frames' or 'scenes'. Using a filmstrip metaphor (see Figure 35B), the system presents a sequence of blank frames that are filled in as the scenes are created sequentially;

B. Story Creation (A-2)

This module through which children construct story scenes by: selecting a cartoon character and an optional graphical prop, and recording/replaying scenes. *Avatar selection*: Previous research has articulated negative experiences using realistic 3D models with children (Robinson, Peng, Quek, & Cao, 2009). Since 2D models do not map easily to 3D motion capture, we developed a 3D paper cutout model where a flexible 2D manifold texture mapped with the character's features is embedded in a 3D space. This yielded the 'cute' interactive cartoon model that we employ in DiME. Depending on orientation of the character, the system switches between

front, left-side, right-side, and back cutout parts. At the start of a scene creation session, the children select a character from a library of characters. *Graphical prop selection:* The children have the option to a graphical prop (e.g., flashlight, bowl, sword) to use in the animation (see Figure 35B). If a graphical prop is selected, the children are prompted to pick up its control proxy in the form of a physical object with the appropriate affordances. Figure 35C shows how a large paddle-shaped physical object may be used to control the animations of a virtual frying pan, fan, guitar, or tennis racquet.

Enactment & recording: Once a character and optional graphical prop are selected, the enactment subsystem is activated. The cartoon characters are controlled by six 'control frames' corresponding to the head, torso, right and left hands, and right and left feet. Each control frame is specified as a solid rigid body with 3D positions and orientations, and the cartoon character is articulated to mirror the motions of these frames while maintaining a set of model connection constraints. As the actor moves through the tracked space, the character animates against a white background on the large screen display (see Figure 35D). Any time the enactment subsystem is active, the children can activate the recording system by pressing the spacebar on a wireless keyboard. When recording is activated, the screen content is captured, and an audio capture subsystem captures the co-temporal vocal utterances and sounds made by the children. This audio stream is synchronized with and embedded in the final animated story video. When the recording is stopped, the screen goes to the Playback mode.

Enactment playback: The enacted cartoon video can be played back for the children, and they have the option to save or redo the scene.

C. Story Publishing (Figure 35***A-3)***

From the DiME 'home screen' showing the story filmstrip, the children can preview and publish their entire story.

Preview story: All cartoon frames can be played back in the order that they were created allowing the children to view the whole story.

Publish story: At the end of the story creation process, all the frames are collected, saved to a library, and output as video files.

VI.7 Pilot study of DiME

Pilot Study Description

The prototype DiME is a system built to embody the concept of performative authoring as guided by findings from our Phase I and Phase II empirical studies. DiME was first pilot tested for usability with two children (one girl and one boy aged 8 and 10 respectively) in a laboratory setting. The updated version of the system after bug fixing was used in a subsequent larger pilot study. The pilot study to investigate the use of DiME by children was carried out at a local 'Boys and Girls Clubs of America' afterschool program. The participants were 7 children (4 girls, 3 boys), all aged between 8 and 10 years old. Parents voluntarily signed up their children for the study, and

completed a consent form. Verbal assent was also obtained from each child for her willingness to participate. The study ran over a period of two weeks. The children used the system in pairs on certain weekdays from 4 to 6 pm. Study activities included a i) familiarization session consisting of an ice-breaking game with the researchers, the researchers explaining to the children how to use the system, and practicing creating stories with DiME; ii) story creation session based on a given theme, and iii) post-study interview. The story theme given to the children for the story creation session was 'An adventure in the jungle'. The children were told that their story had to contain at least two enactment frames and two text frames. Figure 36 and Figure 37 show the use of DiME by children during the study. Since this was a pilot test that allowed us some freedom to explore, we tested various system configurations, variations in protocol, and children grouping throughout the test period. The different test sessions conducted with the children are detailed in.

In the post-study interview, a questionnaire was administered to the child to assess her experience of storytelling via enactment, via text, and via the approach of paper-and-pencil typically used at school. We used survey methods from the Fun Toolkit (Read & MacFarlane, 2006) developed specifically for use with children. These include the smileyometer (5-point likert scales from 'Awful' to 'Brillant'), the Fun Sorter (ranking of storytelling methods on 'I like', 'Is fun', 'Makes me happy'), and the Again-Again table (choice of 'yes', 'maybe', 'no' for motivation to do it again). The amount of time allocated to each activity of the study was not restricted since we were interested in exploring system use and study protocol with the children. Table 10 summarizes the pair groupings of the children (L: Lincoln Center; M: Male, F: Female) and the ID of the full stories they produced. All sessions were audio and video recorded. Table 11 shows the various tests that were run during the study.

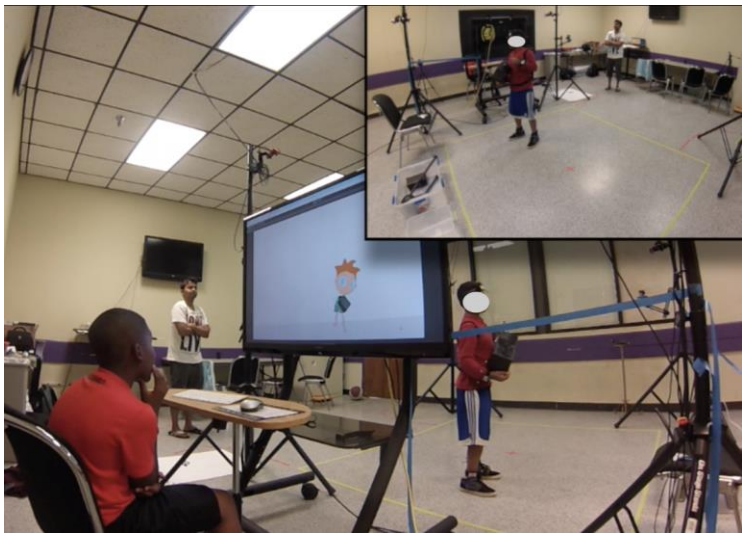

Figure 36. A pair of boys using DiME during the pilot study

Table 10. Children pairs in pilot study

Children	Story ID
L1M, L3F	A
L3F, L5F	B
L2F, L4F	C
L6M, L7M	D

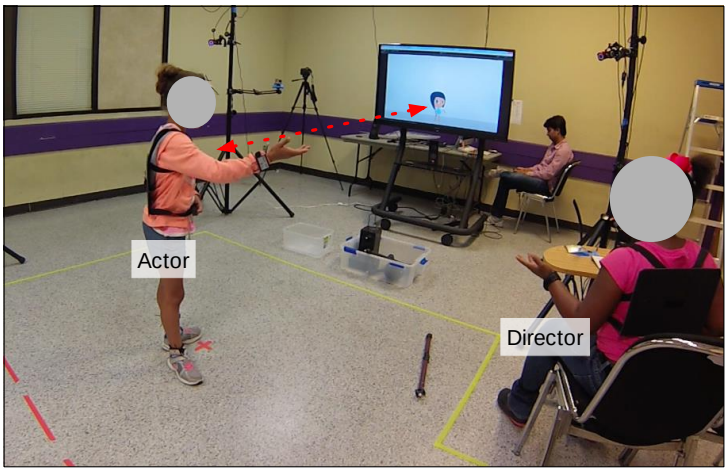

Figure 37. A pair of girls using DiME during the pilot study

Table 11. Test sessions during pilot study

Groups	Protocol	Setup
L1M, L3F	• 15 min system tutorial • 40 min story creation	Screen facing both actor & director
L2F, L4F, L5F	*[Day 1]* • Icebreaking game • 15 min system tutorial • 40 min familiarization *[Day 2]* • 45 min story creation	Screen facing both actor & director
L3F, L5F	• 45 min story creation	Screen facing both actor & director
L2F, L4F	• 45 min story creation	Screen facing both actor & director
L2F, L3F, L5F	• 45 min story creation	Screen facing director only

Data Analysis

Answers to each question in the post-study questionnaires were numerically coded and entered in a spreadsheet for statistical analysis. We used both the animated cartoons created, as well as the actual video of the children's enactments for story enactment analysis. Children's narrations in the enactment videos were transcribed with speaker labels (actor, director), and a text summary of each story scene was produced to facilitate further analyses. Furthermore, observation notes were collated and organized to help us make sense of the effects of the various test sessions that we conducted.

Findings

A. Test Configurations

Our first test with pair [L1M, L3F] showed that the children needed more than the 15 mins of system tutorial that we initially allocated for them to get used to: (i) the concept of actor-director, and (ii) the actual use of the system. With the second group of [L2F, L4F, L5F], we tested having a full 40 mins familiarization session after the 15 mins system tutorial where the children were left free to play with the system in any way that they wanted. We also noticed that personality profiles of the children dictated the success of the enactment sessions to a large extent. In the first [L1M, L3F] pair, L3F had a very dominant personality that did not give space to L1M to freely enact. We changed the pairing of L3F to work with L5F in the third pair to ensure better personality compatibility. The story creation through enactment proceeded much more smoothly, with both of the children asking to come back in future sessions.

In the fourth [L2F, L4F] pair, we were greatly encouraged by an interesting phenomenon in the behavior of L4F. We were informed by the Center administrator that L4F is usually very quiet and shy. In the story creation sessions she took on the lead in story creation and readily volunteered to create the enactment segments. The Center administrator expressed pleasant surprise by this transformation that she saw in our video recording of the children's session. With the fifth group of [L2F, L3F, L5F], we tested a new configuration of the system setup by moving the large screen display in-between the enactment area and the 'director' area so that only the 'director' is able to see the animation in real-time. The children did not seem to mind the change, and 'actors' focused more on the acting instead of attempting to get character poses right. During the test with the fifth group we also observed that although the children had different levels of affinity to the concept of enacting story pieces, even the ones with lower affinity and who preferred taking the 'director' role had to narrate the story scene, thus actively participating in the enactment.

B. Children's System Evaluation

The results of the children's assessment from the post-study questionnaires were overall very positive. Mean ratings on the 5-point likert-scale smileyometer were: Acting ($\mu = 4.3$); Paper-pencil ($\mu = 3.7$); Typing ($\mu = 3.2$). However, examination of the individual scores showed that some children gave the same ratings for at least two of the methods. Results from the Fun Sorter, which

required children to rank order the three authoring methods, were more conclusive. The method ranked 'Best' was given a score of 3, and the one ranked 'Worst' was scored 1. Combined mean scores for the three dimensions of the Fun Sorter are shown in Figure 38. Similarly, results from the 'Again-Again' question, in Table 12, showed that children were overwhelmingly motivated to continue using DiME.

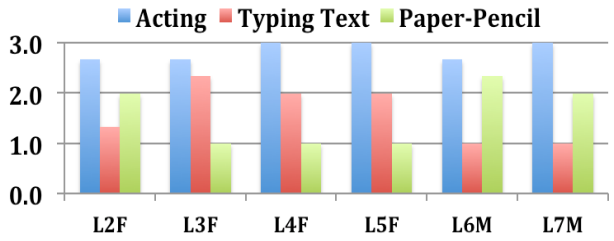

Figure 38. Fun Sorter rankings

Table 12. Again-Again' results

	Acting	Typing	Paper-Pencil
Yes	6	1	2
Maybe	0	5	2
No	0	0	1

C. Children's System Use

There were a total of 11 enacted story frames and 7 text frames across 4 stories. Enacted story frames lasted an average of 50.18 seconds. We describe ways in which the children used the system under three headings:

I. Strategies of Actor-Director Collaboration: We identified three main approaches used by the children to collaboratively author stories during enactment. Collaborative actions were seen at two levels: in terms of the actual content of the story and at a meta level management of the storytelling process (enactment recording, timing, etc.):

A. The *director's initiative* was especially evident in Pair D (ref. Table 10). The director allows the actor to make up the story, but takes it upon himself to terminate the recording of the enactment by himself when he notices long pauses or repetitive moment in the actor's acting. E.g., the actor acts out repetitively fighting against a lion until the director says "Alright" and stops the recording. In this case, story content is determined by the actor while the meta level is controlled by the director;

B. *Co-creation in real-time* was a common approach used by Pairs B, C and D. The director frames the story on the fly or reads off a planned script, while the actor responds to each of the director's speech act by acting out the situation or action specified. E.g., the director announces: "She's looking for her friend Mary." The actor acts out searching around and calls out "Where are you?". Here, the director and the actor co-create both the story content and the meta level;

C. *Communicating through acting* was seen in Pairs A and C. The actor indicates to the director that she wants to terminate the enactment by acting out the story character exiting the scene in some way. E.g., while acting out hitting on a cave wall, the actor calls out still in-character "I'm tired. I'm going to take a rest." In this case, the actor determines both the story content and the meta level.

II. The Role of Text Story Scenes: The children did not seem to understand the concept of continuous story frames represented by the filmstrip metaphor that we used in the story creation interface of the system. The filmstrip is a series of frames that the user 'fills' either with text or an animation to construct the scenes in her story (ref. Figure 35B). The children used text frames in four ways:

A. To express a *summary of the enacted story scenes* that precede it. E.g., after an enactment of using an 'axe' (virtually) to hit around the space, Pair A typed in the following text frame: "once there was a boy and girl named Mary and John and they lived in a cave. one day they got an axe and hit there cave and hit it. and rebuiltit and it looked like the best cave ever."

B. To construct *disconnected, self-contained stories*. E.g., Pair B enacted a story about two friends being separated in the jungle in the first two frames, and then started another story about two sisters getting bitten by a dog in the text frame.

C. To *contextualize the enacted story*. E.g, Pair D used the text frames to set the overall topic of their story ("this story is about this boy finding some gold") and to provide an epilogue after all their enacted scenes ("well that was a good aventure i found gold thats good now im rich and played my catar [guitar] and it was good.").

D. To *continue enacted story* scenes. This was the approach that we expected the children to use for the text frames, but it was surprisingly used consistently only by one pair. E.g, Pair C used two frames to enact a girl falling off a plane into the jungle and being attacked by a tiger, and continued the story using text, writing about a gang of monkey that came to harass her next.

III. Extent of Imagination: We analyzed how DiME supported the child's imagination during story enactment in terms of the three components of pretend play:

A. *Character play.* We coded for the roles that the children created during story enactment. 73% of the enacted scenes contained roles that were socially or culturally identifiable (e.g., pop star, baseball player, gold miner). The other 27% (Figure 39) acted story roles that were situation-specific (e.g., losing a friend in the jungle). We also looked at how the children made explicit the various roles in their story scenes (Figure 40). Most acted the roles in the *first-person* with no explicit

referencing (64%), some used *third-person pronouns* (18%) such as “she lost her friend” especially in the director’s narration, and some *named the characters* they were acting (18%).

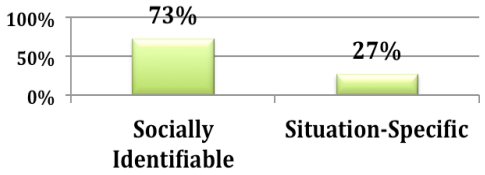

Figure 39. Role identification

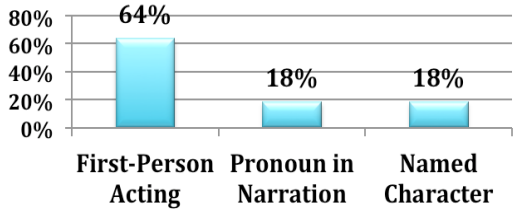

Figure 40. Methods of character identification

B. *Object substitution.* We coded the stories created for objects that the story characters used. We classified the objects according to Kirsh’s model of ‘thinking with external representations’. His model specifies three types of representations: *Perception* – entirely dependent on the physical stimulus present (i.e., the physical object used for enacting, the graphical prop onscreen, and the imagined object in the child’s mind all align. E.g., in Figure 34A, the physical stick object is the digital axe, and is imagined as an axe by the child); *Projection* – anchored to the physical stimulus but not entirely dependent on it (i.e., the physical object and the graphical prop align, but the imagined object does not. E.g., the physical stick object controls a digital axe, but is imagined as a baseball bat); and *Imagination* – entirely not anchored to any physical stimulus (i.e., an object is imagined, but no physical object is used and no graphical prop can be seen. E.g., the child imagines picking up gold nuggets that have no physical representation in reality). Figure 41 shows the distribution of objects in each category.

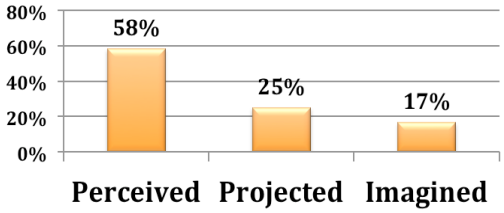

Figure 41. Pretend play with objects

C. *Fantasy worlds.* We coded each enacted story scene for environmental elements, i.e., objects, characters and animals that the child imagines are in the story setting as she enacts. Across all enacted scenes, 73% had some degree of setting imagined by the children. There were on average two environmental elements evident in the enacted scenes. Figure 42 shows the manner in which environmental elements were manifested. Most of the environmental elements were made evident through *enactment of interacting with the element* (58%), e.g., targeted picking up action of a gold nugget, looking around at the "real beautiful flowers" in the jungle. The rest (26%) were evident only through *narration by either the director or the actor's speech*.

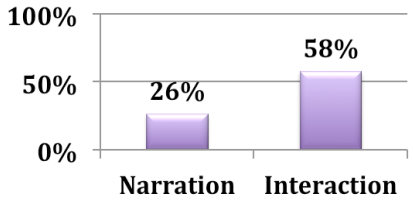

Figure 42. Expression of environmental elements

Summary of DiME Pilot Study Findings

The goal of performative authoring is to enhance the creativity, coherence and richness of children's storytelling by tapping into the imaginative power of pretend play to provide children with the freedom to imagine and the transparency to translate their imagination into actual story-products. Children showed great flexibility in how they collaborated within DiME's director-actor framework to create the story content and the meta level management of process through the director's initiative, co-creation, and in-character acting. All of the three collaboration methods were spontaneous, a lot more like improvisional theater rather than a scripted play. DiME itself did not

enforce or integrate story planning as part of the system interface. Instead, we gave children the option of planning their story using large drawing sheets and markers before enacting, but few of them used them. When used, the children would write out the enactment scenes in their planning sessions. Although we would like to maintain the free flow nature of imaginative play in story enactment, performative authoring as a storytelling method can lead to holistically better stories only when narrative structuring is also supported through the system.

Text was not used in the story enactment system as we expected. We planned for text to be used to describe scenes that advance the story. This indicates that text in a performative authoring system can be integrated in several ways, e.g., as summary textboxes, story scene textboxes, encapsulation textboxes (for prologues and epilogues). This also shows that the filmstrip metaphor that we decided to use to convey the idea of a story as a series of animation frames in DiME is hard to grasp in the child's mental model. A filmstrip is common knowledge for an adult with even a basic understanding of movies. For a child however, authoring a story by creating a collection of scenes did not seem to be intuitive. This runs counter to our intention of extending and sustaining the child's story imagination, and suggests the need for more research to investigate appropriate visual interface metaphors that can convey the connectedness of an animated storyline to children. Moreover, the tendency of children to use a single frame to enact whole, self-contained short stories is also counter to the quick editing and iterative process that is critical to creation or authoring. While using frames for whole stories may not be a problem for consumption-oriented storytelling systems, the capability for quick editing is important in creativity-oriented systems. The problem is that long and continuous enactment segments are unwieldy, and not amenable to the kind of iterative and rapid editing that support creative manipulation. We may need to investigate features that from the child's perspective, allow the system to encourage and support the creation of shorter, micro-enactments that can be edited quickly and constituted into larger story arcs. The support of the layering of imagination over reality through DiME in terms of character play occurred mostly through first-person acting. Taking the role of a character in their story from an egocentric point-of-view required children to engage in perspective-taking and the development of a theory of mind. Object imagination was satisfactory with a good proportion of perceived, projected and imagined props used.

VI.8 Summary of Phase II Design

Based on results from our 'physicality' study (Section VI.3), we decided to design DiME enactment props to have generic affordances to allow for imaginative play while provide sufficient scaffolding to support mental projections. Based on results from our 'contextual digital background' study (Section VI.4), we designed the enactment screen interface such that the cartoon avatar moves against a blank screen, enabling and encouraging the child to project environmental details in her mind's eye. Based on the findings of our pilot study, DiME showed great potential for the support of creative storytelling through pretend play. The findings of our pilot study further led us to

the following design decisions, which were made with respect to the DiME system and setup in preparation for further evaluation:

- The DiME system is better used in pairs.
- The screen display presenting the real-time animated avatar of the child ‘actor’ should be placed such that the director has full view of it, but the actor only has limited, partial view of it.
- Further research is needed to evaluate how text can be effectively integrated into DiME. Since text is not critical to the approach of performative authoring that we want to test, the text option was disabled.
- Instructions have to be carefully prepared to explain the visual interface of DiME to the children before use of the system.

CHAPTER VII
PHASE III: EVALUATION *

VII.1 Evaluation Research Questions

Phase III of our research seeks to evaluate the approach of performative authoring as operationalized through the DiME testbed system for its effectiveness in supporting and facilitating children's creative performance and creative self-efficacy. In so doing, we come back full circle to our overarching question of how digital technology may augment the 8- to 11-year old child's creativity. Phase III asked the following research questions:

1. What are the effects of DiME on the quality of children's storytelling?
2. What are the effects of DiME on children's degree of creative self-efficacy?
3. What are the interactional properties of DiME that produce effects on children's creative performance and self-efficacy?

VII.2 Study Description

The study was conducted at two elementary school summer camps with the revised version of DiME and the modified protocols and instruments after the pilot study. Eleven children (8 girls, 3 boys) participated at the first school over two weeks, and 9 children (6 girls, 3 boys) took part at the second school the following two weeks, yielding a total of 20 children. Parents voluntarily signed up their children by completing a consent form and a *personality* questionnaire (Big-Five Inventory (Rammstedt & John, 2007) — the BFI-10 that includes extraversion, agreeableness, conscientiousness, neuroticism, openness) for their participating child (underlining represents study variables). At each school, gender-matched children were paired and taken to a room where the motion tracking cameras and the DiME system was set up. Each pair took between 2 to 4 hours (approximately 3 hours on average) to complete the study, which was facilitated by two researchers. Because of an odd number of sign-ups for the study, a child at each site did not have a partner. In these cases, one of the researchers played the role of the 'partner', but the child was allowed to make all creative decisions and actions. The study followed the protocol described below:

(i) Ice-breaking exercise: The researchers first engaged the two children in a simple 'In the River, On the Bank' game.

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(ii) Minor's assent: Verbal assent was obtained from each child for her willingness to participate before the study session was formally started.

(iii) Pre-questionnaires: Each of the two researchers assisted one child to fill in several questionnaires —

a. Using the smileyometer (Read & MacFarlane, 2006) (5-point Likert scales with smiley graphics), the first questionnaire assessed the child's *pre-level of self-efficacy in creative storytelling* (Beghetto's (Beghetto, 2006) 3-item 'creative self-efficacy measure' – I am good at coming up with new ideas for stories; I have a lot of good ideas for stories; I have a good imagination for stories).

b. The second questionnaire assessed the child's *visual imagery ability* using Sheehan's adaptation of Bett's 'questionnaire upon mental imagery' (Sheehan, 1967) , which asks the participant to rate how clearly she can visualize various things relating to the five senses (appearance, sound, taste, etc.) on a 5-point scale (graphical versions of 'really clear' to 'not at all clear' were used).

c. The third questionnaire assessed the child's *baseline level of creativity* as measured by Guilford's (Christensen, Guilford, Merrifield, & Wilson, 1960) 'alternate uses test' that asks the participant to come up with alternate uses for various objects (e.g. ping pong ball, brick, pen).

(iv) Control condition: We used 'comics drawing' as a control to the enactment-based intervention that is the subject of our investigation. Drawing is a common instructional tool used in the form of 'creative notebooks' to encourage storytelling in children in the classroom. After being guided through an example, the two children were asked to create a story on the theme of 'An adventure in the jungle' by drawing a 'comics'. After that, the two children were each asked to write separately the story they just made on paper.

(v) Treatment condition: The researchers explained the DiME system to the two children by creating an example story of 3 scenes/frames where one researcher played the role of the 'director' to control the recording of the animation, and another played the 'actor' who enacted the scenes. The children were then asked to create a story on the theme of 'An adventure in the cave' using the system. Figure 36 shows a pair of children enacting a story scene. The children were then separated and asked to write the story they just made, just as they did in the control condition.

(vi) Post-questionnaires: Each child was assisted by a researcher to complete a questionnaire that assessed her:

a. *General attitude* towards different types of story authoring methods, including writing, keyboard typing, and enactment-based authoring, using the 5-point smileyometer.

b. *Preferences* with regard to the story authoring methods using the Fun Sorter from the 'Fun Toolkit' (Read & MacFarlane, 2006), whereby the child ranks the three methods from 'Best' to 'Worst' on several dimensions (Like a lot, Is the most fun, Makes me feel happy, Is the easiest).

c. *Motivation to re-engage* with creative storytelling using the different story authoring methods using the 'Again-Again table' from the 'Fun Toolkit' (Read & MacFarlane, 2006), whereby the child chooses 'Yes', 'Maybe' or 'No' to the question 'Would you like to do it again?'.

d. *Post-level of self-efficacy* using different methods to author stories (measured using the same 3-item creative self-efficacy scale (Beghetto, 2006) used in the pre-questionnaire).

Owing to time constraints, 2 pairs out of the 20 children completed only the treatment condition. The rest of the pairs underwent a within-subjects study design that counterbalanced the order of the control and treatment conditions‡. Four pairs (including the child with the researcher 'partner') engaged in the control condition first and the treatment condition second, and 4 pairs (again including one child with the researcher 'partner') did the reverse.

VII.3 Data Analysis

Responses to variables measured using 5-point Likert scales (personality, creative self-efficacy – CSE, visual imagery ability, general attitude) were coded and averaged into a mean score. For the baseline creativity level, alternate uses were coded according to Guilford's (Christensen et al., 1960) method on dimensions of originality, fluency, flexibility and elaboration, and a mean score was generated for each child. For the ranking of story authoring methods on dimensions of liking, fun, happiness and ease-of-use, each method was assigned a score based on the rank in which it was placed by the child (e.g., first rank is assigned a score of 3, second rank a score 2, and third rank a score of 1).

The written stories provided a common creative output that could be compared across the treatment and control conditions. They were evaluated using Amabile's (1982) *consensual assessment technique*, whereby a panel of experts rate creative products using their subjective understandings along several dimensions. The children's stories were retyped with all grammar mistakes corrected so that language abilities do not present biases to the evaluators. Three 'field experts' (one with expertise in HCI and two with extensive experience as elementary school teachers) were asked to rate the stories on dimensions of creativity, coherence, richness, and narrative structure using a scale of 1 (Not at all) to 5 (Very). The scores of the evaluators were averaged for each dimension, and were integrated across dimensions into a story quality score.

To characterize the creative self-efficacy (CSE) experience of children in the study, we analyzed the data collected for 8 children (6 girls and 2 boys) in our study by using a framework based on the four determinants of self-efficacy that was described in Chapter 3, notably performance mastery, vicarious experience, verbal persuasion, and physiological arousal. The operationalization of these four measures are described in Table 13. The children whose data was selected for in-depth analysis were 2F, 4F, 14F, 16F, 3M, 9M, 13F and 1F.

‡ Animated stories created by the children can be seen on the TEILab YouTube channel: http://www.youtube.com/playlist?list=PLAjR1N5yEJPKt1SR2sthWDiQrndnlVO5Q

Table 13. Operationalization of CSE determinant measures

Measure	Conceptualization	Operationalization
Performance Mastery	Attribute ownership of ideas to oneself	• Total number of ideas proposed by the child • Number of the child's ideas that are integrated into the final product
Verbal Persuasion	Feedback from others on one's output or activity	• Number and valence of evaluative comments directed at the child by herself or her partner
Vicarious Experience	Comparisons with work of others	• Number of comparative comments involving one's output
Physiological Arousal	Overall experience	• Self-reported scores of fun and ease-of-use of the storytelling method

Data sources comprised the video and audio recordings of both the flipchart and enactment sessions, the flipchart writings/drawings, and the final animated cartoon story created by the children. The qualitative coding approach (Strauss & Corbin, 1990) was used to analyze these data sources. The analysis was done by three coders, with consistency checks being done by a single coder after every coding phase. Samples of these data sources are shown in Figure 43. For each children pair, we analyzed the flipchart discussion and the enactment process of the creation of the first and the last story scene. In total, for a total of 8 children in the study, 8 flipchart session segments and 8 enactment scenes were analyzed in full. This amounted to over 112 minutes of video transcribed and coded into around 1648 interaction, discourse, or action events.

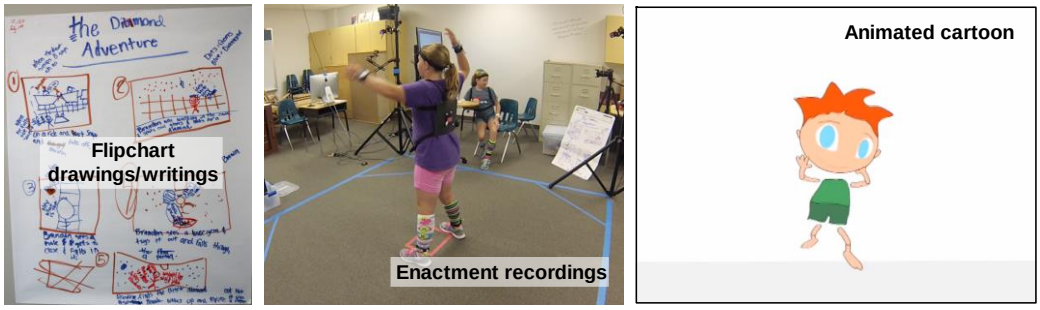

Figure 43. Samples of data sources

The analysis phases involved the following:

(i) *Product review:* For the first and last story scene of each final flipchart drawing/writing and animated cartoon, an 'idea digest' was made, listing all distinguishable idea units that the story scene contained, similar to the process used in the 'media effects' study in Section V.3. Each coder first viewed in full the flipchart and the cartoon, and their associated 'idea digests', of the children pair whose data was being coded to obtain a sense of the story created. The 'idea digests' were further used in the 'determinants scoring' phase described later.

(ii) *Transcription:* For each children pair, the video recordings of the flipchart and enactment sessions of their first and last story scenes were completely transcribed with each utterance being marked with a timestamp, child ID, and associated gestures/actions;

(ii) *Reference chain analysis* (David McNeill et al., 2008)**:** Each utterance in the transcripts was then coded based on three levels of reference – *object*, where the referent pertains to the story being created; *meta*, where the referent was the process of story construction, not the story being constructed per se; and *para*, where the referent was to things and persons in the environment that are unrelated to either the story or the process of story construction;

(iii) *Utterance analysis:* The transcript was re-analysed with a view of identifying whenever a new story idea was proposed by a child, and whether it was followed up by the other child. Story ideas were mostly in utterances coded as *object*, but story ideas that were proposed directly through action (i.e. by directly acting or drawing without any explicit verbal description) were also counted. *Meta* utterances were labeled with appropriate tags, such as 'Evaluation', 'Directive', 'Role negotiation', or 'Number of scenes'. Evaluative comments were analyzed as to whom it was targeted at, whether it had positive or negative valence (e.g., "*That was perfect*" versus "*You took too long*"), and to whom or what the cause seems to be attributed to (the child herself, her partner, or external factors such as the system or other agents);

(iv) *Determinants scoring:* For each child in each of the session analyzed (flipchart first scene, flipchart last scene, enactment first scene, enactment last scene), a Creative Self-Efficacy (CSE) score was calculated using the formulas shown in Table 14.

Table 14. Calculations for CSE determinant measures per session

Performance Mastery	Verbal Persuasion	Vicarious Experience	Physiological Arousal
No. of ideas by the child / Total no. of ideas No. of child's ideas in final flipboard/ cartoon video / Total no. of ideas by the child	No. of positive comments received / Total no. of evaluative comments	No. of positive comparative comments / Total no. of comparative comments	Ease-of-use rating + Degree of Fun rating / Max score possible

A personality profile was also generated for each child by averaging the scores from the BFI-10 as per (Rammstedt & John, 2007). The rankings of each storytelling method on dimensions of 'fun' and 'ease-of-use' were coded by assigning 3 points to a method if it was ranked first, 2 points if it was ranked second, and 1 point if it was ranked third. We note that sometimes a child ranked a method in-between two ranks. Such cases were assigned half-point scores.

(v) Theme analysis: Tags that were assigned to utterances in the video transcript underwent a process of thematic coding whereby categories were formed by grouping tags referring to one issue (e.g, system design, partner's personality, etc.). We triangulated among observation notes and the categories generated to define themes of interest that influenced the creative storytelling sessions of the children.

VII.4 Study Results

Quantitative Results

All scores were entered into the SPSS statistical software package. A repeated measures ANOVA test (child's personality variables as covariates) yielded a statistically significant interaction of *Time* × *Extraversion*, $F^{(1, 14)} = 5.70$, $p < .05$, with the mean post-CSE scores ($\mu = 4.52$) being higher than the mean pre-CSE scores ($\mu = 4.42$). To investigate the interaction effect further, we classified the children into three groups based on levels of extraversion. Children with extraversion scores from 0 to 2.5 were categorized as 'low extraversion'; children with extraversion scores from 3.0 to 3.5 were classified as 'medium extraversion'; and children with extraversion scores from 4.0 to 5.0. The actual CSE and extraversion scores and categories of the children in the study are shown in Table 15. As shown in Figure 44.A, when the interaction effect of *Time* × *Extraversion* is visualized with the children divided by extraversion category, creative self-efficacy scores increased from pre-study to post-treatment times for children with low and medium extraversion levels, but not for high extraversion levels.

Table 15. Personality scores of children

Child ID	Pre-CSE	Post-CSE	Extraversion Score	Extraversion Category
FR1F	4.5	4	4.5	High
FR2F	4.5	5	4.5	High
FR3M	2.5	4.7	2.5	Low
FR4F	3.5	4	3.5	Medium
FR8F	5	5	5	High
FR9M	3	4	3	Medium
FR11F	3	4.3	3	Medium
FR13F	3.5	4.7	3.5	Medium
FR15M	3	5	3	Medium
FR14F	2	4.3	2	Low
FR16F	2	3.7	2	Low
Hm1F	3	5	3	Medium
Hm2F	3.5	5	3.5	Medium
Hm3M	2.5	4.3	2.5	Low
Hm4M	3.5	5	3.5	Medium
Hm5F	3	4.7	3	Medium
Hm6F	2	2.7	2	Low
Hm7F	3.5	4.3	3.5	Medium
Hm8F	2.5	4.7	2.5	Low
Hm9M	4.5	4	4.5	High

A repeated measures ANOVA test (visual imagery ability and baseline creativity as covariates, and the child's age and condition order as between-subjects factors) produced a statistically significant *Medium × Baseline Creativity level* interaction effect between the quality of the written story created from enactment-based authoring and written story quality from comics-based authoring, $F^{(1, 6)} = 6.061$, $p < .05$. Looking at the relationship between authoring methods and written story quality based on three different levels of baseline creativity level, we found that the quality of enactment-authored stories supercedes comics-authored stories only for children with low baseline creativity (Figure 44.B).

Moreover, repeated measures ANOVA tests for each story quality dimension separately, we see a *Medium × Baseline Creativity level* interaction for Story Creativity, $F^{(1, 6)} = 8.076$, $p < .05$, with stories from comics-based authoring having a mean score ($\mu = 2.65$) higher than those from

enactment-based authoring (μ = 2.64). We also see a *Medium × Baseline Creativity level* interaction for Story Richness, $F^{(1, 6)} = 16.714$, $p < .01$, with stories from enactment-based authoring having a mean score (μ = 2.59) higher than those from comics-based authoring (μ = 2.52). A repeated measures ANOVA test (with personality variables as covariates) showed a statistically significant *Attitude × Extraversion* interaction effect among the children's attitudes towards different methods of story creation, including enactment-based authoring, typing and writing, $F^{(2, 36)} = 4.462$, $p < .05$ (Figure 44.C1). Categorizing the attitude scores based on extraversion levels, we found that enactment-based story authoring is least favored by children low on extraversion. Children with both medium and high extraversion viewed enactment-based authoring very favorably (Figure 44.C2).

With regard to preferences, a Friedman Test yielded a statistically significant difference in the ranks of the three story authoring methods surveyed in terms of liking ($\chi^2(2) = 12.177$, $p < 0.01$), fun ($\chi^2(2) = 17.949$, $p = 0.000$) and feeling of happiness ($\chi^2(2) = 8.380$, $p < 0.05$), but not in terms of ease-of-use (Figure 44.D1). Furthermore, a spreadsheet count tabulation of the children's responses on their willingness to re-engage in creative storytelling using the various story authoring methods showed a clear motivation (80% 'yes') to create other stories using enactment-based authoring (Figure 44.D2).

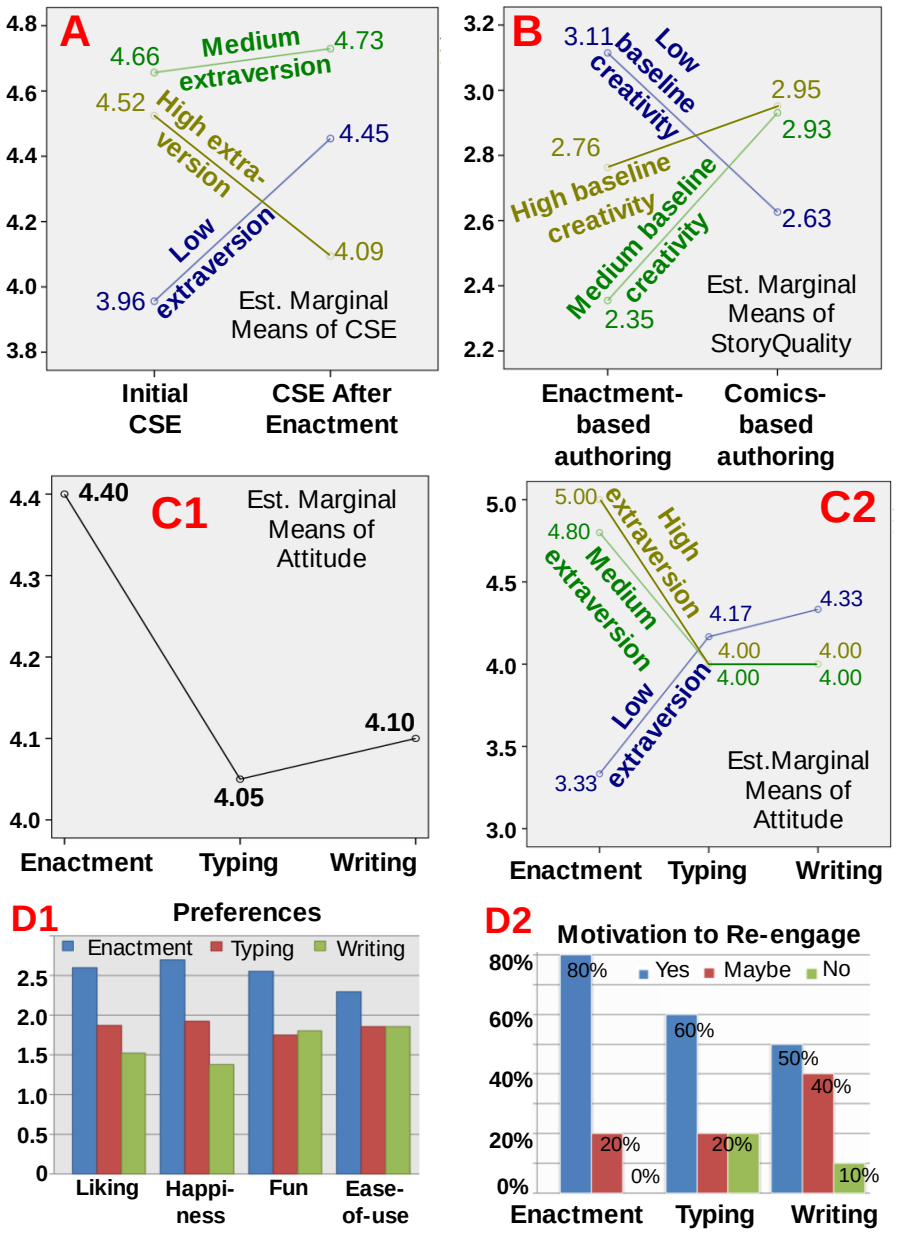

Figure 44. Graphs from study results

Qualitative Results

We also analyzed the interview comments from the children using the qualitative approach of open, focused and axial coding (Strauss & Corbin, 1990). We wanted to find out what the children liked and disliked about the enactment-based authoring method. Phrase units (minimally codable unit of text that carries an idea or a meaning) were extracted from the interview transcripts and assigned a code. The list of codes was then grouped into themes or categories. Six themes

emerged from the interview data as to why they liked the approach: *Fun & Play; Interactive control; Problem-solving; Authoring control; Actualization of real experiences; and Sustained interest in acting*. Among those, the element of fun and play that the system afforded was one of the main reasons: *"Because it was funny. Because I threw the ball so many times. And I was saying I hate you bears." [Fr11F]; "It was really fun…and…um..like how it was … like how I kept on saying ooo la la because I was waiting for Alex to stop the recording." [Fr2F].*

Another significant reason was the ability to control a character remotely in an interactive manner: *"I get to be a funny character. I could move and see what it's like." [Fr8F]*; *"I like how I can control it. And when I control it, I feel like it's a video game I mean." [Hm7F]*. An interesting reason that was mentioned was the pleasure in figuring out how to act out a particular idea, akin to problem-solving: *"I liked acting out when he (story character) figures out it was a dream. When he says 'there's the biggest diamond in the world' or something. And then the narrator is like then he woke up'. So now you got to act like he was sleeping, then he just woke up, and it was pretty fun."* All but two children said that there was nothing that they did not like. The themes from the two children included the *constrained acting space* that was provided, *getting tired when the scene to be acted was very long*, and having *difficulty to remember lines* when acting out.

Creative Self-Efficacy (CSE) Findings

The results of the various CSE measures from the calculations performed in Table 14 are shown in Figure 46 and Figure 47. During our analysis of the results, we noticed that patterns emerged when we separated the data of the children whom we observed as being generally more dominant from the data of those who were more quiet. The actual BFI-10 scores for the various personality traits of the 8 children whose data was analyzed in-depth, as obtained from the parents, confirmed much of our observations of the power relations in the children pairs, although not for all pairs. The personality scores were visualized in a radar chart format based on pairs of children who worked together in Figure 45. In Pair A, although 2F is shown as being more extroverted from her personality scores than 4F, our observations were adamant that 4F was the more dominant child. In Pair B, 14F and 16F scored the same on extraversion. Our observations were that 16F was clearly the more dominant child. Our observations of dominance in social dynamics were in line with the extraversion scores of the children in Pairs C and D. It is interesting that the children who we observed as being more dominant tended to score higher on extraversion and more often than not, lower or equivalent on conscientiousness. We labeled the group of children who we observed as being more dominant in their pair as 'extroverted', and those who were less dominant in their pair as 'introverted'. Figure 46 and Figure 47 present the results of the CSE measures for the children who we labeled as extroverted/more dominant separately from the introverted/less dominant children so as to make emerging trends clearer for the flipchart and the enactment sessions. Hereafter, identification codes (number followed by 'M' or 'F' for gender) are used to refer to the children in the presentation of the results.

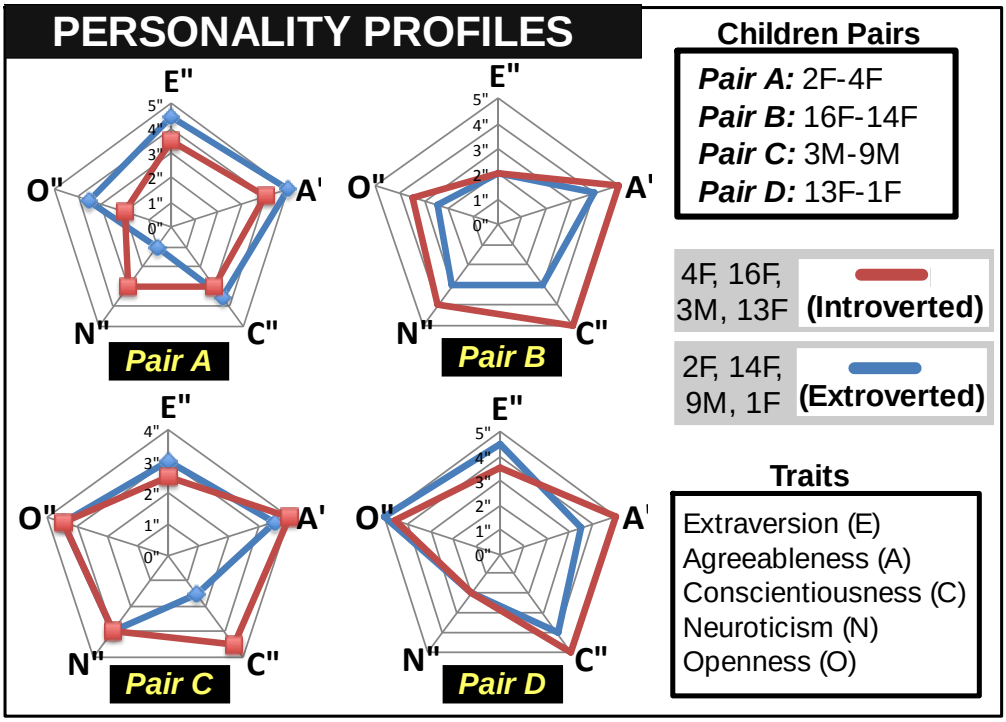

Figure 45. Personality profiles of each children pair

A. Performance Mastery

In the first story scene creation session, extroverted children offered more ideas in the enactment session than in the flipchart session. For introverted children, the number of ideas offered was higher in the flipchart than in the enactment session of the first story scene. This trend is depicted by the red upward and downward arrows in the leftmost barcharts in Figure 46 (except for Pair 1F-13F, which we address later). Interestingly, this trend reverses by the last story scene creation. Extroverted children offered fewer ideas in the last enactment scene than in the last flipchart scene, and introverted children advanced more ideas in the enactment session than in the flipchart session. This is shown by the green downward and upward arrows in the second leftmost barcharts.

As for the number of ideas that were actually integrated into the final product of the session, for the first story scene, the extroverted children had fewer ideas integrated into the animated cartoon than into the final flipchart, even though they offered a greater number of ideas during that session. On the contrary, the introverted children had more ideas integrated in the animated cartoon despite offering fewer ideas (except Pair 1F-13F again). This is shown by the red downward and upward arrows in the second rightmost barcharts. However, for the last story scene, there seems to be a mixed trend (rightmost barcharts) whereby some of the extroverted children had

more ideas integrated in the animated cartoon, while some introverted children had more.

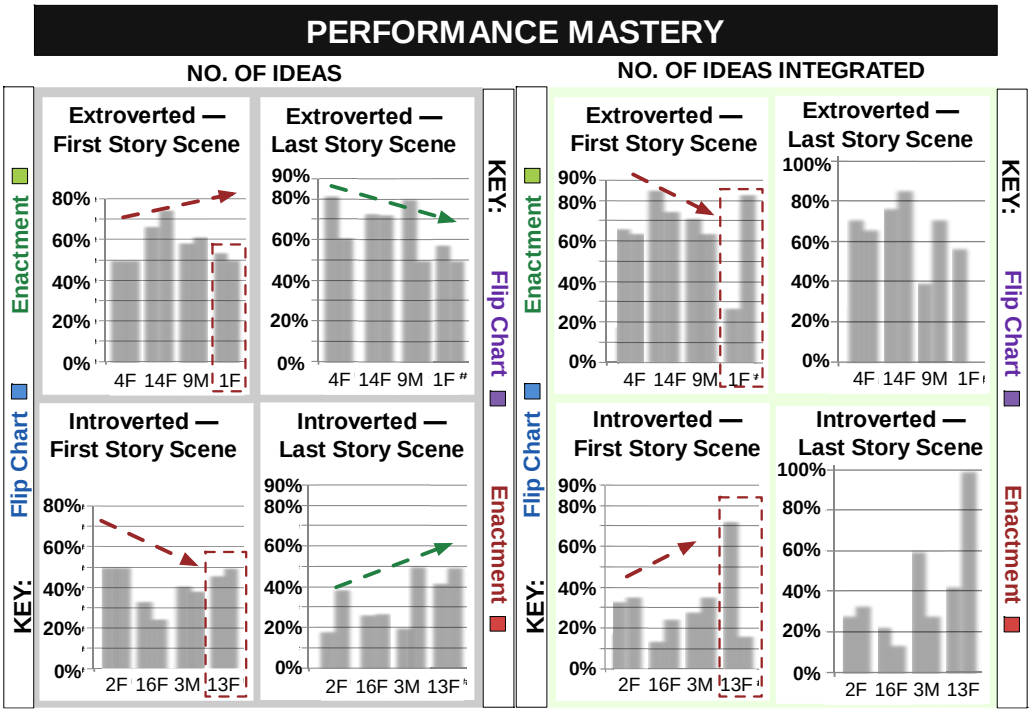

Figure 46. Results of Performance Mastery measures

B. Verbal Persuasion

Almost all positive evaluative comments were made in the enactment session irrespective of first or last scene, except for 16F who received positive evaluations in the last flipchart story scene creation (see red bar in Figure 47 left). We address this anomaly later.

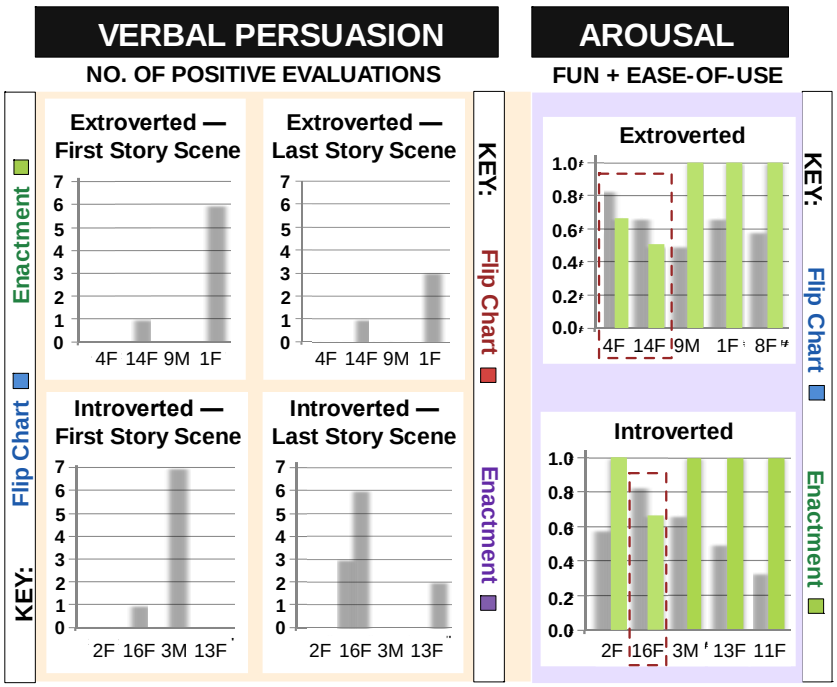

Figure 47. Results of Verbal Persuasion and Physiological Arousal measures

C. Vicarious Experience

We did not find any utterances in our coding related to comparisons with the work of others (e.g., existing animated cartoons, stories by other children) probably because DiME did not allow children to view what others have created before.

D. Physiological Arousal

All of the children rated the enactment sessions as more enjoyable than the flipchart sessions, except for Pair B (16F-14F) and child 4F (see Figure 47 right).

Interactional Affordances of DiME With Respect to Self-Efficacy

Our theme analysis clarified the anomalies (especially with Pair 1F-13F) that we saw in the barcharts, and helped to elucidate the children's CSE experience with DiME further. Below, we describe the three main influencing themes:

A. Social Dynamics

These influences come in terms of each child's personality and prior collaboration experience of the two children in a pair. For instance, Pair D was best friends before the study, Pairs A and C knew each other, and Pair B did not know each other before. 1F and 13F in Pair D thus started out more or less equal in terms of number of ideas offered in the first story scene creation sessions of both the flipchart and the enactment sessions.

The degree of extraversion of the child was also key. For example, we observed that 16F in Pair B was really quiet and shy. Her personality profile (Figure 45) as well as comments from

camp administrators confirmed that. This resulted in her partner, 14F, having to make many of the creative decisions by herself, which is reflected by the high number of ideas offered and integrated for 14F in Figure 46. 16F's extreme shyness also resulted in 14F encouraging her to engage more, even during the flipchart session, which explains the positive evaluations in the last scene of the flipchart session (red bar in Figure 47). Moreover, the introversion of both 14F and 16F may have contributed to the lower arousal ratings they gave to the enactment sessions as compared to the less overt flipchart session.

B. System Design

Some DiME system features were particularly influential in the children's interactions. The 'review' or 'playback' function played such a role. A striking example was Pair D. At the start of the enactment session, 1F imposed many of her ideas (equal number of ideas offered, but disproportionately large numbers of ideas integrated for 1F in Figure 46. About halfway through the enactment session, 13F displayed a transformation in conviction and motivation to create the story that would persist to the last enactment story scene. The change was triggered by one very clear point in time after the pair has reviewed the playback of the second recording take of their enacted scene. 13F exclaimed "Showbiz!" followed by "I think we need to redo". Thereafter, she became more assertive, telling her partner what to say and do and taking charge of the story construction process (shown by the 100% of 13F's ideas integrated in the last enactment scene in Figure 46.

Although DiME was mostly stable throughout the study, minor problems (e.g., 'review video' button not working on first click) with the system, which were quickly fixed, during the enactment sessions of Pair A, may have caused 4F's lower rating of enactment-based storytelling as opposed to writing/drawing.

C. Core System Concepts

The core concepts around which DiME was designed, namely its grounding in body-based enactment and its provision of a cartoon mapping, also influenced how the children created their story. For example, 3M in Pair C was the sole actor throughout the entire activity. His partner and him decided after the first enactment scene to maintain fixed 'actor-director' roles because they were both very enthusiastic about their roles. Interestingly, even though the system did not track facial expressions, 3M enacted raised eyebrows, grimacing, smiles, etc., perhaps evidence of his complete immersion into the story scenes. Another example is 16F, whom we mentioned earlier as being very introverted. Although her arousal rating was lower for enactment-based storytelling, during the enactment session itself she was up in smiles, laughs and giggles every time upon reviewing her cartoon-self acting.

Some Initial Design Insights for CSE-Support Systems

The insights that we gained from our study with DiME provide some guidance as to how to design enactment-based systems for CSE support:

A. Performance Mastery:

Particular attention has to be paid to how children perceive that their ideas are accepted and integrated into the creative product through the system. For instance, the level of automated or predefined support given by an authoring system needs to be balanced with how perceivable idea attribution is to the child throughout the creative act;

B. Enactment Fidelity:

Our DiME system reflected children's broad movements onto the cartoon character. The children made use of this affordance and went beyond, despite the lack of precise track- ing of, for instance, facial expressions. CSE may not suffer as long as the cartoon animation is accurate enough to reflect details of the child's enactment that she consciously put in as being relevant to her story. This indicates that designing an enactment-based mapping system for perfect accuracy may not be essential to support self-efficacy, therefore increasing the likelihood that DiME-like systems could be developed in cost-effective ways;

C. Feedback:

Feedback may act as a catalyst for transformative change in a child's confidence in her ability to story-tell. The child seeing her animated story scene wants it to be 'perfect', and is willing to re-engage in the authoring process over and over to 'get it right', be it to match her imagination as closely as possible or simply to eliminate errors in acting, directing, etc. Conversely, an 8-year-old child writing a story often do not have the motivation or is unwilling to rewrite it, even only for a second time. This potential of enactment-based storytelling to motivate self-efficacious behaviors may be tremendously useful in both formal and informal learning environments.

VII.5 Summary of Phase III Findings

Performative Authoring and Story Quality

In terms of outcome, children's stories created using enactment were judged as being significantly different from their stories created through comics/flipchart drawings. But this difference occurred only for children with low baseline creativity levels, who produced stories of higher quality using performative authoring than with comics-based authoring. Improvement in the quality of the stories occurred in terms of richness, i.e. how textured and detailed the story is. No significant positive effects were found on the other dimensions of story creativity, coherence and structure. This may be partially explained by the novelty of the system to the children. We observed that for many of the children, especially those with high baseline creativity, the story scenes produced were strongly influenced by the graphical props available in DiME. They wanted to use the different props available, and adapted their planned stories to the props as they went on. This may be the cause of the reduced coherence and structure of the children's stories as they reconstructed them in writing, since recall and retelling became more difficult. Unlike coherence and structure however, story richness is evident within each story scene. Since a prop is chosen for and kept throughout each scene, the within-scene richness was not influenced by system

choices. With greater familiarity of DiME, highly creative children may produce stories of better quality with performative authoring than with other methods like drawing comics, which was already a familiar medium for them at the point of the study.

Performative Authoring and Motivation

The children's feedback on what they liked and disliked about the performative authoring approach to creative storytelling provided support for the features that we included in the DiME system. The system provided fun and excitement, prompting the children to step into the 'magic circle' (Huizinga, 2004) to create through playful interactions, interactive control of virtual characters and props, and problem-solving of how to act ideas through the body. Generally, the children exhibited positive valence towards performative authoring, and the majority were willing to re-engage in creative storytelling using the medium.

Performative Authoring and Creative Self-Efficacy

Children's sense of perceived self-efficacy to create stories using performative authoring showed an increase over their initial level of CSE prior to the enactment-based story creation. However, this increase in self-efficacy to create seems to be affected by the child's personality, especially the degree of extraversion. Extraversion refers to the extent to which one is outgoing or sociable (Rammstedt & John, 2007). Our results suggest that a more reserved child experiences improved CSE with enactment-based authoring, but not a highly extraverted child. The influence of extraversion is not surprising, but the positive impact on more reserved children was rather unexpected and exciting. It may be that our approach of performative authoring is directed by an objective function of creating an animation with a cartoon character, thereby presenting a form of 'transformed self' where the child is the actor, but the representation that is shared or viewed is the cartoon character. Thus it may feel less threatening for children who typically attempt to minimize social exposure, causing them to be more self-efficacious in creating stories with our system.

The lack of effect of DiME on the self-efficacy of high extraversion children may be because they gain little from the anonymity afforded by the transformed-self-effect of the cartoon output. There is evidence that self-efficacy is positively related to extraversion (Robins, Tracy, Trzesniewski, Potter, & Gosling, 2001). It could be that a single study session did not have an appreciable effect on their already high self-efficacy. Perhaps longer exposure to and use of DiME may have a measurable effect on the self-efficacy of extraverted children.

There was an interesting paradox uncovered regarding improvements in self-efficacy in low extraversion children and their favorability ratings. Although their self-efficacy in storytelling increased with DiME, low-extraversion children nevertheless indicated a stronger preference for and a more positive attitude (in terms of liking, fun and happiness) toward more traditional storytelling methods (writing and typing) over enactment-based authoring. It is likely that these children's low extraversion made them uncomfortable in the unfamiliar study condition with unfamiliar experimenters, and this discomfort caused their negative favorability ratings for the use

of DiME. With long-term use, the effects of DiME on their favorability ratings may echo their positive creative self-efficacy with the system.

All being equal, it appeared that DiME has a positive or equalizing effect on CSE determinants. The dominance of ideas attributable to introverted children in the enactment scenes suggests that the introverted children engaged more enthusiastically and forcefully with performative authoring than with flipchart storytelling. By the last enactment scene, social dynamics and personalities sometimes overruled that positive effect, and some extroverted children had more ideas integrated. Yet, this points to DiME's equalizing potential. Despite all factors, performative authoring provides an opportunity and motivates introverted children to engage in creative storytelling.

It is interesting that the group of children (that we classified as 'introverted') on whom storytelling in DiME had the most effect are characterized by not only low extraversion but also by high conscientiousness. Conscientiousness is defined by a personality trait of being careful and thorough, and wanting to perform a task well. Performative authoring appears to encourage the introverted children to assert themselves more and to overtly propose and integrate what they think are good ideas in the story, perhaps because they care about the outcome and want it to be distinctive. The overall positive physiological state also provides support for DiME's potential to nurture CSE. It could be argued that the novelty of the system explains the children's fun ratings, but we believe that beyond novelty, DiME allowed the children to create something that they felt proud of. We saw that especially when after the completion of the study, we gave the option to the children to share their animated story on a public website using their real names or pseudonyms. The response was an enthusiastic 'yes' from all of the children, even the introverted children, and they were all excited to showcase their stories.

CHAPTER VIII
PHASE IV: INTEGRATION

VIII.1 Integration Research Questions

We set out to study how digital technology may be harnessed to positively influence the child's creativity in terms of their performance in creative storytelling and their sense of creative self-efficacy. Through a study on 'medium effects', we uncovered the theoretical concept of *micro-enactment*, and proposed a model of how the process of creative storytelling may function. Two studies that investigated the 'physicality' and 'digitality' aspects of enacted storytelling with children helped us to develop the design concept of *performative authoring*. The studies informed us as to how to design affordances that would support the child's imagination, and helped us to understand the compromises that need to be made in a digitally-augmented enactment-based storytelling system. We also developed the MAIA evaluation methodology that assesses children's *broader imagination* during their enacted storytelling. DiME was designed using *Finding-NEVO*, a design methodology developed to ensure scientific validity and faithfulness in research prototypes built to test seed ideas and rationale. A first pilot test enabled us to test the original DiME system for usability, and to understand the configurations and conditions under which the system works best with children. The performative authoring approach to children's storytelling, as operationalized in a revised version of DiME, was then evaluated in a study in two summer camps for its effectiveness to augment the quality of children's storytelling, and their sense of self-efficacy.

To summarize, results showed that the system positively affects mainly children who are low on extraversion and who start out with a low level of creativity (as measured on a creativity test – Guilford's Alternate Uses Test was used). Effects for highly extraverted children or children who are already highly creative were not significant. Less creative children produced better written stories with DiME, and more introverted children experienced increases in their sense of creative self-efficacy. However, in terms of motivation, more extraverted children were more inclined to like the system better. A story creation session with DiME is affected by three main factors: social dynamics, peripheral system design features, and features associated with the core performative authoring concept. These interactional affordances contributed to an equalizing function, allowing the less extroverted but more conscientious children to actualize better their creative potential in terms of story ideas.

In this dissertation, we were interested to explore beyond the use of DiME within an informal setting, such as an afterschool program or a summer camp, to a more formal learning environment, such as within the boundaries of a classroom and a school curriculum. The goal of our further exploration was not to produce any form of policy recommendations, but rather to gain

some initial understanding of the constraints under which DiME would have to perform to have real impact on formal elementary education, and to have grounds for us to be able to envision the integration of the approach of performative authoring into schools. Phase IV asked the following research questions:

1. How may the performative authoring approach to storytelling, as operationalized in DiME, be used by a teacher in a classroom?
2. What is the value of the approach to teaching?
3. What are the problems that may be associated with the approach when used in a classroom setting?

VIII.2 Teachers' Focus Group

We conducted a focus group with 4 teachers to understand how the DiME system may be integrated into the classroom and the school curriculum. The focus group was conducted in a typical room on the university campus, and lasted for about 2.5 to 3 hours. The teachers were recruited through announcements on the university listservs and directly to 3rd, 4th and 5th grade teachers via the administrative offices of two school districts: the College Station Independent School District and the Bryan Independent School District. Teachers were compensated at a flat rate of $70 for their participation in the focus group. The teachers were asked to sign and return a consent form via email before the day of the focus group. The protocol for the focus group was as follows:

1. Introductions and briefing
2. Presentation about goals of focus group and problem that is of concern, notably the Fourth-Grade Slump in children's creative functioning
3. Discussion on how creative storytelling is done in 3rd, 4th and 5th grades currently and the problems encountered
4. Thought exercise of the requirements for a system that would satisfy the teachers' needs to teach creative storytelling in 3rd, 4th and 5th grades
5. Presentation of the DiME storytelling system
6. Discussion on how DiME may be integrated into the elementary school classroom, including specific prompts like:
    a. How can you see yourself using DiME in your classroom?
    b. Design an activity/assignment for 3rd or 4th graders that involve the use of DiME. Decide on a story prompt/theme that you would give to your students as a storytelling assignment.
7. Discussion on traditional activities that may be similar to DiME
8. Wrap-up and compensation

Although the focus group generally followed the plan set out, we note that the discussion was allowed to be more free-flowing, and the conversation shifted in and out, and cut across the various topics. The entire session was video- and audio-recorded.

VIII.3 Data Analysis and Findings

The video and audio recordings were watched/listened to throughout, and episodes of significance were isolated and transcribed with timestamps using the InqScribe software. The transcriptions were imported into the qualitative data analysis software, NVivo. An open coding approach was taken to identify categories and themes from the data. Teachers were identified using ID codes (T1 to T4). The profiles of the teachers were as follows:

- **T1:** Has 1 year teaching experience of English as Second Language (ESL) in subjects including reading, writing and science in 4th grade.
- **T2:** Has 3 years teaching experience of 'dual language' bilingual reading and writing in 4th grade.
- **T3:** Has 16 years teaching experience of music in K-5th grades.
- **T4:** Has 11 years teaching of Math, Science and Social Studies in 1st to 3rd grades.

We describe below the themes that arose related to four main issues associated with DiME's integration:

Current Problems

A few problems were emphasized as being most amenable to benefit from the use of DiME.

A. Richness

T2, for instance, points out the difficulty of students to enrich their story with articulate low-level story details: "They're so quick to say in their story, I'm scared. And so..yes you were scared but show me that you are scared when you're writing, and that's a very difficult concept."

B. Written Text

T3 mentioned students' difficulty with the technicalities of written language: *"they cannot write English, but they could speak it"*. T2 reinforced that this problem occurs frequently with children whose native tongue is not English: *"especially for teachers of ESL (English as Second Language), oh there are a lot of mistakes. But if you only step back, the ideas are fabulous."*

C. Mechanical Actions

T4 pointed out that the methods currently being enforced for teaching sometimes lead to the children performing actions, that are meant to help them in the process of sensemaking of a story or narrative, mechanically without understanding the rationale behind the actions: *"Highlight this, circle this. And I'm like, kids are highlighting, they don't know why they're highlighting."*

D. Testing Standards

T4 expanded on the previous point, bringing the problem to a structural level in terms of how the test standards is counter to effective teaching: "*My kids don't develop their voice until after April, when I'm done teaching the STAAR (State of Texas Assessment of Academic Readiness),*

and I can start teaching them to write." This point was also illustrated by T3's episode: *"It's really horrific. I had a child who could write. She had wonderful writing skill, until she hit the 4th grade and then she's never ever recovered from the 'excellent teaching'. She still loves writing but it just really not the same freedom, and the same voice, and the same..."*

Current Activities

Some activities that the teachers currently use or have used before in their instruction to cater to the problems mentioned above included the following:

A. Story Acting

Each student acts out their story to a partner.

B. Story Narration

Each student narrates their story to a friend, and then revising their written narrative based on details that they included in their oral narration.

C. iPad Video Recording

The students video recorded themselves acting stories.

D. Picture Summaries

Each student would have an iPad displaying 5 to 10 pictures. The student would hold up a picture to a partner, who has to write down a certain number of words to summarize the picture. The pair would do this for all of the iPad pictures, and then sequence the pictures and the word summaries to obtain a complete summary of the story.

E. Drawing and Observation

"One of the thing that we did is that we drew an emotion, like angry, sad, shocked, or whatever it was, and we actually had to act it out…And they have to go to their primary drawing, and show me what angry would look like. So they would like grrr crush your teeth, and they would like write it down those observations, and try and take that and put it into writing" [T2]

Activities with DiME

A. Show, Don't Tell

Consensus was found among all of the teachers that DiME addresses most significantly the 'show, don't tell' aspect of the Language Arts class. The activity with DiME would proceed with the children first creating an enacted story either based on a story prompt or on a freely chosen topic. Each child would then write a personal narrative by watching their cartoon story, and submit the written story that would be subjected to grading. The transcript excerpts below illustrate the activity:

"Record that and then watch themselves, and then look kind of see their facial cues, their body language what did they see, so they use that to write their narrative." [T4]

"they could watch it and they could even compose, like if they still need composing, or whatever the practice. They could write down what they see themselves do." [T2]

"But I could see them, here ok, here is XXX or whatever, I don't know. Act that part out, and they go back, watch or read it, go act it out, now sit back, watch yourself and write it. And turn it into a narrative of that person right there" [T2]

B. Role-Playing

Another activity that DiME could be used for, according to the teachers, is to encourage the practice of perspective-taking. Students would first be given an existing story to read, or be read an existing story. They would then have to select a character from the story, and to act out the story with DiME as it would occur and be seen from the eyes of the selected character. The students would watch the resultant animated cartoon, and rewrite the story from the character's perspective. The following quote illustrates this activity best:

"Where they have to write from the perspective of either Sally or Lopper. So the goal would be to take a perspective, and I think there's a standard in 4th grade and it looks at how a character changes based on a given situation, I can't remember what it was. But anyway I'd do that and then tie it to narrative writing. So I would have them again act out the story of them either as one of those two characters, finding Hank who's eaten these chickens and he's supposed to be guarding them." [T4]

C. Actions-Music Association

DiME could be used beyond a Language Arts class in a music class to teach students how to 'feel' music. The activity would proceed as follows: The students would first listen to a music piece or a song. They would then decide on what the music conveys in terms of feelings and actions, and craft a story around the associations that they make. The students would act their story out using DiME, and then submit the resultant cartoon video integrated with the music to be graded. The following quote explains the activity:

"Express music with actions, and so they would listen to music and then act out a story that uses that music for the soundtrack. And they would submit it as a video with that music as a soundtrack. And then, the next project would be 'write your own music for your soundtrack'." [T3]

Problems with DiME Integration

A. Fitting in the Test

One of the main problems highlighted by the teachers with using DiME in the classroom was that DiME does not directly fit into any one aspect of the curriculum, or does not necessarily follow the story formats set up by the school districts. This would lessen the value of DiME in terms of helping teachers to prepare students for the end-of-year reading and writing examinations.

"Cause they need to see the format. They need to be able to see, here's a picture, personal narratives is gonna have a picture and have a caption under the picture, and then it's gonna say 'think about a time with this. Write about a time with that'. And it was the whole thing." [T4]

"if that doesn't specifically help them prepare kids for some aspect of the test, then the district is not going to allow them to put it into their curriculum" [T3]

"That's the problem, this would really free their imagination and let them do it, but I keep thinking it wouldn't fit in the test." [T3]

It was mentioned that it may be possible to counter this problem by enforcing 'writing' with the system use, either during enactment or after enactment while watching the resulting video:

"And then I would want them to have, to relate to the test, because they do need to have that at the end of the day, I'd want them to write it" [T4]

B. Cost-Effectiveness

Some concerns were raised as to the expense of the system. Especially if DiME is not shown to address specific portions of the curriculum, the value added of the system may not be enough to warrant the cost of installation and maintenance of such a technology: *"I don't know how, the district has practical, they might say, it is a lot expensive or anything"* [T2].

Benefits of DiME

Affordances of DiME that are being beneficial to the support of students' learning were either mentioned explicitly or revealed through discussion of how teachers' needs map to DiME. These include: *immediate feedback* – the ability for the child to see her story output immediately; *motivation* – the novelty of the technology making learning more "interesting", *multimodality* – enabling different input and output formats such as text, video, kinesthetic, aural; and *decrease in inhibition* – the masking of students' identity leading to increased motivation to engage: *"And I think they would see themselves as a cartoon instead of just them, as a person.. That kind of, there's something they may be more drawn to it, and be more like free, less inhibited, and they would really dive into more of their writing"* [T2].

One aspect that was mentioned by the teachers as being desired but not clear in DiME is the need for step-by-step guidance, or guided instruction in storytelling such as the scaffolding provided by graphic organizers in the layout of typical story elements (characters, conflict, setting, etc.).

VIII.4 Summary of Phase IV Findings

Our initial exploration of how DiME and performative authoring may integrate into a school setting, curriculum and practice indicated that teachers were, on the whole, very positive about the value that the approach may bring to their teaching in terms of helping students to learn and engage more readily. Features of DiME have corollaries in values espoused in current activities used by teachers, particularly in terms of collaborative work, enactment and review. DiME has the potential to address key problems in elementary education in terms of children's lack of sophistication in thinking and language skillsets, enforced teaching practices, and systemic and structural problems. These however will simultaneously act as barriers to the adoption of DiME into the classroom.

CHAPTER IX
CONTRIBUTIONS & EXTENSIONS

IX.1 Contributions

This dissertation contributed to a wide variety of disciplines and areas of study. Most notably, we provide contributions to the broad disciplines of education, psychology, human-computer interaction, communication and media studies, and computer science, and to the specific areas of child-computer interaction, embodied cognition and interaction, educational psychology, educational technology, and curriculum and instruction. The different types of contributions that we made are described in Table 16. An *empirical* contribution is defined as one that uncovers new understandings and knowledge solely based on primary data collected. A *theoretical* contribution is defined as one that "evolves, or 'takes shape', from reviewed of conceptual or theoretical perspectives, and/or the data collected" (Imenda, 2014). A *conceptual* contribution is defined as one that is "created by the researcher from a variety of conceptual or theoretical perspectives" to help in the collection, analysis and interpretation of data, and to guide future research (Imenda, 2014). A *methodological* contribution refers to the proposition of a process to address a particular problem. And a *design* contribution is one that relates to the articulation of principles, guidelines or specific ways to create features of a system or artifact.

Table 16. Summary of contribution areas

Type	Topic	Chapter
Empirical	Fourth-grade Slump	II
Theoretical	Model of creative storytelling	III
Theoretical	Embodied creativity support systems	IV
Empirical	Medium effects on creative process	V
Conceptual	Micro-enactment	V
Empirical	Effects of physical affordances	VI
Empirical	Effects of enactment-based storytelling	VI
Empirical	Effects of digital contextual affordances	VI
Methodological	Evaluation of imagination in action	VI
Conceptual	Performative authoring	VI

Table 16. Continued,		
Type	**Topic**	**Chapter**
Methodological	Design methodology for research prototypes	VI
Design	DiME system design	VI
Empirical	Effects of performative authoring	VII
Empirical	Performative authoring integration	VIII

Work in the area of creativity support systems have tended to focus on the development of systems and the support of end products in the form of more creative products. Relatively less work has been done on the support of the creative 'person'. From an analysis of the Fourth-Grade Slump, this dissertation has highlighted the importance of nurturing the creative 'person' for children, especially issues of motivation and self-efficacy. From an empirical study and literature review, this dissertation work has further advanced that micro-enactments of children during the creative brainstorming process provide a valid foundation of design for creativity support environments for children. We contributed knowledge of how various digital augmentations of a micro-enactment-based storytelling system prototype may affect children's creative process and performance. We called such a digitally-augmented micro-enactment-based approach 'performative authoring'. This dissertation work found that such a performative authoring approach appeared to benefit more introverted children and children with low baseline creativity, within the context of the DiME system through which it was tested. We also articulated some insights that may help to inform the design of systems and environments to support children's creative self-efficacy in storytelling, although the testing of performative authoring with only one testbed system in this dissertation does not allow the generalizability of these insights. Finally, this dissertation contributed some initial understanding of how a system based on the performative authoring approach may provide broader impacts into the elementary school curriculum and classroom.

Thus, this dissertation contributes specifically to several fields of study as follows:

- *To the fields of creativity studies, educational psychology and education, we:*
    - Demonstrated the current relevance of the Fourth-Grade Slump from teachers' perspectives.
    - Showed that teachers consider self-evaluation as an important cause of the Slump.
    - Provided support that DiME and the performative authoring approach seem to offer numerous ways to benefit and support teaching in elementary school.
- *To the field of creativity and cognition, we:*

- Advanced a model of the creative storytelling process that integrates recombination of idea fragments, motivation and feedback from perception, and that explicates the contributions of an enactment-based approach to storytelling.
- Developed MAIA (A Methodology for Assessing Imagination in Action) that triangulates among micro-analyses of videos of story enactments, analyses of enactment drawings, and analyses of interview scripts to generate an OBIS (Overall Broader Imagination Score) that measures the extent of mental imagery during enactment of a story fragment.

- *To the field of Human-Computer Interaction, we:*
  - Proposed a taxonomy to characterize storytelling support systems in terms of their interaction techniques.
  - Defined the design concept of Performative Authoring that is grounded in micro-enactment. It adds digital augmentations to the acting out of story fragments using the physical body in the form of real-time feedback of story fragment enactments through mapped cartoon animations.
  - Developed the Finding-NEVO methodology that ensures that a testable system is developed to faithfully embody a seed concept, such as performative authoring, by inserting a gatekeeping step into the HCI design process.
  - Designed DiME, which is a story authoring system for children that embodies the approach of performative authoring by employing a motion tracking system with a custom software interface.
- *To the fields of creativity and cognition and Human-Computer Interaction, we:*
  - Uncovered that a transparent method by which children brainstorm and express creative ideas is through body enactment.
  - Showed that an animation-based storytelling interface appears to provide both affective (motivation and self-efficacy) and performance (richness and accuracy) benefits for children.
  - Defined the concept of micro-enactment as the use of the physical body to act out story fragments to support thinking.
  - Showed that objects with generic affordances appear to be a good compromise to use as enactment props to support children's imagination during enacted storytelling.
  - Demonstrated that enactment of story fragments has to be imaginative (as opposed to mechanical) to have a positive impact on story retelling.
  - Provided evidence that a blank background appears to be more supportive of imaginative story enactment, at least when compared with a fully articulated contextual background.

- Showed that DiME and the performative authoring approach appear to have an equalizing effect on children's pair storytelling creative process, providing the more introverted children and children with low baseline creativity license and the opportunity to contribute to the process.

Below, we provide summaries of the most significant specific findings of this dissertation work with respect to the problem context that we determined and the solution approach that we proposed are listed below in Table 17, following the contribution claims listed above. Key findings are presented only for contributions labeled as empirical. We note that both the findings and the conclusions we derived from them (take-aways of the work) are necessarily constrained by the demographic and psychographic characteristics of the samples that we used in our studies, our sample sizes, the study settings, and any other intruding factors that may have affected the conduct of the studies. Efforts were done to minimize confounds, but the limitations that these possible confounds may present to generalizability should be noted.

Table 17. Summary of dissertation findings and conclusions

Topic	Key Findings Summary	Specific Contributions
Fourth-Grade Slump	• The literature after Torrance's initial studies generally agrees that a slump occurs in one or more aspects of the child's functioning, but there are disagreements as to when the Slump exactly happens. • Elementary school teachers surveyed perceived that children slump in creative thinking at 3rd to 4th grade. • Formal testing in the current education system and the child's anxiety of evaluation or judgment are seen by the teachers as major reasons for the Slump.	• The Fourth-Grade Slump is of current relevance, at least from teachers' perspectives. • Self-evaluation is perceived as an important cause of the Slump.

Table 17. Continued,

Topic	Key Findings Summary	Specific Contributions
Model of creative storytelling	• Recombination of idea fragments was identified as a key process in several creativity models in the literature.	• We proposed a model of the creative storytelling process that integrates recombination of idea fragments, motivation and feedback from perception, and that explicates the contributions of an enactment-based approach to storytelling.
Embodied creativity support systems	• Storytelling systems proposed from the year 2002 to 2012 may be classified into 3 main categories: GUI-based interfaces; Puppeteering; Enactive systems.	• We proposed a taxonomy to characterize the storytelling support systems in terms of their interaction techniques.
Medium effects on creative process	• When using the animation authoring interface as opposed to a PowerPoint text-based interface, children make greater use of 'in-the-world' body enactments. • When using the animation authoring interface, children advanced their story in fragments (micro-units), even while maintaining a macro view of the story being created. • Children are highly motivated to engage in storytelling, and to share their created story, when using the animation authoring interface. • Children are able to retell stories with greater richness and accuracy after creating their story using the animation authoring interface.	• A transparent method by which children brainstorm and express creative ideas is through body enactment. • An animation-based storytelling interface appears to provide both affective (motivation and self-efficacy) and performance (richness and accuracy) benefits for children.
Micro-enactment	-	• Micro-enactment is the use of the physical body to act out story fragments to support thinking.

Table 17. Continued,		
Topic	**Key Findings Summary**	**Specific Contributions**
Effects of physical affordances	• Broader imagination (extent of mental imagery during story enactment) differed significantly across object types, when differences among objects were taken into account (significant interaction effect of *object X object* type). • Children's broader imagination was generally best supported by objects with generic affordances, but this was the case for boys only using the frying pan object.	• Objects with generic affordances appear to be a good compromise to use as enactment props to support children's imagination during enacted storytelling.
Effects of enactment-based storytelling	• Physical enactments result in better storytelling, only if the enactments are performed such that they cross a certain threshold of imagination.	• Enactment of story fragments has to be imaginative (as opposed to mechanical) to have a positive impact on story retelling.
Effects of digital contextual affordances	• Children are more motivated to enact story fragments in front of a contextual background, but the stories created through enactment tend to be more typical than when enacting in front of a blank background.	• A blank background appears to be more supportive of imaginative story enactment, at least when compared with a fully articulated contextual background.
Evaluation of imagination in action	-	• MAIA (A Methodology for Assessing Imagination in Action) triangulates among micro-analyses of videos of story enactments, analyses of enactment drawings, and analyses of interview scripts to generate an OBIS (Overall Broader Imagination Score) that measures the extent of mental imagery during enactment of a story fragment.

Table 17. Continued,		
Topic	**Key Findings Summary**	**Specific Contributions**
Performative authoring	-	• Performative authoring is a design concept grounded in micro-enactment. It adds digital augmentations to the acting out of story fragments using the physical body in the form of real-time feedback of story fragment enactments through mapped cartoon animations.
Design methodology for research prototypes	• The process of designing research prototypes in HCI is often ad-hoc in integrating the systematicity required by science and the creativity required by design.	• The Finding-NEVO methodology ensures that a testable system is developed to faithfully embody a seed concept, such as performative authoring, by inserting a gatekeeping step into the HCI design process.
DiME system design	-	• DiME is a story authoring system for children that embodies the approach of performative authoring by employing a motion tracking system with a custom software interface.
Effects of performative authoring	• Children's stories created using enactment were judged as being significantly different from their stories created through flipchart drawings and writing. • Story richness scores for stories created using DiME were significantly higher than for stories created using flipcharts, but only for children who scored low on a baseline creativity test. • Children whom we categorized as being introverted/less dominant preferred story writing over DiME. • Children's sense of creative self-efficacy in storytelling pre-study was significantly different than post-DiME use. • Children whom we categorized as being introverted/less dominant reported the greatest increase in creative self-efficacy post-DiME use. • The three broader factors that influenced interactions and outputs of the DiME system were social dynamics, system design features, and core system concepts.	• DiME and the performative authoring approach appear to have an equalizing effect on children's pair storytelling creative process, providing the more introverted children and children with low baseline creativity license and the opportunity to contribute to the process. • The current design and implementation of DiME results in a paradox whereby the more introverted children benefit from its use in terms of creative self-efficacy but do not prefer using it.

Table 17. Continued,		
Topic	**Key Findings Summary**	**Specific Contributions**
Performative authoring integration	• Elementary school teachers perceived DiME to be particularly relevant for use in the 3rd to 4th curriculum in a 'show, don't tell' scenario. • Teachers were greatly concerned that without explicit alignment to curriculum testing standards, it would not be possible to integrate the DiME system into the elementary school classroom.	• DiME and the performative authoring approach seem to offer numerous ways to benefit and support teaching in elementary school. • Much more empirical and technical work is required for DiME to properly integrate into the elementary school curriculum and setting.

IX.2 Significance

The contributions made in this dissertation work may be highly significant, given the extent of the potential for broader impacts that the work possesses, and the broader impact that it has already had. The following broader impacts that the work has had can be identified:

Promoting Training in Research

Assisting with various pieces of this dissertation has helped to inculcate several graduate students into the culture of scientific research, helping them to understand aspects of the research process ranging from conceptual development, data collection, data analysis, interpretation, and paper writing.

Exposure to Technology

The various studies conducted to collect data for this dissertation have helped to expose children who responded to our calls for study participation, students in afterschool programs and participants at summer camps to the possibilities and workings of motion tracking technologies and animation. We were delighted by numerous episodes during our studies when the children (especially boys) excitedly asked us to explain how the DiME system works, which we gladly did. During one episode, two boys even insisted to watch how the motion tracking is done 'behind-the-scenes' in terms of the tracking of the human skeleton and object rigid bodies, while others participated in the study. Our studies also exposed the tremendous possibilities of our performative authoring approach to elementary school teachers to whom we talked to.

Support of Creative Activities

The children who participated in our studies in various settings experienced not only a fun and engaging creative activity, but also had the chance to tell their stories. As an education professor put it upon learning of the work in this dissertation with respect to the study participation of one specific boy at the Harvey Mitchell Elementary School summer camp, *"he may forget what*

he did exactly during the study, but he will never forget that you gave him a chance to tell his story". These powerful words reflect the impact that we hope to have created during our studies.

Dissemination of Knowledge

Most of the contributions made in this dissertation have been presented at and published in conference proceedings of the different areas of study addressed by the work. In so doing, we hope to have brought awareness of the research community to not only the problems faced by children, but also to details of the approach that we advocate as a possible solution.

The potential for future broader impact that our work possesses is in terms of lasting benefits to society on the support and nurture of children's creativity, storytelling abilities, and expressive writing at a critical period of their development, notably during the phase of the Fourth-Grade Slump. This has far-reaching implications because not only is a creative new generation necessary to address the complex problems of the world and of society, but also needed is a new generation who can read, write and communicate properly with others and through the creation of artifacts.

IX.3 Extensions

The work presented in this dissertation can be extended in many different ways. We describe a few possible directions for future work below:

Design Features

Several aspects of the DiME system have been designed based on conscious, but subjective decisions. It would be worthwhile to subject these design features to further investigations as to their effects on the child's creative process. One example is the use of the paper cutout style for the cartoon avatars in the DiME system. A possible study may consist of comparing the effects of giving children control of avatars designed in such a style, as opposed to avatars designed in a cartoon-like but full 3D style. Another possible study may entail investigating the effects of giving children the authorial ability to customize body parts of the avatar and elements of the background, as opposed to selection from preset databases.

Scalability

One evident area of future work includes research into ways to reduce the cost of the DiME system, and to make it more flexible and modular so as to be more adapted to the conditions of a formal learning environment. For instance, a technical investigation into the use of low-cost motion sensors, such as the Kinect and the Wii, to realize the concept of performative authoring is warranted.

Architecture

DiME relies on the tracking of children's motions, gestures and enactments. A possible extension of this idea is to expand performative authoring to include a room-sized installation, that essentially creates a technologically-augmented classroom that allows children to enact stories for

any kind of topics for the purpose of narrative construction or expository descriptions. Such an extension would entail research at the architectural scale in terms of how to embed motion sensors into the classroom environment, such that they satisfy the requirements and goals of performative authoring.

Support of Other Higher Thought

This dissertation has focused on the support of children's creativity. It would not be far-fetched to imagine that the approach may be suitable to support other kinds of human higher-level thinking, such as learning, logic, and critical thinking, and in other domains besides storytelling. It would be interesting to understand the modifications needed in the DiME system to support such types of abstract thought, beyond creativity.

Language-Deficient Children

The impact of the performative authoring approach is particularly significant for children who have difficulty with storytelling and story writing. In the United States, this population tends to include a large proportion of children whose native language is not English, and who are usually involved in classes of English as Second Language (ESL). A possible extension of our work would be to study more closely how performative authoring may be beneficial for language-deficient children at the 3rd to 5th grade level.

Epistemic Enactment

What we see as the most valuable extension of this dissertation work is to continue investigations into the conceptual, theoretical, design and empirical development of the idea of micro-enactment and performative authoring. We have looked at how to tap into overt enactment, which is grounded in children's pretend play, to support children's creativity. At the age of 8 to 11 years old, children may not be capable of fully abstract expression, and still enjoy pretend play to a certain extent, so such overt enactment is wholly legitimate and appropriate. However, as the child grows and enters adolescence and even adulthood, overt enactment becomes less frequent and less explicit. As adults, we often even resort to covert (in the sense of 'mental' or 'in the head') enactment, for example, mentally enacting a speech or talk before the presentation day, or a dance routine before a performance. The covert enactment may sometimes be expressed as small, subtle, and abstracted gestures, what Kirsh and Maglio (1994) have called 'epistemic actions' – "physical actions that make mental computation easier, faster, and more reliable".

In storytelling situations that involve story creation and idea brainstorming with other conventional media, we have observed that children unwittingly make use of such epistemic actions to support thinking, express ideas, and illustrate thought. These epistemic actions in storytelling that we refer to are similar to Kirsh's (Kirsh, 2010; 2011) identification of the 'marking' process in dance practice and choreography. He defines marking as "dancing a phrase in a less than complete manner". An example of hand marking is shown in Figure 48. Kirsh (2010) identifies two mechanisms by which marking may be effective in augmenting people's thought: (i) anchoring

projection; and (ii) priming. Furthermore, he advances that marking may happen for one of three reasons: (i) marking-for-self; (ii) marking-for-others; and (iii) joint-marking. We see epistemic actions as being one of the most critical aspects of embodied cognition, and posit that there is tremendous potential for research to study how such actions in the form of epistemic storytelling enactments may be digitally augmented to allow the individual to build upon and assess ideas more effectively.

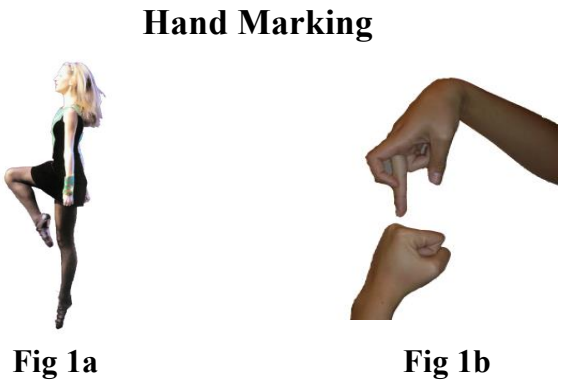

Figure 48. Example of hand marking. Used with permission from Kirsh (2010).

CHAPTER X
LIMITATIONS AND CONCLUSION

X.1 Study Limitations

Each of the studies described in this dissertation necessarily has limitations that require acknowledgement. The general limitations of the studies are as follows:

Small Sample Size

We recognize that many of the studies reported a relatively small number of participants. While it is acceptable and common in the fields of child-computer interaction and design to have sample sizes of fewer than 20 participants, it may not be a satisfactory practice in other disciplines such as psychology and education.

Study Settings

Although much effort was made to control extraneous factors especially during the experimental studies, factors outside our control, such as external interruptions or children's moods, may have affected the results of our studies. Most of our studies were conducted in real-world settings, such as at clubs or elementary schools. These extraneous factors are hard to account for, and were not possible to be incorporated into our analyses of the data collected.

Design Creeps

While we used the Finding-NEVO methodology to ensure that the design of DiME remained faithful to the core characteristics of the performative authoring concept as far as possible, the design and development of a full-fledged, testable system prototype is subject to countless design decisions, ranging from major to very minor. We recognize that our efforts to track our design decisions may have missed some, and among those, some may have been affected by the various creeps (see Section VI.5).

Generalizability

Although the work presented is founded on time-tested and empirically supported theories of child development, we make no claim that our study results are necessarily applicable to all population profiles. While we are confident in the relevance of the performative authoring approach to support children's creative storytelling in the situations that were tested and within the contexts and specificities of our studies, we caution the reader to keep in mind that further research is needed to ascertain the broad generalizability of the study results and approach to distinct children and adult populations with different values, cultural assumptions, needs and capabilities.

X.2 Conclusion

In more ways than one, this concluding paragraph represents the end of a journey captured in this dissertation. We set out to understand how digital technology may scaffold children's creativity in the domain of storytelling. Our inquiry into the phenomenon of the Fourth-Grade Slump focused our attention on the need to support children's creative performance and sense of creative self-efficacy during the ages of 8 to 11 years old. We found that children make use of micro-enactments to support creative idea brainstorming during media-based story construction. We elicited the physical and digital affordances to support children's imagination during enacted storytelling, so as to inform the design of a digitally-augmented enactment-based storytelling system called DiME. Based on the design concept of performative authoring, DiME was shown to effectively scaffold especially introverted and less creative children's storytelling and self-efficacy. We have proposed several directions in which this work may be extended, and our hope is that not only may the approach of performative authoring be used as a testbed to further our understanding of human embodied cognition, but also may it become a staple system in the toolbox of elementary school teachers seeking to nurture children who are both high performers and creative thinkers.

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APPENDIX A

LIST OF PUBLICATIONS

Work	Associated Publications
Creative motivation and the Fourth-Grade Slump	Chu, S. L. (2012). *Adapting the MUSIC Model for Creative Motivation.* Unpublished.
Enactment with physical objects	Chu, S., Quek, F. and Lin, X. (2011) Studying Medium Effects on Children's Creative Processes. *In Creativity & Cognition '11*. ACM: pp. 3-12: Atlanta, GA. DOI: 10.1145/2069618.2069622 Chu, S. and Quek, F. (2013). Things to Imagine With: Designing For the Child's Creativity. In *Interaction Design & Children '13*. New York City, NY: ACM. DOI: 10.1145/2485760.2485793 Chu, S., Quek, F., Gusukuma, L. and Tanenbaum. J. (2013). The Effects of Physicality on the Child's Imagination. In *Creativity and Cognition '13*. Sydney: Australia. DOI: 10.1145/2466627.2481205 Chu, S., Quek, F. and Tanenbaum, J. (2013). Performative Authoring: Nurturing Storytelling in Children through Imaginative Enactment. In *the International Conference on Interactive Digital Storytelling (ICIDS '13).* Istanbul, Turkey. DOI: 10.1007/978-3-319-02756-2_18 ***[Best Paper Award]***
Enactment-based approach to creative storytelling for children and creativity model	Chu, S. and Quek, F. (2013). An Enactment-Based Approach to Creativity Support. In *Proceedings of Workshop on Interactive Technologies that Enhance Children's Creativity at Interaction Design & Children '13*. New York City: NY. June 24.
Methodology for evaluating enactment-based creativity	Chu, S. and Quek, F. (2013). MAIA: A Methodology for Assessing Imagination in Action. In *Proceedings of the CHI 2013 Workshop on Evaluation Methods for Creativity Support Environments*. Paris, France: ACM.
Interviews about HCI methodology	Chu, S., Quek, F., Wang, Y. and Hartson, R. (2013). Finding-NEVO: Toward Radical Design in HCI. In *Proceedings of INTERACT '13.* Cape Town: South Africa. IFIP-Springer LNCS. DOI: 10.1007/978-3-642-40483-2_33
Enactment with physical-digital objects	Chu, S. and Quek, F. (2014). The Effects of Visual Contextual Structures on Children's Imagination in Story Authoring Interfaces. In *Interaction Design & Children (IDC '14)*. Aarhus, Denmark. DOI: 10.1145/2593968.2610484
Exploratory testing of the DiME storytelling system	Chu, S., Quek, F. and Sridharamurthy, K. (2014). Ready...Action! A Performative Authoring System for Children to Create Animated Stories. In *the 11th Advances in Computer Entertainment Technology Conference (ACE '14)*. Madeira, Portugal. DOI: 10.1145/2663806.2663858
Pilot study of DiME system with props and avatar	Chu, S. and Quek, F. (2014). Exploring Performative Authoring as a Story Creation Approach for Children. In *International Conference on Interactive Digital Storytelling (ICIDS '14)*. Singapore, Singapore. DOI: 10.1007/978-3-319-12337-0_6

Evaluation of DiME system and approach	Chu, S., Quek, F. and Sridharamurthy, K. (2015). Augmenting Children's Creative Self- Efficacy and Performance through Enactment-Based Animated Storytelling. In *International Conference on Tangible, Embedded and Embodied Interaction (TEI '15)*. Stanford University. DOI: 10.1145/2677199.2680602 Chu, S., Quek, F. and Sridharamurthy, K. (Under review). *License to Imagine:* Supporting Children's Self-Efficacy to Create Stories through Enactive Technologies. In *Creativity & Cognition (C&C '15).* Boston, MA.
Overall research	**Chu, S.** (2013). Nurturing Children's Creative Practice in Storytelling through Micro-Enactments. *Doctoral Consortium at INTERACT '13*. Cape Town: South Africa. **Chu, S.** (2013). Nurturing Children's Creative Practice in Storytelling through Micro-Enactments. *Graduate Student Symposium at Creativity & Cognition '13*. Sydney: Australia. **Chu, S.** (2013). Nurturing Children's Creative Practice through Micro-Enactments. In *Proceedings of the Conference on Human Factors in Computing System EA, (CHI* Doctoral Consortium). Paris, France: ACM. DOI: 10.1145/2468356.2468699

APPENDIX B

IMAGE PERMISSION

From: **David Kirsh** kirsh@ucsd.edu
Subject: Re: Permission to use pictures
Date: March 1, 2015 at 1:29 AM
To: Sharon Lynn Chu sharilyn@tamu.edu

DK

hello Sharon. Sure. thank you for asking. good luck on the thesis.

- david

On Sun, Mar 1, 2015 at 5:42 AM, Sharon Lynn Chu <sharilyn@tamu.edu> wrote:

> Dear Dr. Kirsh,
>
> I am writing my PhD dissertation, and I would like to use the two pictures (attached) that you have on the first page of your paper published at 'Kirsh, D. *Thinking with the Body*. in *32nd Annual Conference of the Cognitive Science Society*. 2010. Austin, TX: Cognitive Science Society.' as illustrations for the concept of marking.
> My dissertation is titled "Performative Authoring: Nurturing Children's Creativity and Creative Self-Efficacy through Digitally-Augmented Enactment-Based Storytelling". It addresses overt enactment as a possible approach to scaffolding creativity in children's storytelling. However, I find your concept of marking and epistemic actions as being fantastically relevant, and would like to reference it in my dissertation.
>
> Please do let me know whether this is ok.
>
> Thank you very much.
> Best Regards,
> Sharon
>
> ---
> **Sharon Lynn Chu**
> *PhD student*, TAMU Embodied Interaction Lab
> *Lecturer*, Department of Visualization
> Texas A&M University
> *sharilyn@tamu.edu* | (540) 998 6488

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David Kirsh
Professor
Dept Cognitive Science
UCSD, La Jolla, CA 92093

Lab: 1 858 822-2475
Fax: 1 925 407- 4499

http://adrenaline.ucsd.edu/kirsh

APPENDIX C

'MEDIUM EFFECTS' STUDY I QUESTIONNAIRES

Pre-Study Form

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ID:

Gender: M / F Age : _____

Class : _____ No. of brothers: _____ No. of sisters: _____

How much do you think you know about stories in:	Very little	Little	Not sure	Somewhat	A lot	N/A
Storybooks						
Cartoons						
Comic books						
Movies						
Websites / Internet						
How well do you understand the stories you see in:	**Not at all**	**Not very well**	**Not sure**	**Quite well**	**Very well**	**N/A**
Storybooks						
Cartoons						
Comic books						
Movies						
Websites / Internet						
How often do you watch/read:	**Rarely**	**Sometimes**	**Not sure**	**Often**	**Always**	**N/A**
Storybooks						
Cartoons						
Comic books						
Movies						
Websites / Internet						

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ID:

About how much time per day do you spend with:	Cartoons	Storybooks	Movies	Comic books	Websites/ Internet	
30 mins or less						
1hr or less						
2hrs or less						
5hrs or less						
More than 5hrs						
N/A						

Since when have you been watching / reading:	Cartoons	Storybooks	Movies	Comic books	Websites/ Internet	
3 months or less						
6 months or less						
1 year or less						
2 years or less						
3 years or more						
N/A						

Rank the different media (1 to 5) based on what you like most for storytelling.

Storybooks ☐

Cartoons ☐

Comic books ☐

Websites/Internet ☐

Cartoons ☐

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ID:

	Not true	Somewhat not true	Not sure	Somewhat true	Very true
I am good at coming up with ideas for new stories					
I have a good imagination					
I have a lot of good ideas for stories					

	No, always	No, sometimes	Don't know	Yes, sometimes	Yes, always
I like creating stories					
I create stories to get a nice reward					
Creating stories interests me a lot					
I create stories to show others how good I am					
In life it's important to learn how to create stories					
I create stories even when I am not asked to do so					
I create stories to please my parents or my teacher					
Creating stories allows me to learn many useful things					
I choose to create stories to learn many things					

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ID:

What do you like in the stories that you watch / read in:	Cartoons	Storybooks	Movies	Comic books	Websites/ Internet
(perceptual processing: aesthetic details and high-level plot details) *(deep processing: meaning behind story, character intentions, etc)*					

Tell me about two stories that you know most about. They can be cartoons, stories from a book, a comic, stories you read on the Internet, a movie.

Story 1:

Story 2:

Post-Study Form

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ID:

1. How much do you agree with the statements below?

	Disagree	Somewhat disagree	Not sure	Somewhat agree	Agree
I like the story I created today					
It was difficult to create the story					
I needed help to create the story					
I am satisfied with the story I created					
I was happy when I was creating my story					
I felt tired creating the story					
I enjoyed creating the story					
I liked using the software to create the story					

2. Which of the stories presented today did you find:

	Story A	Story B	Story C	Story D	Story E	Story F
Funny						
Interesting						
Fun						
Exciting						
Educational						
Detailed						
Realistic						

3. How true do you think the following are?

	Not true	Somewhat not true	Not sure	Somewhat true	Very true
I have a good imagination					
I have a lot of good ideas for stories					
I am good at coming up with ideas for new stories					

Date:

Post-Interview Guide

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ID:

Post-study INTERVIEW PROMPTS

How did you and your friend create the story?

Did you work with your partner? And how did you do so?

Did the software prevent you from creating your story? If yes, in what ways?

Was it hard to create your story using the software?

- If yes, did you know the story you wanted to create but it was hard to create it with the software?
- If no, did the software help you to create your story?

Did you have any other problems or difficulties when creating your story?

Broader imagination: Ask questions specific to the story of the child

Did you think of anything that you didn't include in the story?

How do you think the characters in your story look like?

Date:

APPENDIX D

'MEDIUM EFFECTS' STUDY STORY PROMPTS

Story 1

The Tweetzer family lives in a big house. There is a wooden cupboard in their living room, and in the cupboard lives Barnabas and his family. Barnabas is a blue vanilla soap bar. Barnabas and his family live happily in the cupboard. They have never left the wooden cupboard. In fact, opening the cupboard door is forbidden.

One night, Barnabas had a dream about the *outside world*. When he woke up, he said: "I'm tired of living in the cupboard. I want to see the *outside world*". He starts to pack up his things. His cousin Dimmy a green pear soap bar, walked in. "What are you doing Barnabas?" he asked. "I'm going out to see the *outside world*. I don't want to stay here anymore," Barnabas replied. Dimmy was surprised. Barnabas took his backpack, and walked towards the forbidden door. Dimmy ran after him and said: "I'm coming with you."

What do Barnabas and Dimmy do at this point?

Story 2

Amy received Red, Blue, Yellow and Green colored pencils from her mum for her birthday. But she did not like drawing very much. So she put them on her work table and forgot about them. But every night, the colored pencils came alive and visited her work table. For the colored pencils, Amy's table was a dangerous place.

One night, the colored pencils came out of their box. "Let's go visit beyond the books today," said Red. He pointed to the big stack of books on their left. Green exclaimed: "No, it's too dangerous!". "Don't be so scared, Green. Let's go!" Red replied, and he walked towards the books. They started climbing to the top. Red went first, followed by Yellow, Blue and lastly Green. They jumped on the edge of each book. Suddenly, a strong wind blew. Green slipped and fell. He was going to hit the floor, but managed to hold the edge of a book. "Help me!" he shouted.

What do Red and the others do?

APPENDIX E

'FOURTH-GRADE SLUMP' STUDY

Teachers' Interview Guide

For interviewers only *March 19th, 2012*

INTERVIEW GUIDE: (Teachers') Interviews

Demographics

- School & Gender
- How long have you been teaching?
- What grades have you taught before?
  - What grade(s) are you teaching currently?
- Which subjects have you taught before?
  - Which subject are you teaching currently?
- Do you have any other teaching experiences outside of the classroom or in informal settings?
- Do you have children?
  - If so how many, and of what age?

Classroom Activities

- How many children are there in your class?
  - Gender & Age breakdown
- What kind of creative activities do the children engage in?
  - With regards to the curriculum/ out of curriculum?
  - In what context?
  - Specific examples
  - Frequency of activities
  - What are the children's attitudes towards such creative activities?
  - Is there any specific example that you can give me of an activity that triggered an unusual level of enthusiasm in the children?

Explanation of the Fourth-grade Slump by interviewer

Definition:

A rather extensive study in 1967 across 7 different countries found that a precipitous, sudden decrease in creative thinking in the third or fourth grade is common in the 9-year old child

Study examples:

- Children were encouraged to write "on their own outside of the curriculum". Fourth grade children produced fewer contributions than did the children in grades 3, 5 and 6.
- Perception of objects in ink blots. Fewer numbers by fourth grade children.

- Do you agree that there is a slump that happens in third and fourth grades?
- If yes,
  - How do you see it as manifested?
    - Do you see it as a decrease in creative thinking abilities themselves or decrease in the willingness to engage in creative activities?
  - Does the slump happen to everyone?
    - All students, or what proportion %?
  - Is there a particular subgroup in the class who is more affected? (e.g. by gender, specific age, domain, type of activity, etc.)

- Why do you think the slump happens at this particular time and age?
- What factors do you think affects the happening of the slump?

- If no,
  - Do you see that there is any other change at all (increase, neutral) in creative thinking performance or motivation for creative activity?
  - Do you see any kind of slump with children in other grades?
  - Why do you think some researchers have found a slump?

Drop in Motivation

- *[If teacher has taught other grades before]* How would you compare children in your other grades with respect to children in third and fourth grades?
- Based on your personal experiences with and observations of third and fourth grade children, have you noticed any decrease in engagement in general academic activities?
  - Creative activities?
  - Can you give me examples of any specific instances?
  - *[If teacher has children within age range]* Did you notice any change in attitude with your own children?
- In terms of completing assignments, have you noticed any drop in creativity in the way the students approach work and activities?

Ideas for Approach

- *[If teacher has acknowledged drop in motivation]* What do you see as a possible approach/solution to remedy to this drop in motivation among the children?
- Do you think that heavy consumption of media has any effect on children's imagination or creativity?
  - What kind of stories do children tell at fourth grade?
  - Are the stories more creative, repetitive, original?
- Do you think that having the children create using animation will help to increase their engagement in creativity?

Relationship to MUSIC model

- What factors do you think are important to motivate the child to participate in creative thinking?
- The key dimensions that have been identified as being important for motivation in research are:
-

Empowerment	How much control the child perceives she has in the activity
Usefulness	How much the child sees the activity to be useful immediately or later
Success	How much the child perceives that she can complete the activity successfully
Interest	How much the child enjoys the activity
Caring	How much the child thinks others care about the product of the activity

How do you see those in terms of relevance to motivation for the child to engage in creative thinking?

‘Fourth-Grade Slump’ Questionnaire

ID:

Fourth-Grade Slump Questionnaire

For each question, tick in one of the boxes:

1. To what extent do you agree that there is a slump in ***creative thinking*** at about the age of 9 years old?

Strongly Disagree	Disagree	Somewhat Disagree	Not sure	Somewhat Agree	Agree	Strongly Agree

2. To what extent do you agree that there is a slump in the child's ***imagination*** at about the age of 9 years old?

Strongly Disagree	Disagree	Somewhat Disagree	Not sure	Somewhat Agree	Agree	Strongly Agree

3. To what extent do you agree that there is a slump in the child's ***motivation to engage in creative activities*** at about the age of 9 years old?

Strongly Disagree	Disagree	Somewhat Disagree	Not sure	Somewhat Agree	Agree	Strongly Agree

4. To what extent do you agree that there is a slump in the child's ***motivation to engage in any school activity creatively (i.e. approaching the activity in a creative manner)*** at about the age of 9 years old?

Strongly Disagree	Disagree	Somewhat Disagree	Not sure	Somewhat Agree	Agree	Strongly Agree

5. To what extent do you agree that there is a slump in the child's ***creative storytelling ability*** at about the age of 9 years old?

Strongly Disagree	Disagree	Somewhat Disagree	Not sure	Somewhat Agree	Agree	Strongly Agree

6. To what extent is each of the following components important for motivating creative thinking in students?

Empowerment:	How much control the child perceives she has in the creative activity
Usefulness:	How much the child sees the creative activity to be useful immediately or later
Success:	How much the child perceives that she can complete the creative activity successfully
Interest:	How much the child enjoys the creative activity
Caring:	How much the child thinks others care about the product of the creative activity

	Not important at all	**Not important**	**Somewhat not important**	**Somewhat important**	**Important**	**Very important**
Empowerment:						
Usefulness:						
Success:						
Interest:						
Caring:						

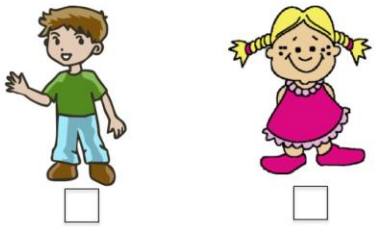
APPENDIX F

'PHYSICALITY' STUDY

Children's Pre-Questionnaire

No.:

- Are you a boy or a girl?

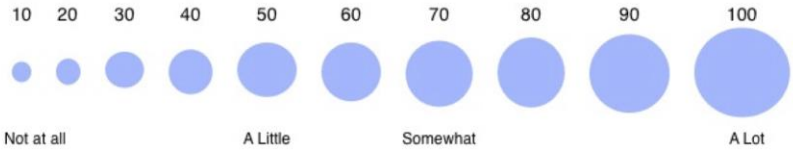


- How old are you?

☐

No.:

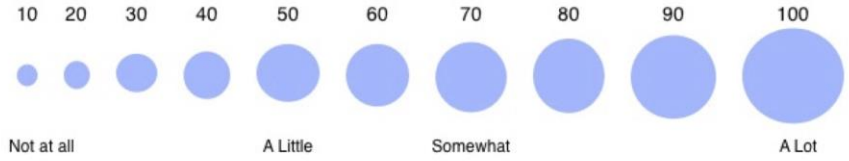
How much do you enjoy listening to stories?



Choose a number

No.:

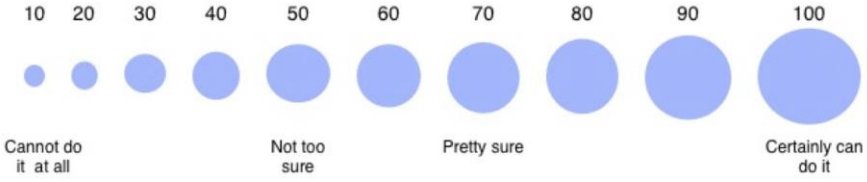
How much do you enjoy telling stories to others?



Choose a number

No.:

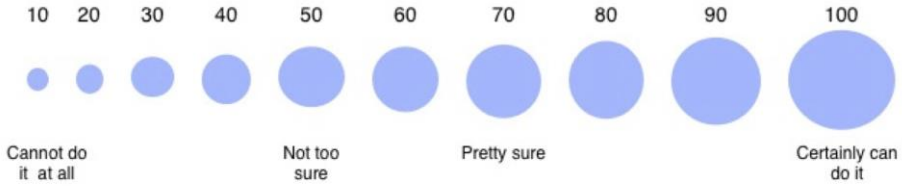
How sure are you that you can tell a creative story?



Choose a number

No.:

If I tell you a story, how sure are you that you can act it out?



Choose a number

No.:

What kind of stories do you like?

Write on your paper!

No.:

How often do you tell stories?

A. All the time
B. Often
C. Sometimes
D. Never

Choose a letter

No.: _____

What do you think each of these objects can be? Write down all that you think of.

Object	It could be a...
	
	
	
	
	
	
	

Personality Questionnaire

Child&ID:&&

MOTION PAINTING STUDY

&
Thank&you&for&allowing&your&child&to&participate&in&our&study.&Please&fill&in&the&table&below&as&accurately&as&you&can.&The&purpose&of&this&personality&questionnaire&is&**solely**&for&us&to&learn&about&which&factors&affect&the&data&that&we&collect&from&your&child.&No&judgment&or&evaluation&of&any&sort&will&be&made&based&on&this&data,&and&neither&will&it&be&used&for&any&purposes&other&than&research.&
&
How&well&does&each&of&the&following&phrases&describe&your&child's&personality?&(Tick&in&a&box&for&each&row)&
&

My child…	Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly
…is reserved					
…is generally trusting					
…tends to be lazy					
…is relaxed, handles stress well					
…has few artistic interests					
…is outgoing, sociable					
…tends to find fault with others					
…does a thorough job					
…gets nervous easily					
…has an active imagination					

&
&
&

THANK&YOU!&
&

Slideshow Story with Narration

(Slide 1) Gerda, Darok, and Berin and the Lost City By Joshua Tanenbaum

Once there were three young dwarves, Gerda, Darok, and Berin, who lived in a magnificent city underground. They were best friends, even though they each liked very different things. Gerda was a junior apprentice in the Cave Rangers guild, and was learning how to explore the many tunnels and abandoned mine shafts around the city. Darok was an apprentice to the Machinists Guild, and was learning the secrets of crafting clockwork devices. Berin, the youngest, had just started an apprenticeship with the Loremasters guild, where he studied the histories and legends of the dwarf society.

(Slide 3) On the day that our story begins, Gerda, Darok, and Berin were on their way to breakfast before going off to their apprenticeships when all around the city, the watchmen began to hammer on warning bells. “Our ancient enemy has returned!” announced the High Councilor to the assembled crowd. “Mendlin, the Chief Cave Ranger has confirmed that our city is soon to be besieged by the same evil that drove our ancestors from the depths. We must prepare our defenses!”

(Slide 4) Teams of dwarves were being sent out into the mines and caverns to gather supplies for the siege, or to try and slow down the advance of the enemy. Among them were Gerda, Darok, and Berin, who were sent to gather cave mushrooms. Each was given a backpack with a pickaxe, a lantern, and a camping kit that included some basic cooking tools, a bedroll, and a knife. “I wish we could do something other than gathering mushrooms!” Gerda said as they descended into the mines. “I wish we hadn’t missed breakfast!” Darok replied. “I’m starving!”. “I found a recipe for fried Cave Mushrooms in the archives.” Berin said. “If we find some, we can have breakfast.”

(Slide 5) All the cave mushrooms near the city had already been picked by other teams, and so the three friends found themselves moving deeper into the caverns. Eventually they found a low cave with a stream running through it, and a whole bank of mushrooms. Gerda got out her frying pan while Darok started a small cookfire. Darok sliced the mushrooms into three big slabs, and seasoned them from his cook kit. Then, one at a time, Gerda fried up the mushrooms, occasionally shaking the pan to keep them from sticking and burning.

Slide 6 -- (ENACTMENT – FRYING PAN)

(Slide 7) “Watch this!” Gerda cried, and flipped a slice of mushroom up into the air, before neatly catching it again in the pan. “Stop showing off and feed me!” Darok groaned. Soon the three friends had filled their stomachs and their mushroom gathering bags.

(Slide 8) They decided to set out for home. Unfortunately, the three friends soon found that they were in an unfamiliar section of the caves. “We should have been home by now.” Gerda said. But the caves kept getting less and less familiar, with weird veins of minerals, and strange rock formations everywhere. Eventually they had to admit that they were hopelessly lost. “HALOOO!” Gerda shouted “CAN ANYONE HEAR ME?!”. “Stop that!” Darok hissed. “You don’t know what is out there!”

(Slide 9) Darok’s call echoed back and forth in the tunnels, only to be drowned out by a ruckus of flapping wings and shrieking. “What’s that?” Berin asked as the screeches grew louder! “Those are bats!” Darok cried. Disturbed by Gerda’s shouts, hundreds of bats poured out of a side tunnel and swept toward the three dwarves. “I hate bats!” Darok shouted. He grabbed his lantern. “Stay close to me! I’ll take care of this!” As the writhing mass of bats swooped ever closer he held up his lantern, and began waving it at the bats. The bats were angry at being disturbed, their leathery wings flapping against each other as they flailed about wildly with outstretched claws. There were so many of them! Darok swung the lantern and flailed his arms around wildly, creating a pocket of space where the bats would not enter.

Slide 10 -- (ENACTMENT – LANTERN)

(Slide 11) After a few minutes the bats had mostly flown away. The friends continued on, even though they had no idea where they were going. Berin took the lead, with Darok behind him. Gerda felt really bad about the bat incident, and was silently bringing up the back.

(Slide 12) They turned a corner and came face to face with a dead end. Rubble and debris had collapsed to seal off the tunnel. “Now what?” Darok asked. “Do we go back?”. “What if this is a cave-in set by another Cave Ranger group to slow down the enemy?” Gerda asked. “It would mean that we are getting closer to home.” “That makes sense to me.” Berin said. “I’m going to try and clear a path.” Berin took his pickaxe and started to dig his way through the fallen debris. The cavern was narrow and there wasn’t room for the others to help, so they busied themselves moving loose rocks and dirt out of the passage as Berin worked. Berin swung his pick rhythmically, steadily cutting through the rock as the clang of metal on rock rang throughout the corridor. Clang, crunch! Clang, crunch! Clang...hissss!

Slide 13 --(ENACTMENT – PICKAXE) (Slide 14)

“I’ve broken through!” Berin shouted excitedly before breaking off in a fit of coughing! Stale air from the sealed passage rushed out through the gap he had cut, causing their touches to flicker and flutter. It filled the tunnel with a sour moldy smell. Choking for breath the three friends held up their lanterns to the opening to see into the tunnel beyond. “I don’t think this was a recent cave in.” Gerda said quietly. The others agreed: the tunnel stretching away in front of them had ornate script carved into the walls, and ancient looking columns holding up the ceiling. They had found an ancient passageway that had been abandoned for many generations!

Act II – (Slide 1-2)

The three friends had spent most of the day exploring, fighting off bats, and breaking through into the passage, so they decided to set up camp for the night. Darok broke out his cook kit and fried up some more mushrooms for dinner. “I’m going to be sick of mushrooms if we have to eat them for every meal.” Berin complained. “We don’t have much choice,” Darok said, expertly flipping the fungus in the frying pan, “unless we find something else to eat down here we’re stuck with this.”

Slide 3 -- (ENACTMENT – FRYING PAN)

(Slide 4) The three of them ate a quiet dinner before settling down to sleep. In the morning they set off down the passageway.

(Slide 5) The walls and ceiling were perfectly squared off; unlike any mine shaft they had seen. The walls were smooth rock, and ornate columns were regularly spaced along the corridor, descending into darkness. Even so, signs of age were everywhere: spider webs, rocks crumbling to dust, writing on the walls worn down so far that they couldn’t decipher any of it. Even the air felt stale and old. After several hours Gerda motioned for them to stop. There was a break in the passageway, and a small rough cave opened up to one side. “This is incredible!” Gerda said! “Look at the walls!” The dwarves shone their lanterns around the inside of the cave.

(Slide 6) The light reflected back in reds, blues and greens. “It’s a gemstone farm!” Darok exclaimed! “The master smiths talk about them, but I don’t know anyone who has ever found one!” “If we could find our way out of the mountain with these, we could hire as large an army as we want!” Gerda said, hefting her pickaxe. “Let me try this!” Gerda began picking at the rock that held the precious gems in place.

Slide 7 -- (ENACTMENT – PICKAXE)

(Slide 8) It was slow going but after some time swinging her pickaxe steadily she was able to extract a large hunk of what looked like rubies. The other two just watched, endeavoring to stay out of the way of her swinging pick. Eventually Gerda had gathered several sacks of gemstones: rubies, emeralds, and sapphires. They emptied one of their bags of mushrooms and filled it with

precious stones. Humming a satisfied tune, Gerda shouldered her treasure, and they continued down the passage.

(Slide 9) The further they traveled down the corridor, the more spiderwebs started to appear. At first it was just wisps of cobwebbing, dangling from the ceiling, but after a while the webs started to cover the walls. Soon, the passageway was clogged with sheets of spider webbing, blocking their passage. Berin waved his lantern experimentally at one of the large spiderwebs and it burned up with a whoosh! They continued on, with Berin swinging his lantern around them to burn up any spiderwebs that blocked their way.

Slide 10 –(ENACTMENT – LANTERN)

(Slide 11) "Where do you suppose the spiders went that made these?" Gerda asked, as they walked. "I don't know, but I hope we don't meet any of them!" Darok replied with a shudder. "They must be gigantic to spin webs this size!" In front of them Berin destroyed another large cobweb with another whoosh of fire and ash! He was having far too much fun.

(Slide 12) It was hard to tell, through all of the webbing, but the corridor was getting wider, and they were amazed when the last cobweb Berin destroyed revealed an enormous underground cavern sprawling out before them It was much bigger than the cavern that their city was housed in! Spreading out in front of them was the biggest city they had ever seen!

Act III – Slide 1 (Slide 2)

"Thorin's beard!" Gerda exclaimed! "What is this place?" Berin's eyes shone in the green light. "I don't believe it!" he gasped. "I thought it was a myth!" "What?" asked Darok. "The lost city. The first dwarf city. Underhome!" he whispered. Underhome was a shadow of a legend in Dwarf society; a great shining metropolis beneath the mountain that had been home to the first dwarves. The three friends stood and looked down on the legendary city in shocked silence. Finally Gerda broke the spell. "It's too late to start exploring the city tonight." She said. "We should make camp here and continue in the morning."

(Slide 3) In the morning, Berin was awake before his friends. He had hardly slept, he was so excited about the city! He had read a few things about Underhome in the archives, and couldn't quite believe that it was here! He made his way to the edges of the city walls, and just stared up at them in awe. As he walked back and forth below the walls, he suddenly stepped on something with a sticky Crack! He looked down, to see a patch of large spider eggs!

(Slide 4) Back at the camp site, he woke his friends up. "I've got breakfast!" he said happily! "Not more mushrooms!" Darok groaned. "Nope! Spider egg and cave mushroom omelets!" Berin took out his frying pan, and broke one of the large eggs into it with one hand. He swirled it around over the flames of the campfire, tossing the egg together with mushrooms and spices.

Slide 5 – (ENACTMENT – FRYING PAN)

(Slide 6) Soon a rich buttery flavor filled the air around the campsite, and the other two dwarves gathered eagerly around for their first real breakfast in days! "This is delicious!" Darok said, around a mouthful of food. "Where did you find the eggs?" "There are lots of them along the wall of the city." Berin replied.

(Slide 7) "Thorin's Beard, Berin! What were you thinking?!" she shouted. "Where do you think the eggs came from?" She pointed towards the city. In the dim green light, they could now see giant hairy spiders crawling over the walls to tend their nests. Hurriedly the three dwarves stamped out their fire, and gathered up their things. The spiders hadn't seen them yet, thankfully! With exaggerated caution the three of them crept away from the spider nests, and around the outer wall of the city. "We need to find a way inside!" Berin said. "Why?" Darok asked. "I know this is amazing, and I know you really want to explore Underhome, but how will it help our city? There is no army in there!" "You have no idea what is in there!" Berin said. "Who knows what weapons were left behind by our ancestors!"

(Slide 8) They continued circling the outer wall of the city until they came to a section that was crumbling and damaged. Darok unlimbered his pickaxe and began to open up a hole in the

wall. He swung it steadily against the broken section of wall, throwing up clouds of dirt and slowly loosening up the ancient stones.

Slide 9 – (ENACTMENT – PICKAXE)

(Slide 10) Eventually he had created an opening that the dwarves could squeeze through. The streets of Underhome were broad, with statues and fountains at every corner, but they were eerily empty. The whole city seemed to be holding its breath. Cobwebs connected the roofs of many of the houses and shops together: the spiders had overrun the entire city! The three dwarves crept carefully through the streets, avoiding the biggest spider nests, and trying to stay silent in order to avoid attracting any attention to themselves. They slowly made their way toward the center of the city, where a large drum shaped Keep rose above the other buildings. None of them noticed the spiders shadowing them from the rooftops. They arrived at the Keep, and were surprised to find its doors wide open.

(Slide 11) Inside was a great throne room, with old faded tapestries on the walls and an ornately decorated mosaic floor. A seed of an idea had been building in Berin's mind as they traversed the city. "What if we brought our people here?" He asked suddenly. The others stared at him. "Why not?" he asked. "This city is huge, it's easily defensible, and it's filled with history and lore that we could use against the enemy! I saw a library back there filled with scrolls: lost knowledge that could be used to save our people." "But our city is under siege. How would we get people out? Even if we could find our way back home, how would we find our way back here?" Darok asked. "Look at the floor!" Berin said. The three friends stepped back to study the mosaic patterns. Slowly the other two realized what they were looking at. "It's a map of the mountain." Darok said. "With secret tunnels leading to other cities." Berin said. "If we can find the tunnels, we could use them to get home again, and then use them to lead our people to safety." "And what about the spiders?" Gerda asked. "One of the legends of Underhome claims that it could defend itself." Berin said, his excitement building. "We could activate the city's automated defenses and drive the spiders out!"

(Slide 12) "We'd better hurry if we are going to do that!" Darok shouted. Spiders were dropping down from the ceiling, scuttling along the columns, and boiling up from behind the tapestries! Gerda grabbed her lantern and lit it. "You two try to find some weapons, or something!" She shouted. "I'll follow and hold off the spiders!" Waving her lantern in all directions, Gerda pushed back the writhing mass of legs and eyes, and the three of them sprinted for a spiral staircase behind the throne.

Slide 13 – (ENACTMENT – LANTERN)

(Slide 14) They arrived in what might have been a control room at one point. Gerda continued to wave the lantern, causing the spiders to Hiss and back away. The other two heaved an ancient door shut and barred it with their pickaxes. It was time to take back control of Underhome!

APPENDIX G

'DIGITAL AFFORDANCES' STUDY

Post-Interview Guide

Post-Enactment

Activity	Question
Story retelling	Tell me the story of the dwarves so far
Enactment retellings	Tell me the story you were trying to tell when acting out using [this]
Imagination during enactment	What were you thinking about when acting out this part? Scene components targeted questions with 'Now'/'Then' cards
Enactment difficulty	Did you feel it was difficult to act this time?
Storytelling	Tell me a story of what you think will happen next in the story
Drawing explanation	Tell me about your drawings

Post-Study

Variable	Question
Enjoyment of acting	Did you like acting out the stories? What did you like acting out most? What did you not like acting out? What did you like about acting in general? What did you not like about acting in general?
Prior experiences	Do you know of any other stories that have dwarves? Did these stories influence you when you were acting?
Imagination post-enactment	Can you describe the places where the dwarves live?
Storytelling	Tell me a story of what happens after the dwarves have pushed away the spiders in the throne room

APPENDIX H

DIME STUDY

Children's Questionnaire for Vividness of Mental Imagery

ID: _____

VIVIDNESS OF VISUAL IMAGERY

Think of your bestfriend. Visualize him/her in your mind. In your mind, how clearly do you see his/her:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
A.	Face, how he/she looks like					
B.	The way he/she moves around while playing					
C.	The clothes that he/she usually wears					

Think of a setting sun/sunset. Visualize it in your mind. In your mind, how clearly do you see:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
D.	The sun going below the horizon					

Think of a cat meowing. How clearly can you imagine:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
E.	The sound of a cat meowing					

Think of a cat again and this time, imagine that you are stroking it fur. How clearly can you imagine:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
F.	The touch of the fur					

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IRB APPROVAL DATE: 05/09/2014
IRB EXPIRATION DATE: 05/01/2015

ID: _____

Imagine that you are climbing up a staircase. How clearly can you imagine:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
G.	How you move to climb the stairs					

Think about apple juice. How clearly can you imagine:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
H.	How apple juice tastes like					

Think about perfume. How clearly can you imagine:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
I.	How perfume smells like					

Imagine that you are hungry. How clearly can you imagine:

		Perfectly Clear	Reasonably clear	Moderately clear	Vague and dim	Cannot see at all
		1	2	3	4	5
J.	What it feels like to be hungry					

IRB NUMBER: IRB2014-0253
IRB APPROVAL DATE: 05/09/2014
IRB EXPIRATION DATE: 05/01/2015

Alternate Uses Test

ID: _____

ALTERNATE USES TEST

Do you know what a ping pong ball is? Tell me as many uses as you can think of for a ping pong ball.

		Originality	Fluency	Flexibility	Elaboration
1					
2					
3					
4					
5					
6					

Do you know what a brick is? Tell me as many uses as you can think of for a brick.

		Originality	Fluency	Flexibility	Elaboration
1					
2					
3					
4					
5					
6					

IRB NUMBER: IRB2014-0253
IRB APPROVAL DATE: 05/09/2014
IRB EXPIRATION DATE: 05/01/2015

ID: _____

Do you know what a pen is? Tell me as many uses as you can think of for a pen.

		Originality	Fluency	Flexibility	Elaboration
1					
2					
3					
4					
5					
6					

Minor's Assent Form

TEXAS A&M UNIVERSITY HUMAN SUBJECTS PROTECTION PROGRAM
MINOR'S ASSENT FORM

Project Title: Investigating Enactment as an Approach to Story Authoring for Children

You are being asked to join a research study. A research study is a science project that is trying to answer a question. This research project is trying to see if children like you can tell stories using acting. To do this, we will ask you to create stories using different ways, for example, writing a story and using this system. We will ask you some questions after you have created your story.

You do not have to be in this research study and you can stop at any time. If you have any questions, you can talk to me, our parents, or your supervisor.

Do you have any questions? Do you want to be in this research study?

_____
Minor's Name

_____ _____
Presenter's Signature Date

Presenter's notes about verbal assent given:

_____

_____

IRB NUMBER: IRB2014-0253
IRB APPROVAL DATE: 05/09/2014
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APPENDIX I

'TEACHERS' FOCUS GROUP' ACTIVITY PLAN

Design Workshop Plan with BISD Teachers

1. **Description of how creative story writing is done in 3rd and 4th grades**
    a. What exercises/assignments/activities are given?
    b. What strategies are taken?
    c. Successes and failures with current methods
    d. What difficulties do the students face?
    e. Use of technology

2. **Design an ideal system that would satisfy all your needs to teach creative story writing to 3rd and 4th graders**
    a. Key features of system
    b. How would it look like?
    c. What are its advantages?

3. **Presentation of the story authoring system design and prototype**
    a. General feedback on design
    b. General feedback about concept

4. **Integration of the story authoring system in the classroom**
    a. How can you see yourself using the system in your classroom?
    b. Design an activity/assignment for 3rd or 4th graders that involve the use of the story authoring system
    c. Decide on a story prompt/theme that you would give to your students as a story writing assignment

5. **Presentation about study design**
    a. Will such a study design integrate in your classroom?
    b. Can you think of a comparative activity to the system-based one?