What Children Learn through Game-Based Learning Systems?

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Outline
• Introduction
  – Why games and toys?

• Examples
  – T-RHYTHM
  – Epro/CarettaKids
  – CoGAME

• Discussions
  – Issues to be investigated

• Final Remarks
Why Games / Toys for learning?

“Oh, if kids were only as motivated in playing Nintendo …” Instead of this lament, education needs turn a bug into a feature

in *Communications of the ACM*" by Elliot Soloway (1991)

Can we accept this claim now?

Cognitive/Psychological Backgrounds

- **Constructivism**
  - People construct new knowledge through their experiences
  - Games/toys can enhances their experiences?
- **Motivation**
  - Challenge, Fantasy, Curiosity
    
  - People learn more in a realistic setting?
- **Flow**
  - Optimal experiences
  - Immersed into plays of games/toys
Technological Backgrounds

• Mixed reality, mobile, pervasive, ubiquitous technologies
  – allow people to interact with themselves and artifacts in the real world
  – plays of games/toys in any time and any place
  – Make virtual and real worlds seamless
  – ...
• High computing performance
  – makes virtual things more realistic
  – less processing time, prompt feedback
  – makes people more immersed, less frustrating
  – ...

Key ideas

Why games/toys for learning?
  □ *Enhancing learning experiences*

• Designing learning experiences by learners themselves

• MR, mobile, ubiquitous, robotics technologies are useful for enhancing interactions between learners and artifacts in physical/virtual worlds.
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Examples

• T-RHYTHM (2005)
  – For learning rhythm patterns of music

  – For learning environmental and urban problems

• CoGAME (2006)
  – For supporting spatial cognition / understanding
Overview of T-RHYTHM Project

• [Goal] Supporting school children’s rhythm learning in solo and ensemble situations

• [Approach] Stimulating learners’ senses of touch in sync with the music

• [Evaluation] Educational practices in an elementary school

Why Rhythm Learning?

• One of the goals of music classes is that children acquire the fundamental skills for musical expressions and enjoy them through rhythm learning


• What symmetry is to the plastic arts, rhythm is to music

  in “The World as Will and Idea” by Arthur Schopenhauer (1883).

• …..
Music Learning in Elementary Schools

- Children are not always good at music (too difficult for them to recognize the rhythm of the music by listening its melody) and are not so motivated for learning.
- Schoolteachers try various teaching methods: e.g. they pat each of their children on the shoulder in sync with the music, in order to let her know her rhythm patterns intuitively.
- Many children (30 ~ 40) in a classroom → almost impossible for a teacher to pat all children’s shoulder
- “Noisy” environment for individual learners → easy to listen ??

Goals of T-RHYTHM Project

- Supporting school children who do not have rich experiences in music learning.
- Rhythm understanding and expression through senses of touch
  - Sense of touch: unusual experiences for children in a music class, which raise the level of their motivation and engagement for learning
- Used by individual children in solo, or simultaneously by multiple children in ensemble.
# Senses of Touch

- Comparisons with vision and audition

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- Sensitivity: as low as 0.2 \( \mu \) amplitude, 5 mg pressure threshold

> A system that supports *rhythm learning through senses of touch* is possible!

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# T-RHYTHM: Demo Video

[Image of a keyboard and a device]
System Overview

Vibration Device
T-RHYTHM in Classrooms

• T-RHYTHM has been used in educational practices (music class for age 10-11 children).

• Individual children feel the rhythm and perform an instrument following the tempo set by themselves, and finally play in ensemble.

• Preliminary user studies indicated that providing learners with tactile stimuli was effective for recognizing and expressing the rhythm patterns of the music.

Overview of Epro/CarettaKids

• Learning about urban planning and environmental issues in face-to-face situations for fourth to sixth graders (age: 10-12).

• A physical interface allows learners who are not good at using computers, to join collaborative learning.

• Learners can test knowledge acquired through textbooks or teachers in a physical space.

• A sense of play is introduced for raising learning motivations
Initial Ideas of Epro

Design Requirements for Epro

• [Hardware issue] The system should automatically and rapidly recognize types and locations of objects that are manipulated by learners.

• [Software issue] Based on the arrangement of the objects, the system should calculate environmental changes and visualize them through simulations.
Prototype Design of Epro

• **Paperboards and pieces**: we designed different sizes of paper boards and pieces, in order to examine suitable design for children.

• **Simulation and visualization**: through collaboration with teachers, we decided to designed simulation model not too complicated: three type of pieces (house, tree, and factory), and five parameters (noise, air/water pollution, garbage, finance)

Issues Found through Evaluations

• **Behavior**: children pulled/pushed, and leaned over the board so that they could easily put pieces on it.

• **Size**: the board should be large enough for four to eight learners to sit around it.

• **Resolution**: 300 to 500 pieces were necessary to give each learner sufficient opportunities for manipulating pieces, and to make the simulation results educationally meaningful.

• **Simulation model**: The simulation model was simple, but children could find relations between pieces and environmental parameters, and discuss constructively.
Design Decisions of Epro

- **Technology:** A method with image processing or a touch sensitive display *is not suitable*. We used a sensor-based method to accept simultaneous multiple inputs by a group of users.

- **Size and Resolution:** The board has about 500 grids, each of which a sensor (RFID reader) is embedded.

Backgrounds of CarettaKids

- In Epro, a visible space is shared among all the learners; their manipulations are *interfered* with each other, and difficult for individual learners to recognize the results of their own manipulations.

- Some children who were the leaders among their classmates seized the leadership and the other children often followed without discussions.

- The system does not provide each learner with an opportunity to examine his/her ideas, which may hinders his/her reflection.

- A computational media that retains features for supporting collaboration, but also allows each learner’s reflection.
Design of CarettaKids

Integration of personal and shared spaces

• **Shared space**: an immersive environment for collaboration that raises the level of awareness among learners. A *multiple input device* and *augmented reality* technologies are used

• **Personal space**: a *mobile space* for an individual user without being disturbed by other users

• The proposed system, *CarettaKids*, (formerly, *Caretta*) allows learners to smoothly transition between both spaces

System Configuration

- **Shared space**
  - sensing board
  - server computer
  - LCD projector

- **Personal space**
  - PDA

- Data communication between two spaces
  - WiFi
  - RFID reader (sensing board) & RFID tag (PDA)
How CarettaKids is Used

• Shared space

• Personal Space

Requirements for CarettaKids

• Learners on their individual personal space can conduct tasks that they can conduct on the shared space.

• From collaboration to individual reflection: Learners can transition from the shared space to their own personal space in an intuitive manner.

• From individual reflection to collaboration: Learners can transition from their own personal space to the shared space in an intuitive manner.
Transition to Personal Space

An intuitive transition method from the shared space to a personal space

• Users are collaboratively working on the shared space. One of them wants to test his idea without being disturbed by the others.
• He/she wants to examine the idea on his/her personal space (PDA).
• Scrolling on a small display of a PDA to find an area of interest on the shared space is an irritating task.
• Intuitive method: bringing a PDA close to an area of interest on the shared space, then the corresponding area immediately appears on the PDA.
• The learner can test his/her idea on the PDA.

Transition to Shared Space

Intuitive transition methods from a personal space to the shared space

• A learner individually has tested an idea on his/her personal space.
• The learner finds a good idea, and wants to discuss about it with the other learners.
• The learner can display his idea on the shared space in an intuitive manner (by bringing the learner’s PDA close to the shared space).
• The idea shown on the shared space is collaboratively discussed with the other learners.
Educational Practice

• CarettaKids has been used in an elementary school classroom (age 11 – 12).

• Integration of personal and shared spaces can help promote children's participation in synchronous / co-located interactions in the classroom and deepen their understanding of subject matter.

Overview of CoGAME

• Intellectual training for children
  – Inspired by Water Works (card game) or Candy Train (board/puzzle game)
  – Spatial cognition and inference
• Collaboration GAME (also CoGAME means a turtlet: 子蠵）
  – Multiple players & a robot (turtle)
• Interaction with physical and virtual objects
  – Virtual paths and obstacles, a physical robot and obstacles
• Intuitively manipulate a robot in any location
  – Manipulation by projection
How CoGAME is played

Technological Details

- Mobile computer augmented with a small-size/ lightweight projector
- Realtime calibration of a moving projected screen using an accelerometer sensor
- Recognition of a robot using a camera attached to a mobile computer and control of the robot to make it follow a projected path
- Automatic image correction between multiple projected images
Initial Evaluations
Inquiry results from demos
- Easy to manipulate robots using a mobile projector
- To successfully guide the robot to its goal, players’ communication and collaboration are inevitable.
- More than two players and multiple robots will make the game more exciting and challenging, and will be more effective for children’s training for their spatial cognition / understanding.
- ...

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Discussions

• Enhancing learning experiences: Using game based systems for enhance learners’ experiences seems a good strategy
  → Learners respond positively to enjoyable experiences, and therefore have motivations for their further activities.

• What experiences are given to learners through game based systems? --- Just fun? or useful knowledge/skills?

Issues to be investigated

• Game based learning systems do not always make learning efficient
  – People enjoy processes rather results of game plays.
  – Learners are not always given explicit learning goal: “learning by exploration”, “learning by discovery”, “learning by chance”.

• If features such as, “exploration”, “discovery”, or “contingency”, are eliminated and learning goals are fixed, a learner may not feel interesting, will not be fully motivated or engaged.

• Game based learning systems should be designed so that although learners feel it’s just a fun at the beginning phase, they become engaged in their activities and become motivated for their learning itself.
Final Remarks (1)

What do children learn through game-based learning systems?

*No compulsory learning can remain in the soul. . . In teaching children, train them by a kind of game, and you will be able to see more clearly the natural bent of each*

in *The Republic*, by *Plato*

*Just a sugar coating for fun, to conceal a bitter experience inside?*

*Whether children are affected badly by (TV, Video) games?*

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Final Remarks (2)

What should be done next?

- Assessment based on scientific evidences without any preconception

- Design methodology: what technologies used for who, to learn what, in what situations?
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Thank you for your attention!