

# Storytelling Systems: Constructing the Innerface of the Interface

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## Abstract

*Although recent years have seen an explosion in educational technology, there is still a lack of computational tools specifically designed to encourage exploration of identity and communication issues. Storytelling is a good medium for this type of exploration as it enables reflection about the inner world. This paper presents a new approach to interactive storytelling: SAGE (Storytelling Agent Generation Environment), a construction kit that supports children's creation of their own wise storytellers to interact with. In this system, programming is a vehicle for the transformation of ways of thinking about communication as well as for constructing knowledge about technology. In order to encourage children's emotional engagement in the SAGE environment, the storytellers are embodied in an interactive stuffed animal — a soft interface — which is also programmable by the children. This paper presents some technical aspects of SAGE's design and implementation and focuses on empirical results from research with children using SAGE.*

## 1. Introduction

Computers are evocative objects that can enable a self-reflective discourse[47]. However, there is a lack of computer tools and programming environments explicitly designed to impact on identity formation. SAGE (Storytelling Agent Generation Environment), a construction kit that allows children to create their own wise storytellers, was designed with this explicit goal and uses storytelling to achieve its purpose.

Stories are one of the many ways in which the self is presented to others and to ourselves. When people communicate they often do it through telling stories about their experiences and by finding personal

relevance in other people's stories. SAGE encourages, enables and enhances this type of storytelling, as well as provides a framework for children to design and program their own embodied interactive storytellers. This latter, meta-level, activity supports changes in the way children think about themselves, and about storytelling as a communicative activity.

Thus, SAGE supports two modes of engagement. In the first, storytelling interaction, children are invited to talk about their lives with a wise old sage, who listens and then offers a relevant traditional tale in response. In the second, storyteller-designing interaction, children are invited to add to the library of wise old sages by designing their own storyteller for themselves and other children to interact with. In order to support children as designers, as well as users, of the storytellers, a visual programming language was implemented. With it they designed and programmed: 1) the scripts that are used by the storyteller, 2) the conversational structure or flow of the interaction, 3) the body behaviors of the toy —which behaves as the storyteller's assistant; and 4) the database of stories that are offered in response by the storyteller.

## 2. Context of the work

Although little research has been done on how technology can be used to encourage children to learn about their inner worlds, a fair amount of research exists in relevant fields that impact upon this issue. In what follows we present a theoretical framework, drawing from research in areas such as narrative theory, psychology, interactive fiction, artificial intelligence, human-computer interaction, and education.

### 2.1 Telling and listening to stories

Narrative is the primary form through which we understand and give meaning to our experiences [39].

At the individual level, a narrative of our own lives enables us to construe our role in the world. At the cultural level, narrative gives cohesion to shared beliefs and transmitted values. At the family level, storytelling is used -- even unwittingly -- by parents to enculturate children -- to teach them what stories are appropriate and important, and how to become competent tellers of the stories of the family's life [31].

Our research focuses on a particular kind of narrative —conversational stories of personal experience— described by Polanyi [38] as highly structured linguistic productions found in the context of everyday talk.

Narrative, including conversational stories of personal experience, serves at least three vital functions:

1) A cognitive function. Personal stories are fundamental constituents of human memory, and new experiences are interpreted in terms of old stories and generalized story scripts [2,45]. Bruner [8] distinguishes two modes of thought that provide distinctive ways of ordering and understanding experience: the paradigmatic or logico-scientific and the narrative. The latter contributes to what we call “intuitive understanding”.

2) A social function. The tales that one knows and can tell define the social group or culture to which one belongs [49]. Myths, legends, and traditional stories provide a sense of continuity between generations. Life stories are told and retold by adults according to certain conventions and in many different contexts [27].

3) An emotional function. Storytelling has been used in very different forms of psychotherapy [54]. The emotional value of tales has been explored by Erickson in hypnotherapy [42] and in fairy tales by Bettelheim [4]. As Anna Freud [17], Erik Erikson [16], and others have shown, through the verbal-play experience of storytelling, children can find not only recreation but also self-cure.

For all these reasons, it is important for children and adults to have a place to tell their stories. SAGE was conceived to help children “play out” what is happening in their lives by telling and listening to stories. In interaction mode, SAGE explicitly encourages children to tell the stories of their lives. In design mode, SAGE allows children to also play the role of a wise old person listening and responding to other's stories. Taken together, these two modes allow children to find and express their voice [10] as well as their identity.

## 2.2 Technology meets storytelling

To date most of the research on computers and storytelling has focused on interactive games, mystery simulations, and interactive fiction —

although see [14,26]. Interactive games and mystery simulations present a plot by way of short descriptions of characters and places, and they allow users to navigate through the spaces and find out more about the characters. Interactive fiction presents a short story or novel in a hypertext format -- the branching nodes allow users to read a different story each time by choosing different links. Unlike personal narratives, this work concentrates on how to adapt fiction by professional authors to the constraints and possibilities of the computer. Other work has used computation to assist production and viewing of narrative structure models for cinema. For example, “Agent Stories” [6] is an environment for non-linear, cinematic story design and presentation that can be used by cinematic story writers.

Interactive storytelling for children has been limited to interactive fiction of the type described above, and so-called storytelling systems that encourage children to tell stories by giving them a choice of first sentences, a set of characters to arrange on the screen as inspiration, or sample illustrations for their story. Many of the products produced by the new ‘girl game’ companies, attempting to make technology that is appealing to girls, fall into this category.

Some work in Artificial Intelligence has approached narrative with the vision that — as a step towards machine understanding with broad applicability — computers should try to re-create the cognitive processes that people use to understand stories. In this area, research has been done on producing models of the world that contain particular knowledge organized around standard situations or cases [44]. This story understanding research depends on a theory of narrative as primarily constituted by goals and actions in the context of plans. Another tradition in AI, drawing from anthropology and ethnomethodology instead of cognitive science, has proposed a theory of situated action as complementary to the traditional planning approach [46]. The emphasis is not on mental processes but on social relations produced through the actions people take in the world. The integration of social and cognitive approaches has also been proposed [56]. Theories that include an understanding of how meaning involves a social as well as a mental dimension are more compatible with the notion of stories as social as well as cognitive artifacts.

Recently, alternatives to the whole AI approach have been proposed in the form of a focus on believability over ability. Research has shown that the construction of emotionally believable characters with a limited field of interaction can maintain the suspension of disbelief of the user [3]. However, choice of a character to model is key. The most successful is “a parodic interactive character whose computational rigidities model recognizably

human types" [32]. SAGE offers a meta-level construction tool kit to build exactly this sort of predictable character. SAGE borrows from Eliza [52], Parry [11] and Julia [29] the notion of a simple conversational system with a well-defined character but, first, extends the domain to the world of narrative, and second, allows storyteller construction as well as interaction.

### 2.3 Learning by telling

The educational philosophy of constructionism [33, 35] asserts that learners are likely to have access to more and different kinds of new ideas when they are building things that they can reflect upon and share with others in their learning community. In the light of this approach, SAGE focuses on the building of stories and sage storytellers as "evocative objects" [47,48] that invite reflection about identity and communication.

Extensive work has been done within constructionism on creating tools to help children think in different ways about the sciences and mathematics [22]. For example, educational software such as Logo supports direct manipulation and creation of computational artifacts as well as reflection about the programming process [36]. Starlogo is an extension of Logo that allows parallel processing and invites children to create and reflect on decentralized systems [41]. Environments such as Boxer use the spatial metaphor of objects on a screen to "encourage people to interpret the organization of the computational system in terms of spatial relationships" [12]. However, little work has yet been done on designing technological tools that help children learn about themselves, cultural values, narrative and language —although see [51,23,7].

Within the constructionist approach, computational construction kits are tools that support children's design and construction of their own projects within some domain [40]. SAGE is a construction kit that includes the two types of connections required by constructionism to bootstrap

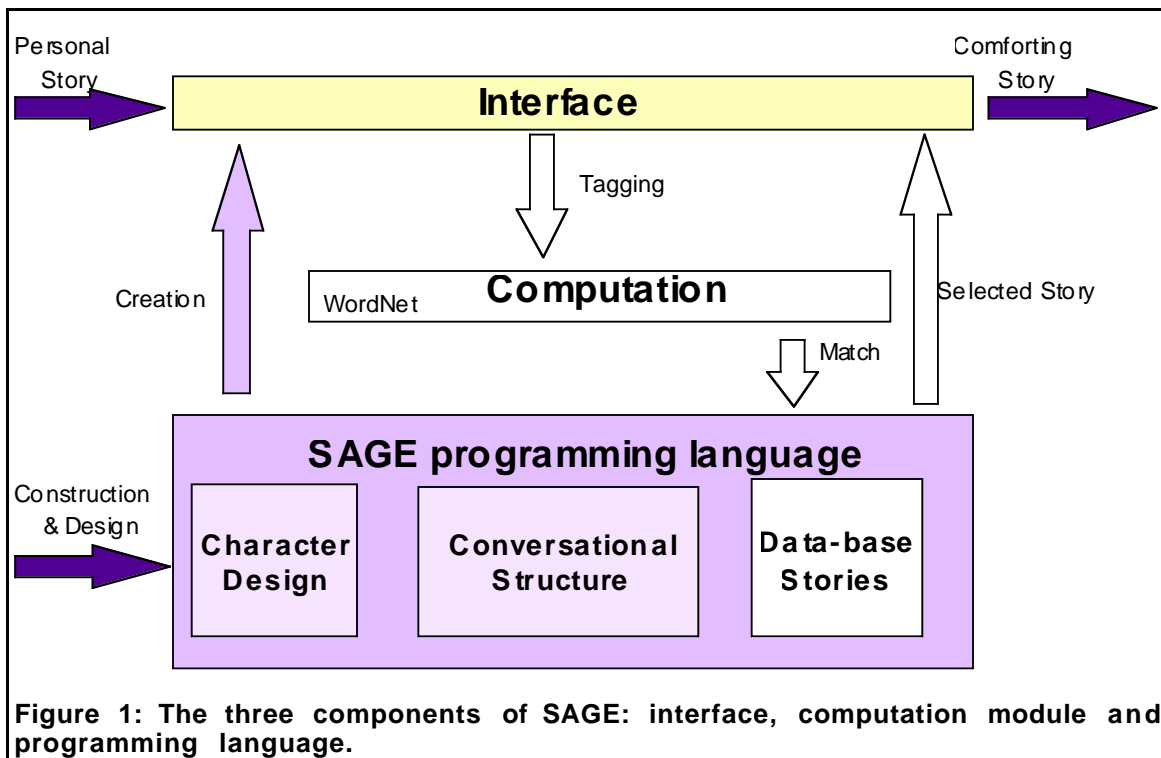
learning: 1) personal connections: children can program their interactive embodied storytellers according to their own culture and interests, and 2) epistemological connections: SAGE encourages new ways of thinking about storytelling, communication and the self.

### 2.4 Things to tell with

The discipline of human-computer interaction is moving from GUI to TUI — from a mouse and keyboard to ubiquitous computing and tangible media [24]. The challenge is to unite the digital with the physical world so as to integrate the power of computing seamlessly into everyday life, and to exploit the affordances of everyday objects in the construction of computing interfaces. Different materials have different characteristics, engage different senses and support different types of exploration. For example, Dr. LegoHead [5], a computational construction environment, allows children to build creatures out of high level Lego parts such as eyes and mouths, thus exploring powerful ideas about the nature of metaphor and shared understanding [1].

Stuffed animals are an example of an object whose emotional affordances can be exploited in building computational interfaces for children. Children establish intimate relationships with their toys [13,19]. The natural tendency to communicate at a deep level with soft objects can be leveraged by adding computational abilities so toys can give feedback [50]. The result is computationally-augmented toys for storytelling [18].

The psychologist Winnicott [55] introduced the term "transitional object" to refer to the first "not-me" infant's object. However, not all the objects have the same value: the favorite toy, as described by Winnicott "must seem to the infant to give warmth, or to move, or to have texture, or to do something that seems to show it has vitality or reality of its own."



**Figure 1: The three components of SAGE: interface, computation module and programming language.**

Druin [15] explored the idea of an interface that emphasizes emotional as well as cognitive engagement by building a gigantic furry animal called Noobie, an alternative to the traditional computer terminal. For example, squeezing parts of Noobie, children could observe the selected animal part on the screen in Noobie's stomach. Following this line and in order to support emotional engagement, SAGE embeds the sage storyteller in a programmable interactive stuffed animal — a soft interface. The stuffed animal is capable of some of the types of nonverbal behaviors that humans use to indicate engagement, and that are commonly found in conversational narratives between people [9]. In interaction mode, children can watch the stuffed animal move as they converse with it. In design mode, children can decide on the toy's communicative behaviors as well as the different personalities that it might have.

### 3. Design and Implementation

SAGE was designed to support the creation of wise storytellers who always have a story at hand related to the user's experiences. Children can engage with SAGE in two modes: 1) by choosing from a library of sage storytellers and then telling personal stories to that persona, and 2) by creating their own characters and storytelling interactions.

The LISP-based SAGE architecture has three main components as shown in Figure 1:

- the SAGE computation module: in charge of parsing the user's story, expanding keywords and performing a match between the user's personal story and a comforting story in the database.
- the SAGE programming language: used by children to design their own interactive characters.
- the SAGE interface: the interactive toy, the screen (output) and the keyboard (input).

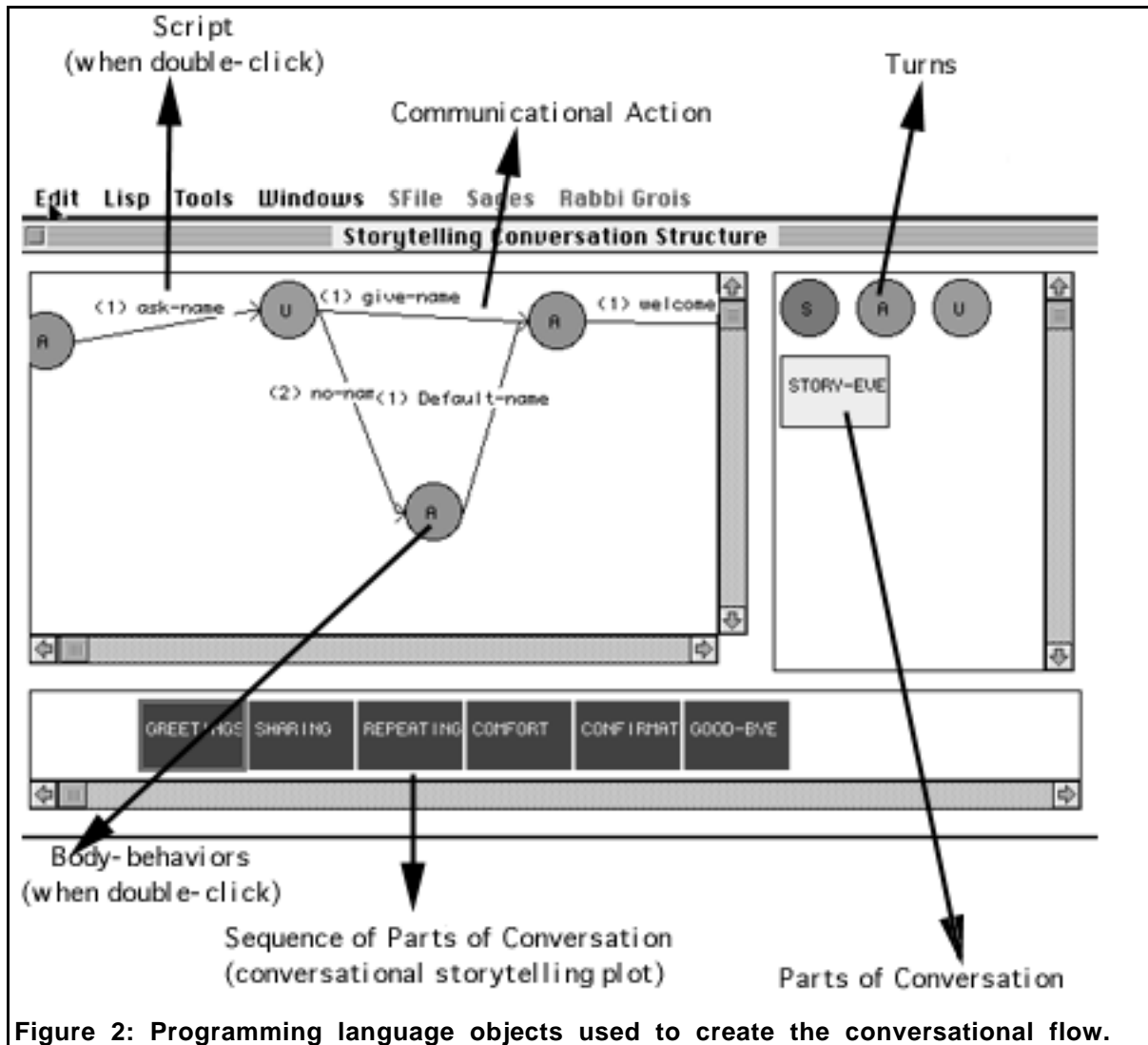
#### 3.1 The computation module

The SAGE computation module is in charge of processing the user's story and retrieving a story for the sage storyteller to give in reply. The process is as follows: The user's story is parsed. Nouns and verbs are extracted from the parse and submitted to WordNet, a hierarchical semantic lexical reference system in which nouns, verbs and adjectives are organized into sets of related concepts [30,43]. Different keywords that can be grouped under one single concept result in weighting that concept more highly than others in the list. The weighted nouns and verbs are matched against nouns and verbs indexing stories in the story database. The story that is most like the user's story — that deals with the same themes — is retrieved and told to the user. This level is not directly accessed by the user

#### 3.2 The programming language

The SAGE programming language has a graphical user interface that allows children both to design

and placing them in the conversational structure window in order to model the conversational



**Figure 2: Programming language objects used to create the conversational flow.**

storytellers to interact with and also to model different types of communication and storytelling situations. The environment supports children's creation of their own embodied interactive storytellers by providing three windows that can be chosen from a menu and in which design takes place:

- Character's creation: children describe different facts about the lives of the sage storyteller and an optional storyteller's assistant —the interactive stuffed toy. These facts will determine how the storyteller (and assistant) interact with the user. Users also use this window to load pictures of them (scanned photos or sketches done in a drawing program).

- Conversational Structure window: children design the conversational flow by selecting off a palette three sets of objects —turn-taking states, communicative actions and parts of conversation—

storytelling interaction (see Figure 2). In order to help children understand what these abstract conversational units are, children always have the option of referring to — and/or copying/modifying — the conversational structure window of existant storytellers designed by previous users.

- Database of stories: users can write or scan in comforting stories in text; they also have the possibility of recording comforting stories in their own voice. It is in this window, too, that children categorize or annotate the stories with story values, and nouns and verbs that they consider good descriptors of the main story points, in order to determine when a story is matched to a user's input story.

The SAGE programming language has the following characteristics:

- Graphical user interface (GUI) : a standard graphical representation for children to easily create, manipulate and edit conversational flows.
- Scaffolding: novice users can get started with their projects quickly. Later, however, after becoming expert users, children remain challenged to develop further understanding and complex productions.
- Availability of examples: children can always look at other children's storytellers and use parts of their code by "cutting", "pasting" or modifying it.
- Ease of use: the GUI allows children to create conversational flow in the same way that they usually play pretend games, by planning "who" is going to say "what", and "when".
- Limited domain: the SAGE programming language only allows the user to create directed conversational storytelling situations. The nature of the conversational system is always machine-controlled —mixed-initiative is not readily an option.

### 3.3 The interface

The SAGE interface is the layer through which a user communicates with the system. The output device is composed of an interactive stuffed animal with programmable body behaviors and the computer screen with a graphical representation of a storyteller and his/her talking balloon and speech/sound output. The input device is the keyboard.

Since the technology is not yet available to create a stand-alone interactive toy (the main obstacle being the lack of adequate speech recognition systems for children's speech), we integrated the computer with a physical toy. Output is multimodal, and input is typed text only. In order to explain the absence of symmetry in the interaction, in interaction mode the stuffed animal is presented as being the assistant of the sage storyteller that lives on the computer screen. This assistant character, with an internal microphone, can interactively respond to the user through a speech synthesizer. The sage storyteller is presented as being a character that lives in the computer. He or she is only in charge of telling the pre-recorded real-voice comforting stories from the database.

Children choose which sage storyteller they wish to interact with by placing different hats on the stuffed animal. The stuffed animal has a set of hats with a small resistor whose unique value is read by the Handy Board [28]. This microcontroller interfaces, via a serial connection, the physical stuffed animal with the SAGE software running on a Macintosh computer. It allows the system to know which character is loaded at any given moment, and it controls the movements of the interactive programmable stuffed animal (see figure 3).



**Figure 3: the programmable interactive rabbit (wearing a yalmulke, and holding the hat of a Taoist Sage) and the Handy-Board.**

## 4. Empirical Research

We claim that the SAGE storytelling system is an example of how technology can be used to encourage children to reflect about their inner life, and to support their learning about narrative and communication. In this section we describe empirical research that investigates this claim.

### 4.1 Description of workshops

Several pilot studies were conducted to examine children's interactions with the sage storytellers, and their ability to build their own sages. Our earliest research showed that children were in fact quite ready to engage deeply with sages that we had designed. Children opened up willingly to tell personal problems to both the Rabbi and the Taoist scholar sage [50]. And the nature of their engagement was no different whether they understood the workings of the implementation, or believed that the computer understood something deep about them. This result led us to believe that children would also be able to interact with sages of their own design.

Research was conducted with fourth and fifth graders in order to test SAGE's impact on storytelling awareness, self-reflection skills and the interaction between these skills and technological fluency.

Children of this age are almost adult-like in their narrative productions [25,21] but are still not capable of explicit meta-linguistic comments about the structure of narrative [20]. Likewise, American fifth graders are in general familiar with computer applications but, for the most part, are not fluent programmers. The general claim here is that SAGE integrates programming and storytelling skills by supporting the design and modeling of abstract structures, needed and used in both set of activities.

In order to understand children's design and creation of their own meaningful storytellers, two-day weekend workshops were conducted at the MIT Media Laboratory. Children were solicited for the workshops through local schools and personal connections. Children who participated in the workshops came from a range of backgrounds, and were not particularly computer-competent. Workshops were conducted with two groups of four children: two girls and two boys per group. Each workshop comprised one pre-study personal interview, two full days of design and programming, one post-study personal interview, and one demonstration for the parents given by the children. Each child worked on a separate computer to design and program a storyteller of his/her choice, and kept his/her own design notebook with ideas, problems, etc.

The methodology used for the study was based on an ethnographic approach, with a natural observation method, extended personal interviews and an experimental task. In order to avoid "technocentric questions" [34], the methodology was centered on what children do with SAGE and not what SAGE does to children.

#### 4.2 The presentation of the self

In building a sage, children designed that person to whom they wished they could turn with their problems. But it is essential to note that the sage that they designed is also an aspect of the inner life of the child designer. That is, since the children were creating their own characters and databases of stories, they were also playing with different notions of self, and creating or imitating the narrative voices they wanted or needed to hear. One might claim that the children were simply imitating images of role models that they had perceived in their environment. But imitation is linked to understanding. As Piaget [37] said, "Imitation is always a continuation of understanding, but in the direction of differentiation with respect to new models." Children created storytellers as projections of fears, feelings, interests and role models. These projections allowed the presentation of the self to themselves as well as to others.

Out of a total of eight storytellers built during the workshops, three were based on actual characters or people: Doug, a cartoon character, Tera Randof, based on a mixture of a real sports figure and family members of the author, and Shaquille O'Neil, a well-known basketball player. The other five characters were fictional, although two of them, Spot and the Big Orange Fox, clearly tell stories based on the authors' personal experiences.

During the workshops Tracy<sup>1</sup>, a ten-year-old girl with no previous programming experience, created Tera Randof, a twelve-year-old female basketball player "*who will become a sports figure*" like the ones Tracy admires. In the post-interview, Tracy revealed that Tera's personality is a mixture of Tracy's mother and grandmother, and that the stories that Tera tells are Tracy's mother's childhood stories. Tracy created the character and the conversational structure, as well as wrote all the stories in the database. By interacting with her own programmed storyteller over and over again, Tracy improved the program. In the process, Tracy also reflected on how people become good listeners. And, despite the fact that she was interacting with a storyteller of her own design, Tracy shared real personal problems, and engaged with the program to make sense of the advice being given.

The following interaction between Tracy and her sage storyteller took place during the design process.

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SAGE : Hello my name is Tera
Randof. I am 12 years old. I
love basketball. I play center
on my school team. Anyway enough
about me what's your name?
USER : My name is Tracy.
SAGE : As I told you I am 12.
You are probably 10 or 11. Am I
right?
USER : Yes. I am 10.
SAGE : Wow! I guessed your age
right? Great! I have a lot of
problems like wondering if my
team is going to win the big game
or if I will mess it up for
everyone. Please tell me a
problem you have.
USER : I am sad because my
parents told me that we can't
take my dog on vacations with us,
so I will miss him.
SAGE : Your problem reminded me
of this story. Kerri is my best
friend. Kerri knows everything
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<sup>1</sup> Names of children and other identifying details have been changed.

about me and I know everything about her. Every Friday we sleep over each others houses. Switching houses each week. This week it was at my house. I got the usual snacks: popcorn, pizza, chips, soda, and candy. A few hours later Kerri came by with her sleeping bag. You could tell she was in a bad mood. I asked her to lighten up, and she snapped, "Fine." and left. I was stunned. What was her problem? I waited the few minutes that it took for her to walk home then called her. Her mom answered. I asked to talk to Kerri. Her mom said Kerri doesn't feel like talking to you right now. Kerri didn't talk to me in school for a month. Then I got the horrible news: my mom got a great job in L.A. so we were moving there! Kerri didn't even come over to say good-bye. I have never seen or talked to her since. Maybe she wasn't really my best friend. Did you like that story? Did you understand the moral of it? Please tell me what you think that story meant.

USER : You didn't see your friend ever again, but I will see my dog when we come back from vacation. I guess that is not that bad.

SAGE : Good job! I think you understand the story. Well I better go or I might miss basketball practice. I really liked talking to you. Hope to see you soon. See ya!

USER : Ok, bye!

Tracy created a very coherent and developed personality for Tera Randof. And the stories that Tracy created for Tera to tell are complex linguistic and narrative constructions which skillfully use reported speech and tense shifts to create suspense, which lead up to a surprising denouement, and which convey a complex message.

Tracy is only one of the many cases in which we observed, by analyzing the logs of the interactions, that a deep knowledge of how the system works doesn't affect emotional engagement and sharing of a personal problem. At the same time, Tracy's knowledge of how SAGE works allowed her to reflect about the nature of sharing problems in a deeper way and compare it with her intuitions about

how people help one other: "A person already knows how to react to a question but the computer doesn't. You have to feed in information about what to say and that is like creating a mind and a personality. [ . . . ] When people communicate they take an experience they had or think of something that the other person might want to hear, a same sort of problem, something familiar or similar and they just tell it."

### 4.3 Storytelling and programming skills

In the following example we look at the interaction between the formal representation of human-machine dialogue, and intuitive understanding of how conversational storytelling works.

Mother Nature is a storyteller with a lot of personality, and good conversational skills, created by Mischa, a fourth-grader who wants to be a teacher when she grows up. Mischa created a very complex conversational structure that has two parallel branches, one for people who like to be in nature and one for people who do not. She decided to index her stories in the database according to different topics in nature: flowers, animals, rain, etc. She reported that, despite her lack of previous programming experience, she loved SAGE because "it is a program for you to make another program" and demonstrated her nascent understanding of the formal aspects of what she was doing when she admitted that she found it hard to "type all the possibilities for what a person [user] might say".

Below is a log from an interaction with Mother Nature. The story offered by Mother Nature, written by Mischa, reflects not only Mischa's love for nature and understanding of conversational storytelling, but also her experience during the workshop, where she wrote stories about different animals in nature.

SAGE : Hello,I'm Mother Nature.What is your name?

USER : Mira

SAGE : I am very old. I am already 3183! How old are you? Please tell me in numbers.

USER : 24

SAGE : Well you're not too old honey! So,do you like to be in nature? I live in it!

USER : yes

SAGE : That is very nice! So have you ever done something good for nature?

USER : yes

SAGE : Oh,OK now I will tell you some stories.First I need you to tell me what your favorite thing

in nature is because I might know a story about it!

USER : animals

SAGE : In school Julie had to list all the animals she could list not including insects or sea animals. Julie was a very creative girl and she thought it would be boring just listing them. She wanted to make up a creative story about them. So she asked her teacher if she could. Her teacher, Ms.Corty, said that was fine. As soon as Julie was home she started right on her story about animals. For each animal she wrote an adventure. Her first animal was the dog. Julie loved dogs! The story was about a little dog who could not talk nor make a sound. He thought he had the worst life but he really had the best a puppy could have! Even though he could not talk he had a special talent. He could dance better than any dog or human being. Now he knew this but no one else did. The little puppy thought dogs should not dance so he did dance in an alley where almost no one goes. But one day a super star searcher was doing his job and found the puppy. Soon the little dog was bigger than Michael Jackson! Julie finished the stories of the animals and brought it to school. She got an A+. Julie was so happy! The End!

USER : thanks !

SAGE : I hope you liked my story! I have to go and make it rain in Hong Kong! Good bye.

USER : bye

In the post-interview, reflecting on her authoring experience, Mischa said: "The most fun part was working on the computer and programming kind of a game for people to use. I liked creating what it might say and the questions and the structure and writing the stories and I learned that people can type anything and that you always have to be prepared because people might type not just "yes" or "no" but, for example "I guess so", so you have to use more branches". Based on her understanding of stories as reflecting what one knows about particular topics, Mischa created a storyteller who retrieves a story about a particular topic, rather than a story that is

comforting. Mischa's understanding of storytelling bootstrapped her understanding of programming — that one has to be ready with an output for any input.

SAGE facilitates the exploration of notions of communication as children observe conversational breakdowns in their own and others' interactions with the created characters. The most frequently observed communication breakdown was due to children's difficulty in decentering and designing interactions in which other people, different from themselves, could participate. By decentering, we mean the ability to imagine a conversational interaction from the point of view of another interlocutor [21]. That is, more generally, the moving out of the phase of egocentrism where one cannot differentiate somebody else's point of view from one's own [37]. The iterative design experience, which involved programming and immediate testing with a real audience —themselves, their parents and other children — gave children the opportunity to decenter and debug their conversational structures after observing other people's interactions. Communication and computational bugs are not the same, and both become explicit with the use of SAGE in its authoring mode.

## 5. Conclusions

In this paper we discussed the importance of technological tools specifically designed to encourage children's exploration of the identity and communication. We proposed personal storytelling as a way to access the inner world as well as to explore notions of communication. Constructionism — the notion that learners are likely to have access to more and different kinds of new ideas when they are building things that they can reflect upon and share with others in their learning community — informed the educational goals of our work.

We presented the design and implementation of such a technological tool; SAGE, a construction kit to create embodied interactive storytellers with whom one can converse. We described children's interactions with the SAGE tool, concentrating on case studies that exemplified the results of our research on children's authoring experiences with SAGE.

On the self-reflective side, children created storytellers as projections of fears, feelings, interests and role-models and these storytellers allowed children to explore their own inner life, as well as to present themselves to others. On the communication side, children created storytellers that exemplified many different kinds of conversational storytelling, and allowed the sharing of different problems. Both aspects were supported by the iterative design experience which allowed children to *decenter* and

*debug* after observing other people's interactions with the storytellers they created.

## 6. Acknowledgements

Thanks to the members of the Gesture and Narrative Language and the Epistemology and Learning Research Groups at the MIT Media Lab. Thanks to Interval Research Corp for supporting part of this research.

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