LEARNING ABOUT INTERACTIVITY FROM PHYSICAL TOYS

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Interaction Design is about designing interactions. We thus need to understand what makes up (good) 'interactivity'. This paper discusses experiences with an exercise that aims to sensitize students for interaction qualities and to make them familiar with central concepts on the nature of interactivity through analysis of physical toys. Reflection on students' insights and observations reveals how these abstract notions interrelate in complex ways and provides vivid examples, giving evidence of the exercise's value.

INTRODUCTION

Interaction Design is generally being defined as the design of interactive products, concerned with designing the user experience (e.g. Sharp, Rogers and Preece, 2007). Moving from Interface Design to Interaction Design means that "design thinking as a whole has to focus on the interaction" instead of just on the widgets (Winograd 2007, p. 91). Most textbooks nevertheless largely avoid the question of what makes up the interactivity of products and how the user experience is influenced by the style of interaction. Pinning this down is astonishingly difficult as interaction turns out to be an elusive, albeit ubiquitous phenomenon. To sharpen perception and understanding, it is often useful to focus on simple examples. I here reflect on insights from a student exercise in analysing physical toys for their interaction qualities. The aims of this paper are to contribute to understanding interactivity and to exchange experiences in how to sensitize learners for qualities of interactivity.

The exercise builds upon central notions from conceptual interaction design literature (Löwgren, 2001, 2002; Shedroff 2000, Crawford, 2002) on the nature of interactivity and interaction qualities. Pairs of students are asked to select physical toys, to play with them for a while, and to reflect on their experiences. Guiding questions relate to the toy's behaviour, reactions and expressivity, the expressivity and freedom it allows its 'user', the constraints it sets, the size of the interaction space, locus of control with the 'user' or the toy, etc.

Analysing a non-digital object reduces the complexity of the exercise (effectively restricting objects' functionality) and allows learners to focus on the interactivity itself – discussing general principles and basic concepts by looking at simple but fundamental examples. Further, analysing something that does not obviously belong to one's field of study encourages learners to take a fresh, unbiased perspective. Interacting with toys that have no 'task' and where efficiency is not a purpose, has students focus on 'raw' interactivity. At the same time the limited functionality of physical toys means that repetition or single-purposeness are easier to detect while there is less risk of non-interactive features like flashy graphics and sound dominating over the use experience.

In summarizing and reflecting on students' observations, many issues highlighted in the literature (even if not present in the exercise brief) become apparent, and abstract notions are filled with life. While it is not yet clear how to best integrate this exercise into a curriculum so as to exploit its full power, the insights gained by learners (and teachers) provide evidence of its value in attaining a deeper understanding of interactivity and of interaction qualities.

The next section introduces concepts providing the foundation for the exercise from the discourse about interactivity. Then the context of the educational situations for the exercise is described, and the actual exercise presented. The main section discusses and compares students' observations and illustrates these with excerpts from written essays (translated by the author from German) and verbal quotes.

WHAT IS INTERACTIVITY AND HOW CAN WE ASSESS IT?

Whereas HCI traditionally focuses on usability and effectiveness of systems, interaction design, influenced by product design, art and game development, is more interested in the aesthetics and joy of use (Monk et al 2002), in seduction, and the use experience of interactive products. „A user may choose to work with a product despite it being difficult to use, because it is challenging, seductive, playful, surprising, memorable or rewarding, resulting in enjoyment of the experience." (Djajadiningrat et al. 2000, p. 132). This discussion questions the traditional dichotomy of work and enjoyment and opens avenues to learn from successful entertainment applications.

The efforts being made to understand what makes up the attractiveness of interactive products show that this is due to a diversity of *interaction qualities*. These emphasize the 'feel' of products and their behaviour (Svanaes 2000). Interaction Design thus concerns both the "aesthetics of use" (or "grace") and of appearance (Crampton-Smith 2002). While no unified (and universally accepted) theory of interactivity exists so far, many researchers (Shedroff, 2000; Crawford 2002; Löwgren, 2001, 2002; Svanaes, 2000; Winograd, 1997, 2007), each focusing on different aspects, share a view of interactivity as a process, with the user experience being created through the interrelation of system behaviour and user activity. To experience this process, users must enter it; they need to actively interact in order to conceive the "dynamic gestalt" or feel of interactive products (Löwgren, 2001; Crawford, 2002; Rijken, 1999, Svanaes 2000). Interaction is a process because it has a "dialogical temporal element"; there is a sequence and flow of interaction (Winograd, 2007, cf. Svanaes, 2000). The focus on interaction as a process differentiates interaction design from interface design, being less interested in static properties of e.g. a single screen, than in the experiential and time-based aspects of moving around over time.

Interaction Design requires the ability to "create meaningful interactions" and "valuable, compelling and empowering information and experiences for others" (Shedroff, 2000, p. 282, 287). Shedroff identifies *user control* over the results (type, order and tempo of actions) and system *feedback* as essential aspects of interactivity. Further aspects are *creativity* and *productivity*, (human) *communication* and *adaptivity*. Shedroff argues that creativity, productivity and communication require engagement as well as activity (they involve interaction by nature) and are experienced as satisfying. Systems can be interactive to a varying degree regarding all of these criteria. To some extent passive experience is possible (a movie or a rollercoaster ride), but real interaction needs an active contribution of the user (Shedroff, 2000; cf. Crawford, 2002).

Crawford (2002) proposes 'conversation' as a metaphor to understand interactivity. At first this metaphor might sound simplistic, but I have found it to be very useful if used as a metaphor. Conversation is a process in which two actors alternate in *doing/speaking*, *listening*, and *processing/thinking* to generate a response, resulting in a loop of information being exchanged. The quality of a conversation is determined by the quality of all three activities. One of the main questions for analysis if using this metaphor is whether there is symmetry or a lop-sidedness of contributions. Currently computers would be only good in 'talking' (displaying information), but very bad in 'listening' and understanding the user. The designer's task should be to maximize the utility of the conversation. This means enabling the user to do relevant things by *offering 'verbs'*, which correspond to choices, actions or abilities that the user is provided with or enabled to. Verbs should be concise, but abstract in order to cover a range of situations. Furthermore *process intensity* should be improved – sophisticated functionality processing the users' input.

To further pin down what is a meaningful or compelling experience, and what kind of experience is adequate for which purposes, researchers begin to explore *use qualities* such as playability, seduction, pliability, immersion, transparency, elegance (power and simplicity), surprise and para-functionality (Löwgren, 2002) or the expressiveness of embodied interaction (Djajadiningrat et al, 2000). These qualities are held to be useful for analysing systems and for setting requirements (Löwgren, 2002). We can assume that this list is just the beginning of an evolving vocabulary due to our expanding understanding of interactivity.

Winograd (1999) introduced the metaphor of interaction design as „design of spaces for human communication and interaction" and explained that software generates spaces in which the user lives. The analogy is with architects who create spaces which users appropriate and fill with own life, while pre-determining feasible adaptation and movement paths. "The user creates an ‚experience' while acting within an information environment. (…) It reminds me of how a building or a town doesn't force a single specific route or function, but offers a number of connected spaces and possibilities. However, design decisions do ultimatively determine the possible experiences. The space then works as a process facilitator. Experience is the dynamic end result of design." (Rijken 99, p. 48).

Game designer and theorist Crawford (2002) builds on this metaphor and visualises *(inter)action spaces* as decision trees with knots and branches denoting states and possible user actions. These trees can be narrow or broad, flat or deep, tightly or weakly meshed (fig. 1). Linear successions offer only the illusion of an interaction space but leave no choices. Flat trees with short branches make users stop mid point and are very predictable. Linkmeshes provide long interaction chains as they can fold back. Putting computational power inside knots allows for variable system behaviour dependent on prior interaction history. Good action spaces are usually deep, but narrow and tightly meshed, offering functional power for a defined set of problems without being overwhelming.

EDUCATIONAL SETTING FOR THE EXERCISE

The exercise has been run four times in different settings, all based in computing-related rather than design-school oriented educational settings. It was used twice in 2003 and 2004 as first written assignment (handed in by pairs) in a ten-week course 'Interaction Design' (taught with Dr. Hilda Tellioglu at the TU Vienna). The course follows an HCI introduction class in a media engineering degree program at bachelor level. Twice the exercise was used as in-class exercise during introductory three-day courses/workshops.

In the first iteration of our 2003 class the exercise was verbally described and handed out. In the following year it was introduced in class by handing out physical toys, students playing and analysing for half an hour and discussing observations for 15 minutes. This provided students with more confidence for this rather unexpected assignment. Many needed some persuasion to engage with the exercise, but then succumbed to play, with detailed and lovingly described reports handed in. As purely in-class exercise it was used 2003 in a three-day course on interaction design during a 'women's summer university in computing' with ten mixed-background participants and 2006 during a

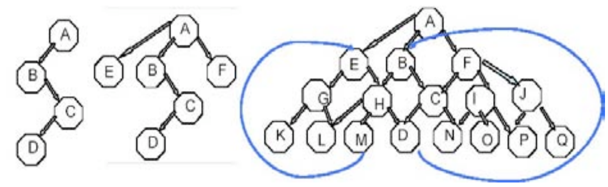

Fig. 1: Interaction spaces as decision trees: a linear 'storyline'; few choices and sudden stops; "linkmesh", a densely meshed tree with context-dependent behaviour in knots

three-day workshop on interaction design at the HitLabNZ in New Zealand, focussing on user-centred approaches, for 15 HCI students and PhD students with engineering background (taught with Mark Billinghurst and Amanda Mander from Zanzara Inc). The conceptual background was covered in more detail in the ten-week courses with written reports requiring students to spell out their observations and conclusions in detail while in class teams verbally reported for only about five minutes.

Teaching 'Interaction Design' in educational settings that can be described as media engineering, we felt the necessity to focus on user-centred design and HCI aspects, if this is to be students first and possibly last contact with Interaction Design. As there is more to it than 'just user-centeredness', sessions relating to design aspects and theory were included. In particular we aimed to let students think about what it means to *design interaction* and to provide them with conceptual anchors and first-hand experiences. Still, this context meant that these topics could not be iterated upon or investigated into further, as would be possible in a design-oriented curriculum or a specialized advanced course.

THE EXERCISE AND ITS SET OF QUESTIONS

The exercise idea has been adapted (with permission) from a course given by Chris Crawford in 2002 at the University of Bremen, extending his original set of questions with notions from other authors. The instruction sheet explains the aims of the exercise:

"What is interactivity? What makes for engaging interactive systems? Why do we like interactivity? Is there different ways of being interactive? What are interactive qualities? Sometimes it is easier to understand very general principles by looking at simple examples. For this reason we will investigate physical toys. These are interactive in various degrees – e.g. a ball will react on being thrown… a puppet can be moved and manipulated. Investigating something that seemingly has little relation to software systems can help you 'think out of the box'."

Students are asked to work in pairs, taking notes. They can play alone or together for about an hour, looking at a minimum of two toys. One learner should keep the questions in view and remind the player to verbalise impressions and thoughts on the following issues:

- Can you do interesting and exciting things with this toy and can you act in versatile ways (*your own expressivity, vocabulary of 'verbs'*)
- Which constraints and limitations does the toy set (or the rules connected with it)? Is there repetition or are there unlimited variations? What is your freedom of choice? (*your (inter)action space*)
- How interesting or complex are the reactions of the toy to your actions (*its functionality/processing*)
- How interesting or aesthetic is the *toy's expressive behaviour* (sounds, images) *(its speaking)*
- Do you react to the toy or do you control it – or is it a game of give and take? (*type of conversation*: monologue or dialogue / *degree* of *user control*)
- What do you like of the interaction, what is frustrating or boring? (*personal reaction*)
- Who would like this toy? (*target users*)

For a written report, students had to write about four pages, conclude which was the best toy and why, and to reflect how toys and software might be related.

The analysis of student observations (pairs and threes) provided here is mostly based on overall 16 written reports. Furthermore students' verbal responses to the toys have been noted down during the 2006 workshop.

RANGE OF TOYS ANALYZED

At the two three-day events the lecturers had provided toys. For the 2006 workshop these included building blocks, a magnetic construction kit, a ball, a talking alarm clock toy for learning to read the time, a yoyo, and a jigsaw puzzle. A more unusual toy used in the 2003 workshop was the handheld baseball stadium shown in figure 3 that has the player pull a trigger to shoot the ball and counts the number of goals. Here angle of holding the toy and strength of trigger pulling were relevant, requiring training and skill.

Students handing in written reports after a week sometimes had access to their own childhood toys, younger siblings' toys, or to things they had in their student dorm. An overview of the analyzed toys shows an amazing variety roughly categorized here.

10 physical skill toys (single user) (2 yoyos, 5 gyrotwisters, Mikado, wooden maze, etc.)
9 creative, constructive toys allowing for free-form play (4 plasticine, 2 classic sets of Lego bricks, 'HappyCube', colored pencils and wooden blocks)
6 specialized construction kits that can serve as a stage for play after construction (e.g. Playmobil space station, Lego set, wooden train with tracks)
7 ball-like toys, either played alone or with partner, requiring physical skills, (4 balls, a hackysack/ footbag, marbles, Chinese chiming marbles).
6 animal or human figures or dolls (action figures, animation doll, puppet, plush toys).
6 strategy and chance partner games, such as Ludo, Chess, Abalone, and card games
4 ball sports exercise games, usually requiring a partner (Badminton, Tennis, Baseball).
5 vehicle toys (e.g. matchbox cars, a car propelled by a balloon, or a dredge)
5 puzzle-like manipulation toys, such as Rubics' cube and a sliding puzzle.

This list, intended for a quick overview, is orthogonal to e.g. Ackermann's (2005) classification, which focuses on toys with creature-like qualities and their role for children's socio-emotional development. As readers will see later, some of Ackermann's notions relate to students' observations.

INTERACTION QUALITIES OF PHYSICAL TOYS

Groups, when comparing the toys they played with (two at minimum, on average four), often rated toys that allow to play with a partner as more fun and offering more surprise, or selected free-form play construction/creation toys as the best. Being able to do unexpected things with a toy and discovering new options over time was rated highly, as was initial 'ease of use' coupled with reliance on creativity and skill. A few groups felt that their chosen toys were too different in possibilities, expressiveness or aesthetics to make a ranking, or that the best choice depended on the 'users' age group.

CREATIVITY AND SOCIAL INTERACTION

"The complexity (of a game of cards) is dependent on the concrete case and the participating people."

In the students' responses the relevance of Shedroff's criteria (human communication and creativity) becomes very apparent. Toys that engender **communication** are richer in possibilities, as communication with a partner extends the action space and the range of responses.

"Although it is not boring to play on your own with these small matchbox cars, the highlight of playing is driving a race with friends."

Similarily toys which enable **creativity** (the creation of things) were rated highly, the user's creativity tending to define the action space. This relates to Resnick and Silvermans guiding principle 'Design for Designers':

"One can represent an infinite number of things with a few bricks or include other objects."

Tools for creativity need to be good in 'listening' and to offer powerful functionality.

Fig. 2: a range of the toys explored (pictures taken from reports). Top row: plasticine, car driven by a balloon, wooden maze, glass marbles. Second Row: Kermit puppet, ‘Happy horse’ set, ‘Happycube’, Mikado sticks. Third row: set of cards, Abalone game, matchbox cars, sliding puzzle. Last row: toy train, Rubics cube, planetary rings, Gyrotwister.

“*The possibilities for being expressive or to play with colour pencils are almost unlimited. (…) You can do pictures or handwritten poems, just about everything. (…) Even though the tool is controlled directly, the created product triggers creative processes in the user. This spawns an interplay between creating and creation.”*

CONSTRAINTS

Constraints limit possible actions. Students often were not able to identify all **physically embedded constraints** that the toy sets and the ‘user’ tacitly accepts. For example with Lego one cannot stack blocks in any orientation, but only in right angles. Some students found that plasticine sets no limits whereas others identified statics and available colours as constraints. A construction set with very specific parts or a limited amount of elements also sets constraints.

If the toy has **rules for play**, these rules can be considered as constraints. Playing within these rules can be the very nature of the game and the essential challenge, as with chess where the complexity of the toy results from the logics of the rules: *“The restrictive game rules do constrain you. But this provides a frame for the game, as the complex rules make up the charm of the game. The almost unlimited ways the game can go keep the tacticians interest alive.”*

Rubics cube has hard constraints as one can *“turn only at six points, which restricts the action space. Yet the same movement in different situations can have completely different effects. Each move results in a new configuration posing a new problem”*. This toy is complex, but predictable once one has understood and memorized the algorithm. This requires the player – if to keep engaged – to invent new goals and seek new challenges (eg. colour patterns), or to compete on speed with another player, changing the game.

Some toys make **change of rules** easy (for a ball: "*constraints are only given through the rules of a chosen game, apart from this the player can do anything*"), while others had rules more or less embedded into the physical structure of the toy, thereby limiting appropriation options. For a few toys the constraints lay not in the toy, but rather in the **user's skills**, such as with a yoyo. The more skilled the user, the larger the action space.

Identifying constraints seems an important exercise for sensitizing, as in developing software we often impose constraints on what users can do without noticing it.

IT IS NOT JUST THE TOY ON ITS OWN

"When playing on my own with PlayMobil I know exactly what happens next, as I control the story, set the rules and actions. With two or more players it is more exciting and varied. Players interact in a spiral. Playmobil is different from the other toys in that the environment gets integrated creatively into play – it has an optimal size to play on furniture (...) using a book as island and the carpet as sea."

A significant insight when reflecting on the students' responses was that very often 'the toy is not just the toy on its own' – it is **part of a system of players and environment**. If the toy interacts with the players and the environment in the type of play it allows for, it effectively allows for appropriation.

Enjoyment extremely depends on the user. Some students knew that toys they considered as limited and boring are liked by toddlers. Others observed that creativity tools require **imagination and involvement**, so as not to quickly get boring. Some toys require **physical dexterity, skill, and patience** in order to be enjoyed (e.g. a yoyo). Sometimes lack of skills can provide a major constraint and reduce the action space.

"Although chess provides a lot of complexity and an almost unlimited number of options of moves for a solitary player, one looses excitement soon. I control the entire game and the toy can't do anything to add to the excitement. As chess is meant for two players we then played together. The situation changed totally. There was interrelation between the players and the board. As one can not read the other's thoughts and my partner won't tell me why he did a certain move, the game suddenly is interesting and exciting."

For many games **social interaction** with other players is an essential part of the game and its very complexity and challenge result from the interplay of players. If students reached a level of proficiency that made the toy non-challenging, they often decided to **change the rules** for the game, and thereby set themselves new constraints. Quite often complexity was increased by **involving the environment** into play – ballgames were shifted from indoors to outdoors, and furniture used as setting for play with model cars: "*I can throw this ball high and catch it or throw it against a wall and try to catch it. I can roll it on the ground, let it bounce off something in the room and try to make it come back to me.*"

The change of environment can change the very nature of play, introduce new constraints and possibilities, offering new challenges and goals. Not all toys allow for this integration – e.g. the handheld baseball stadium (figure 3) cannot interact with its environment. Still, players can decide to play against each other or set new goals.

INFLUENCE OF SETTING ON INSIGHTS GAINED

"Playing with these model cars really starts being fun if a suitable route exists. For planning and building a route there are no limits to imagination. With bad weather you can use the house, the route goes from the entry door through the floor into the lounge and the kitchen. With good weather you can use the courtyard and garden. Ideal are sandpits or construction sites."

An interesting observation in comparing students findings in the different settings of the exercise (homework, in-class) was that while students in the in-classroom setting predominantly described balls (regardless of material) as rather limited in play value, behaviour and action space ("*you can bounce it, throw it – that's about it*"), many teams that chose a ball as one of their objects for the homework exercise came to the conclusion that it was in fact the most versatile toy.

Fig. 3: in-class exercise, working with a construction toy and a handheld baseball stadium that counts how often the ball is shot into the goal

This at first comes as a surprise, yet in hindsight a range of differences of the exercise settings are clear. Students in homework could (and often did) spend extensive time, mingling work and joint entertainment and thereby moving into 'play mode'. They could choose their environment, and describe **integrating the environment into their game** – it provides further constraints, challenges, or becomes part of the rules of the game – and they often played together, **creating new game rules on the fly**. In a classroom setting the ball in contrast was hardly explored at all. Here the setting has many **observers**, provides a limited **time frame and distractions**, and the physical and social environment discourages ball play – windows might break, others might be endangered or disturbed. 'Stationary toys' that one can put on a table (such as puzzles, building blocks, or the handheld baseball stadium) therefore fared better in the classroom setting than toys relating to sportive physical exercise.

How open an artefact is to its context thus becomes apparent if exploring the artefact in a context that is conducive to experiments. Some artefacts are a 'closed system' and others, although minimalist as solitary objects, **allow integration into a context** and creation of novel 'systems' they are a part of. As this insight seemed to be one of the most crucial observations by students, conducting the exercise as homework has clear advantages.

EXPRESSIVITY CAN ARISE IN INTERACTION

"The yoyo on its own is a blank, characterless thing."

If we think about the expressivity of a system we often tend to look at the system on its own. A surprising observation for some students was that for several toys expressivity increased when interacting with it. Only through moving or deforming it, creating noises it would get alive, as in the case of dolls and puppets.

"As with dolls and puppets the expressivity and action space for this toy (a wooden duck puppet) *are immense, as it is possible to simulate animal (or human) behaviours. (...) Feelings and emotions can be shown as well (...). This puppet fosters and requires creativity. (...) The puppet had the biggest expressivity of all toys analyzed, although this depends largely on the imagination and skill of the player."*

With some toys expressive behaviour arose from an intense **interplay between toy and player**, making it impossible to distinguish between the expressivity of the toy and of the player. An example is a yoyo, the **expressivity of the toy depending on skills and creativity of the player**.

"*The toy* (yoyo) *reacts to my actions, and the complexity of the game depends on my actions. (...) If you are good at this, it results in very beautiful, acrobatic, aesthetic movement. The more virtuosity the player has, the more beautiful and interesting it gets.*"

SIMPLICITY AND ABSTRACTION

"The action space (with wooden blocks) *is sheer unlimited: One can represent an infinite number of things with a few bricks or include other objects."*

Some of the toys demonstrate the **power of simplicity**. Abstract and simple representations can enhance creativity and enlarge the action space. Playmobil figures for example are rather abstract and do rarely prescribe functions for a figure (or can be quickly re-configured), different from Action figures or Barbie dolls. Many rather simple looking toys (building blocks, 'Happy Horse' figure) were described as surprisingly expressive despite of being simple and abstract. Aesthetics are unimportant if creativity is enabled, while high-tech toys (the gyrotwister) often only feign complexity: *"Initially it is interesting, but the reactions are always the same and thus monotonous. The feigned complexity of technology does not keep it interesting for long"*.

Simple rules make a game easily learnable. Nevertheless it can have **strategic complexity and depth**, as in the case of Abalone: "*The game presents itself similar to chess, but there are less rules and combinations. (...) This enables to quickly start playing. Yet in the course of play new possibilities get visible all the time. (...) Abalone thus won over chess in terms of play fun."*

Simple rules thus can provide what Resnick and Silverman (2005) call "low floors and wide walls" (or high ceilings for 'experts'). Moreover, many games with limited **action spaces**, due to a clever set of rules or physical constraints, have **large decision spaces inside these limits** (fine-grained and densely knit with situation-dependent effects), making the toy's behaviour difficult to calculate and predict.

DOWNSIDES OF EXPRESSIVE BEHAVIOR

Some toys with expressive behaviour of their own were found to be limited in terms of play variation. They may more or less control the user while reacting alike all of the time. This was the case e.g. for a baseball training set for kids which simply popped out balls at high speed that the player has to hit. The space of action for the user is very small here and there is no interaction loop:

"*We quickly came to the conclusion that there are not many interesting things to do. Sure one is forced to react to the actions of the machine, but then the toy does not react to hitting the ball. (...) there is no variation."*

A dredge with voice output was described as initially interesting, but as very limiting in play, making improvisation or doing something 'un-dredge-like' difficult. This toy was described as having expressive behaviour of its own (voice-output) but was felt to be rather annoying. Students thus have come to a similar assessment as Frederking et al (2007) of the tendency of modern toys for 'bells and whistles' "flooded with flashy and unnecessary features" that children get tired and bored off quickly.

FUNCTIONALITY AND PREDICTABILITY

"The reactions of the ball are difficult to predict and thus require intense thinking to win the game. (...) The difficulty of predicting the trajectory of the flying ball makes the player react as well as act."

The functionality of a physical toy could be translated as the 'algorithm' it performs when reacting to the user. A dice provides a chance element and the mechanics of Rubics cube embody a set of logical relations. Some of the analyzed toys with inherent behaviour (baseball set that throws balls, gyrotwister) came with a very **fixed purpose** and range of reaction. Unless the user's aim is training a certain skill they get boring quickly. They tend to control the user or to draw him/her in a very intense interplay that **forces the user to react** without leaving many choices. Limited behaviour in combination with a limited range of reaction tends to limit the users' action space – it is not possible to change, adapt, or enhance the game.

Behaviour that is very predictable can make interaction boring – there is not enough dialogue and challenge. Creativity tools without independent life are being experienced as much more exciting.

Small unpredictable aspects keep a toy interesting for long-term use (a ball is affected by wind and obstacles, card games rely on chance, hackysack has physical behaviour that needs to get used to, Mikado is difficult to predict and analyse) as control shifts between the user and the toy. Quite similar, toys that have an open-ended learning curve, providing challenges for any level of proficiency, remain interesting. E.g. with a yoyo "*the complexity of play depends on the complexity of my actions and you can always increase the complexity (...) the action space depends on your proficiency or the number of moves you have learned and the variations you can do (speed, height, angle)*".

WHO CONTROLS WHOM

Toys with behaviour and functionality will not only react, but also give the user something to react upon – they may even take over control. They can have varying degrees of autonomy and responsiveness (cp. Ackermann 2005). Typical toys that one has almost **total control** of are Lego, plasticine, puppets and dolls. These largely react by executing whatever transformation is done to them. Here 'give and take' take place in the mind of the player, as a **dialogue with one's own creation**, that one student describes: "*Although the tool is controlled directly, the created product triggers creative processes in the user. (...) This generates an interplay between creating and creation.*"

A few toys were described as **controlling the user** and **making him/her react**. This was in particular the baseball training set throwing balls at the player ("*Certainly one is forced to react to the actions of the machine, but then the toy does not react to hitting the ball.")*, some specialised construction kits where the manual more or less directs the user's actions, and the talking alarm clock for toddlers that sets very clear tasks ('set the time to 7 o'clock'), something only adequate for a toddler who would enjoy repetition.

Other toys allowed for a stronger **interplay and shift of control**, such as the gyrotrainer (although still felt to be rather dominant), a yoyo *("the user controls it, but it also has a life of its' own")*, card and dice games (**chance** interfering with users' sense of control), and ball games (the balls **physical behaviour** and environmental influence): "*The difficulty of predicting the trajectory of the flying ball makes the player react as well as act.*"

This directly reflects Ackermann's (2005) statement about Animates: "they intrigue us because of their relative autonomy: responsive yet with a mind of their own" and her category of 'toys to tango with' that provide partial or shared control. Some toys allowed for shifts between phases of control, such as toy cars that one can have total control over, but can also introduce chance by letting them run freely, roll down a slope etc., requiring consideration of mechanics and physics.

A remarkable toy that seemed to promise control to the user but tended to **surprise and resist** was a magnetic construction kit. It was experienced as more restricted than e.g. wooden building blocks, but also as "*more magical*" – "*you control it – to a point!*" With this toy students were fascinated, but unsure about how much they could actually do with it before being bored. Building towers with wooden blocks gives high control to users, yet with gravity interfering this turns into a "*partial dialogue*" that can even fascinate adults.

LEARNING ABOUT INTERACTION DESIGN

"Ideally the use of software would be intuitive to learn and it would be possible to create complex products with simple tools."

Although the question of how this exercise may inform interaction design of digital systems was not easy for most students to answer, a number of teams came to useful conclusions (if these seem trivial, it rather shows how important it is to provide students in engineering-oriented degree programs with simple yet powerful first hand experiences!). An insight shared across the different groups and settings (written reports and in-class) was that toys cannot cater for a universal user – they often need to be specialized. Students furthermore realized how much depends on the range of participants for a user test and were often surprised how differently people would experience the same thing. The following report conclusion covers essential aspects of the early analysis phase in Interaction Design:

"The question for the best toy has to be answered with another question: for whom and what for? (...) As different as the toys are, as different the uses. (…) Similar it should be with software. (...) Questions to take account of in software design: the user group, the required functionality, goals and intentions, pre-knowledge and skills of users? How to clearly show the functionality of the system? Should the software be self-explanatory? Should it inspire creativity?"

Students reflect on how to transfer positive qualities found in toys to software:

"Most toys do not need a manual, they invite to interact and to explore. This requires that sequences appear logical, that the toy gives feedback (e.g. on coming closer to a goal or if toy is going to brake). Toys need to be self-describing and to present their action space. Software would be better if one would not need a manual. It would be important to show the user the existing alternatives of action and to allow finding out what one can do with it by exploring."

An issue in many student reports was the appropriate level of complexity for the first encounter with a toy/system, how to be interesting and novel, and how a system can grow with use in order to cater for experienced users as well (cp Resnick and Silverman, 2005). Important insights for some students were that seemingly simple and open-ended creativity toys were often the must fun, inferring that creativity tools should enable the creation of complex products with simple tools, and that systems should be open-ended and not constrain the user more than necessary.

"I would like from good software what good toys do – using them should be fun and the user should be motivated to use it often and over extended time. Fun can be enhanced through beauty (anything that pleases the senses). (...) Those toys that continually provided new challenges were fun. Similarly software should always provide new challenges so beginners as well as experienced users can enjoy it. The degree of difficulty should orient itself by the user's skills and be adjustable. (...) Toys that least constrain the user with restrictions and rules, and leave open space for creativity and inventiveness were the most fun. Software should be as open as possible and the input of the user should not completely determine the next steps, leaving space to the users choice."

CONCLUSION

Even though an explicit transfer of insights from toys to digital systems was difficult for most students, the reports reveal highly valuable insights and a deep level of engagement. Overall it is evident that the exercise succeeded in providing learners with a better understanding of concepts and theories presented in class, and sharpened their perception for interaction qualities. Students had first hand insights, such as the superiority of 'simple' yet adaptive and creative tools over 'feigned complexity' of flashy, techie toys; the differences between different types and aims of toys; the value of unpredictable aspects and of the ability to adapt the rules for a game and to integrate the environment into play.

How to put the exercise to best effect in teaching is still to be determined. From employing it four times a few tricks to ease it became evident. Introducing and running the exercise first in class through letting students play with, analyse, and discuss a few provided toys gave students more confidence for this rather unexpected assignment and improved their analysis. Using the exercise in a classroom-based setting has to overcome the initial embarrassment of being asked to play in public. It works well to leave the class after the first few minutes with an excuse, coming back after about ten minutes. On returning I always found students to be intensely interacting with the toys, having forgotten the initial awkwardness of the situation.

The insights made seemed to be deeper when giving students a weeks time for the exercise and requiring a written report than with a one hour exercise in class plus a short verbal report. Students spent more time and often wrote considerably more than required. Aspects such as the ability to integrate the environment into play were discovered more often and collaborative play was more frequent than with the in-class groups. This indicates that the 'homework' setting is more fruitful or at least more than an hour's time should be given.

In all of the four uses of the exercise the rest of the course focused largely on user-centred design and the theme of 'interaction qualities' was not iterated. Thus it is difficult to tell in how far students' understandings and design thinking were influenced. I assume that a long-term focus would be required to exploit the insights of this exercise further, e.g. by having students reflect on the other teams' reports and summarize their insights, and later-on focusing in practical design tasks on bringing out specific interaction styles or qualities. These could e.g. focus on the role of rules and constraints as both limiting and defining a space of action. Good toys and games often have adaptable rules that may be broken or interpreted loosely. This makes toys long-term interesting and enables adaptation. Systems that interact with their environment tend to have softer constraints than 'closed' systems. Student projects might explore e.g. how to create complex systems out of simple rules and constraints (Abalone) and how to soften constraints by enabling the user to change the system environment, reconfiguring it.

Overall, the exercise has been effective in providing learners with a much deeper understanding of previously abstract notions, filling them with life, and uncovering their interrelations and ambivalences through simple everyday examples. Students came to discover that different interaction qualities might be more (or less) adequate for different types of activities a toy supports (goals). Some recurring themes in the submitted reports go beyond the concepts introduced in the lectures. The notion of open-endedness had not been explicitly present in the literature the course was based on, but came up in many reports as an important quality related to the player's expressivity (ability to act in interesting and versatile ways) and freedom of choice (action space). Students identified social interaction not only as an end (according to Shedroff (2000) a system enabling communication is inherently interactive), but also as a means to increase a toy's complexity and surprisingness. Understanding toys as being part of a system of environment, players and situation provides us with simple examples for phenomena that we encounter with ubiquitous and mobile technologies. These, similar to the 'open-ended, integrateable' toys that students identified as being most versatile, do not function as a stand-alone system but at their best interact with other technologies and the surrounding. As 'beyond the desktop' interaction design becomes ever more relevant, this might be a central learning outcome.

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