What Children Learn through Game-Based Learning Systems?

Masanori Sugimoto
Dept. of Frontier Informatics
Dept. of Information & Communication Engineering
University of Tokyo
sugi@itl.t.u-tokyo.ac.jp

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

    in *Cognitive Science*, by *Thomas Malone (1983).*
  - 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

- Epro (1999) & CarettaKids (2004)
  - 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**

  in "*Course of Study for Elementary Schools*" by *Japanese Ministry of Education, Culture, Sports, Science and Technology* (2005)

- 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 emsenble.

Senses of Touch

- Comparisons with vision and audition

	skin	eye	ear
perception time (ms)	20	20	20
minimum time interval of two stimuli (ms)	5	25	0.01

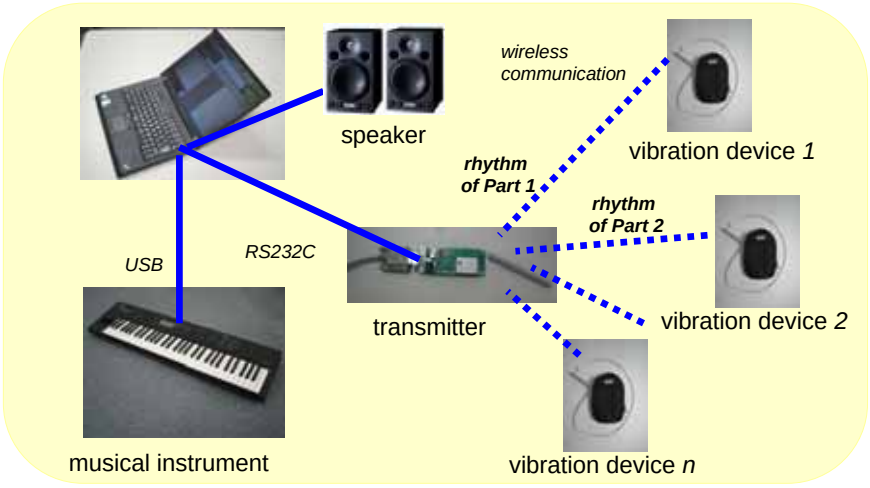
- Sensitivity: as low as 0.2 μ amplitude, 5 mg pressure threshold

in *The Psychology of Touch*"
by M. *Heller* (1991)

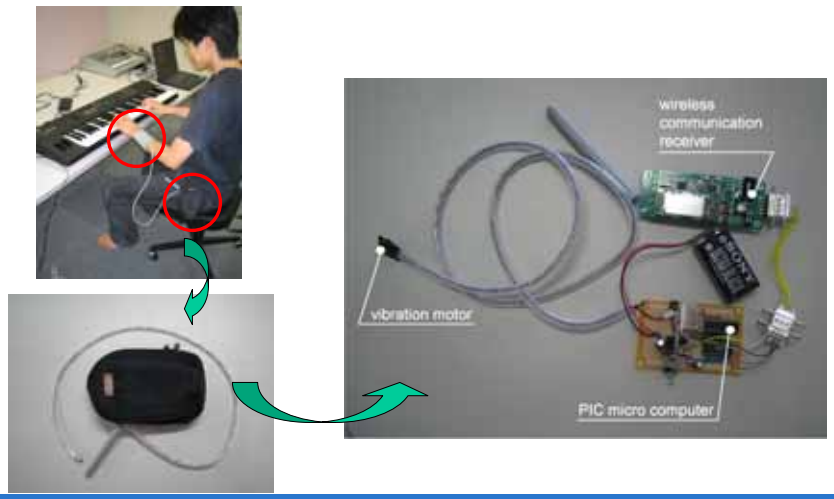
A system that supports *rhythm learning through senses of touch* is possible !

T-RHYTHM: Demo Video

System Overview



Vibration Device



17

T-RHYTHM in Classrooms

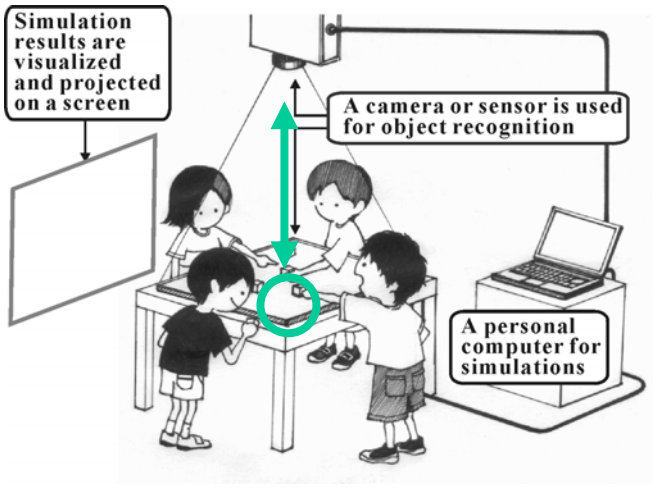
- T-RHYTHM has been used in educational practices (music class for age 10-11 children).
- Individual children feel the rhythm and perform an instrument following the tempo set by themselves, and finally play in ensemble.
- Preliminary user studies indicated that providing learners with tactile stimuli was effective for recognizing and expressing the rhythm patterns of the music.

18

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

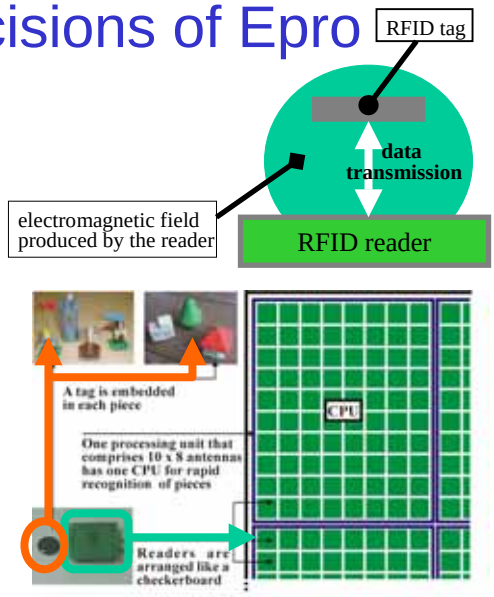
- Behavior: children pulled/pushed, and leaned over the board so that they could easily put pieces on it.
- Size: the board should be large enough for four to eight learners to sit around it.
- Resolution: 300 to 500 pieces were necessary to give each learner sufficient opportunities for manipulating 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*.

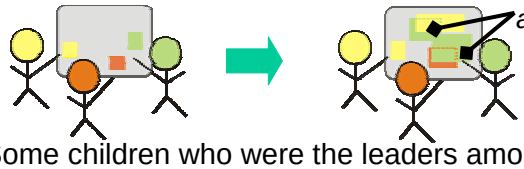
  → we used a sensor-based method to accept simultaneous multiple inputs by a group of users.

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



Backgrouds 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.



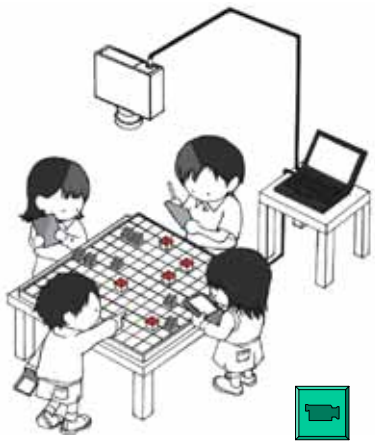
- Some children who were the leaders among their classmates seized the leadership and the other children often followed without discussions
- The system does not provide each learner with an opportunity to examine his/her ideas, which may hinders his/her reflection.
- A computational media that retains features for supporting collaboration, but also allows each learner's reflection.

25

Design of CarettaKids

Integration of personal and shared spaces

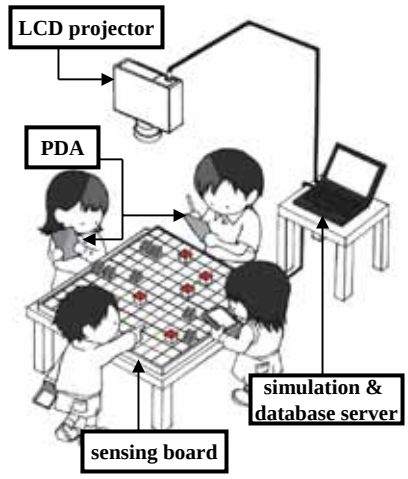
- Shared space: an *immersive environment* for collaboration that raises the level of awareness among learners. A *multiple input device* and *augmented reality* technologies are used
- Personal space: a *mobile space* for an individual user without being disturbed by other users
- The proposed system, *CarettaKids*, (formerly, *Caretta*) allows learners to smoothly transition between both spaces



26

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.

29

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

30

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.

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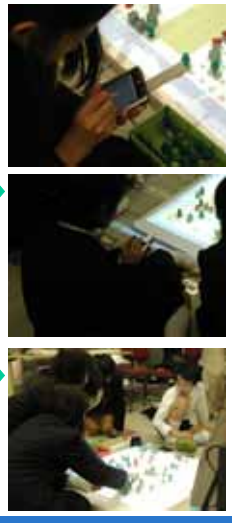
- The learner can display his idea on the shared space in an intuitive manner (by bringing the learner's PDA close to the shared space).
- The idea shown on the shared space is collaboratively discussed with the other learners.



Educational Practice

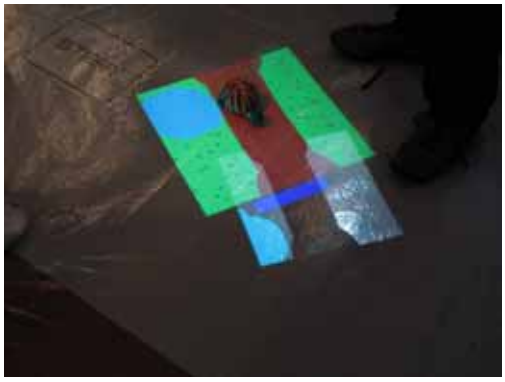
- CarettaKids has been used in an elementary school classroom (age 11 – 12).

- 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

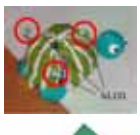
- Intellectual training for children
  - Inspired by *Water Works* (card game) or *Candy Train* (board/puzzle game)
  - Spatial cognition and inference
- *Co*llaboration *GAME (*also *CoGAME* means a turtlet: **子龜**)
  - Multiple players & a robot (turtle)
- Interaction with physical and virtual objects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

How CoGAME is played



Technical 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?

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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