Πανεπιστήμιο Αιγαίου

ΤΕΧΝΟΛΟΓΙΚΑ ΥΠΟΣΤΗΡΙΖΟΜΕΝΗ ΣΥΝΕΡΓΑΤΙΚΗ ΕΡΓΑΣΙΑ
Problem-Based Learning in Virtual Worlds

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Τμήμα Μηχανικών Σχεδίασης Προϊόντων και Συστημάτων

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Problem-Based Learning in Virtual Worlds

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Structure of the presentation (1/3)

- ‘Learning through constructing’ in Virtual Worlds…
  - A variety of alternative approaches:
    - Constructivism/constructionism, experiential learning, inquiry-based learning, game-based learning, problem-based learning (PBL), etc.
  - Affordances of Virtual Worlds for learning through constructing
    - simulation, role-playing, (co-) presence, co-construction, enpowerments, etc.

Structure of the presentation (2/3)

- Framing of our PBL approach
  - Problem-based, practice-based, teaching and learning
  - Subjects of design and engineering,
  - Late graduate and postgraduate courses,
  - Higher-level skills (21st century skills), etc.
- Overview of our studies
  - Case 1: VWs in User interface design (short-term (1-day collaborative design activity), exploratory)
  - Cases 2 and 3: VWs in architectural and interior space design (medium-term (sessions within a few days) formative/summative assessment)
  - Case 4: VWs in HCI design studio (long-term (full-semester) course; formative/summative assessment)

Structure of the presentation (3/3)

- A general approach of employing PBL in Design & Engineering Education
  - Learning Goals and Activities…
  - Learning Environment and tools…
  - Learning Assessment…

Learning through constructing in VWs

- A variety of alternative approaches…
  - They have been implemented using VWs in experimental or applied educational settings, with encouraging results.
- **1. Communal constructivist approaches** (e.g. Girvan & Savage,2010):
  - Learners collaboratively construct knowledge,
  - Publish and discuss their findings in the environment,
  - Communicate them to future learners
- Many approaches of learning in VWs fit well with communal constructivism…
  - If learners construct knowledge through/by the construction of artifacts, then the approach would be consistent with constructionism (Papert, 1990).

Learning through constructing in VWs

- In Girvan & Savage (2010):
  - Training of educators (field: Development Education)
  - Learning environment: a flat map of the world with learning resources around it
  - As avatars move across the map, sensors trigger location-specific learning content
  - The (group) task was to create a book in *Second Life* for future learners (topic: North-South Irish independence).
- *Question: Why not use a Web-based collaborative learning environment for this course?*

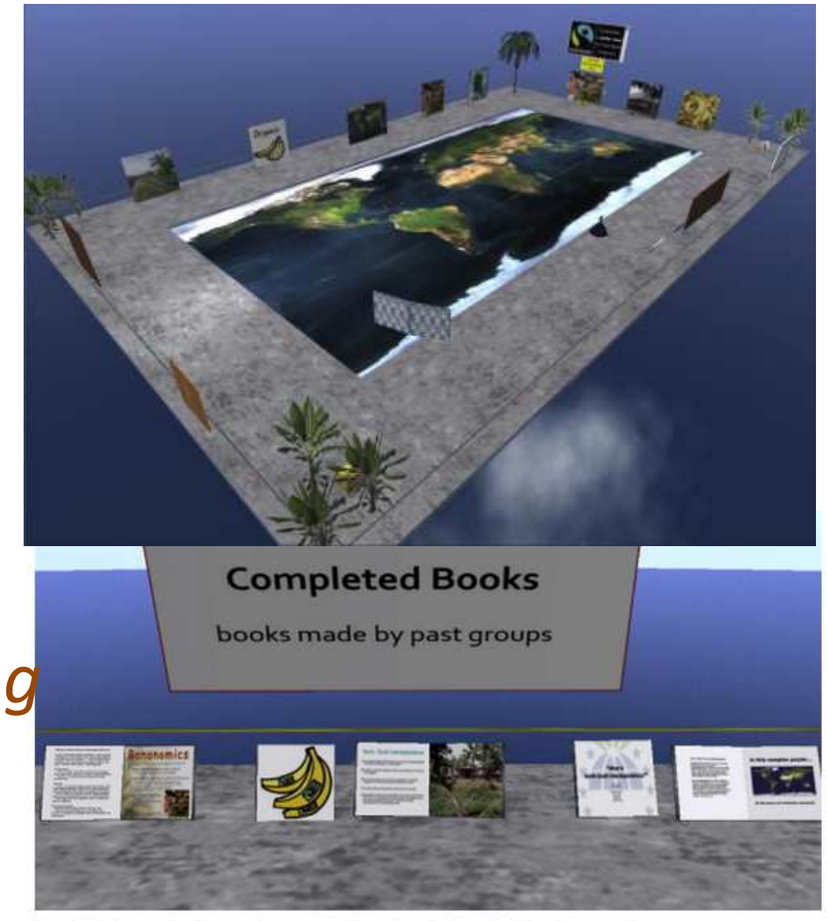


Fig. 2. Books created by each group remain on the platform for future learners to use.

Learning through constructing in VWs

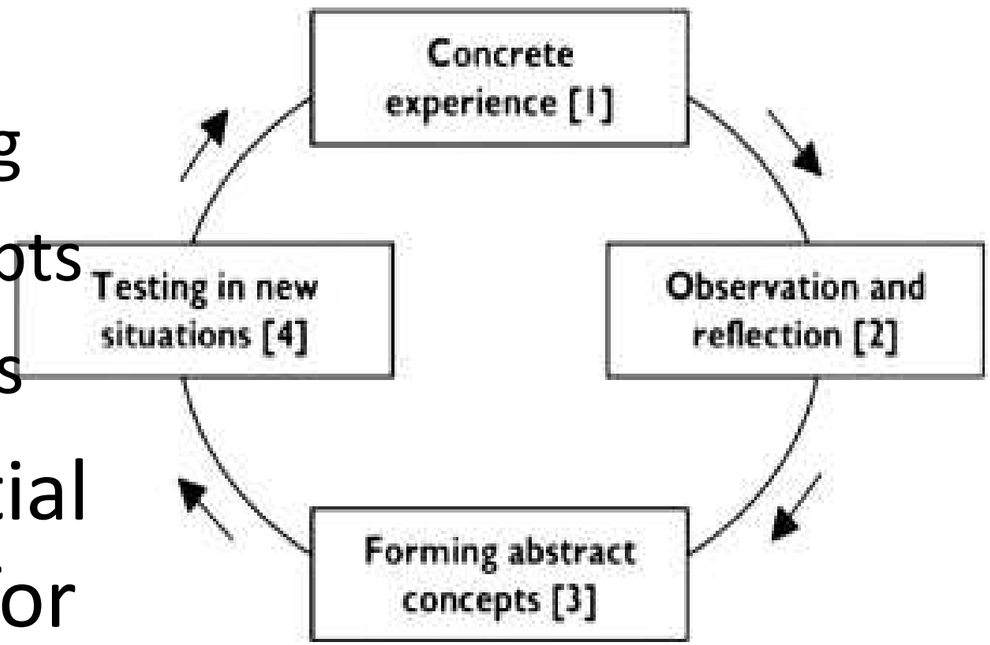
- **2. Inquiry-based learning** approaches:
  - Let students learn as they search for information
  - Drive them to expand their knowledge about a subject
  - Perform in-world activities in order to pursue some goal
  - E.g. River City, http://muve.gse.harvard.edu/rivercityproject/

Learning through constructing in VWs

- In River City (Dede et al. 2004):
  - Teams of students to solve a 19th century city's problems with illnesses…
    - Approximately 100 teachers from 12 US states implemented River City,
    - Over 5,000 students (age 9-12, science courses)
  - Inquiries include: interactions with avatars, with virtual agents, with digital artifacts and several tacit clues.
- *Question: Why not use a Web-based collaborative learning environment for this course?*

Learning through constructing in VWs

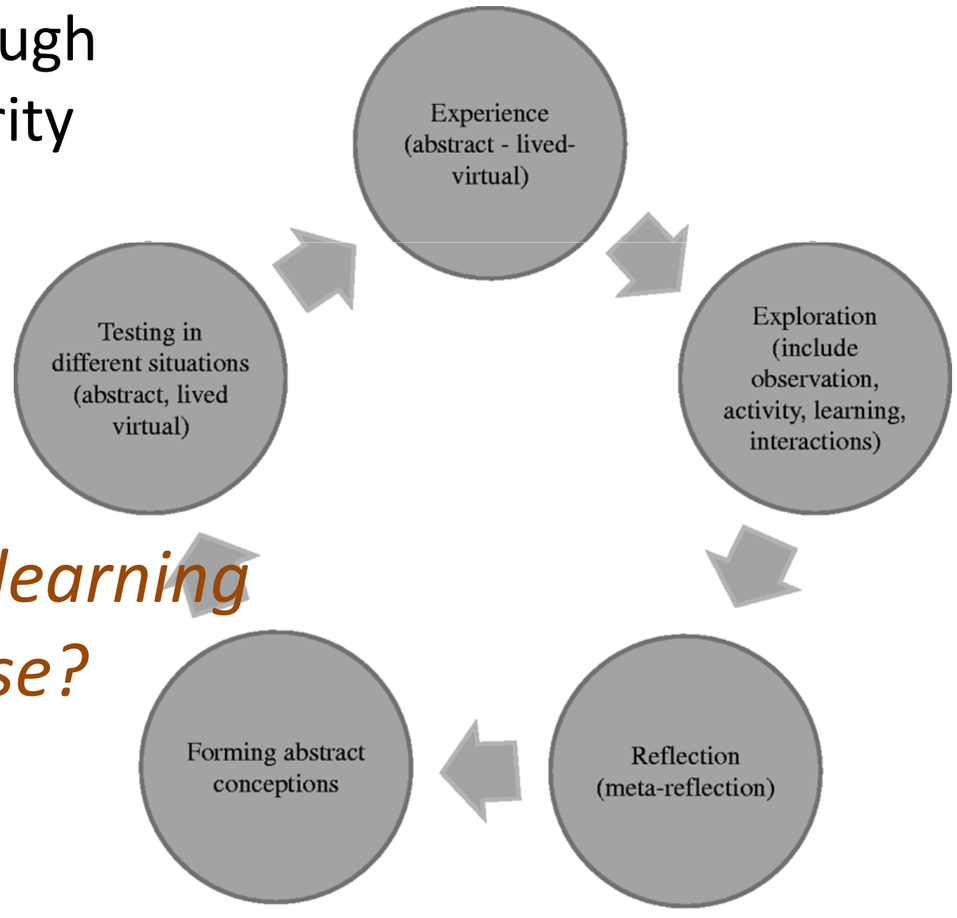
- 3. In **experiential learning** (Colb, 1984)**,** students learn new concepts through:
  - Active experimentation,
  - Observing and reflecting
  - Forming abstract concepts
  - Testing in new situations



- The model of Experiential Learning was adapted for VWs by De Freitas & Neumann (2009).

Learning through constructing in VWs

- In De Freitas & Neumann (2009):
  - ‘Serious games in healthcare’ scenarios, e.g.
    - Triage Trainer: sorting through casualties, in order of priority
    - Training for clinical staff in the area of infection control (in hospitals)
  - *Question: Why not use a Web-based collaborative learning environment for this course?*



Source: De Freitas and Neumann (2009)

Learning through constructing in VWs

- 4. **Game-Based learning**:
  - Learners are placed in a gaming environment,
  - The educational content is blended with the challenges they have to face during the game
  - They learn as they play
  - E.g. Quest Atlantis, http://atlantisremixed.org;

Learning through constructing in VWs

- In Quest Atlantis (Barab et al. 2005):
  - Students respond to quests, to help the Council of Atlantis restore lost wisdom.
  - Students (age 9-16) are engaged in educational tasks that require learning and motivation.
    - more than 20,000 children on five continents
    - learning gains in science, language arts, and social studies
    - students have completed thousands of Quests
  - A set of online spaces assists students, mentors and Atlantian characters to interact with each other.
  - Regalia and rewards are associated with advancement and wisdom.
  - Students have their individual home pages, showing their advancement and history of their work.

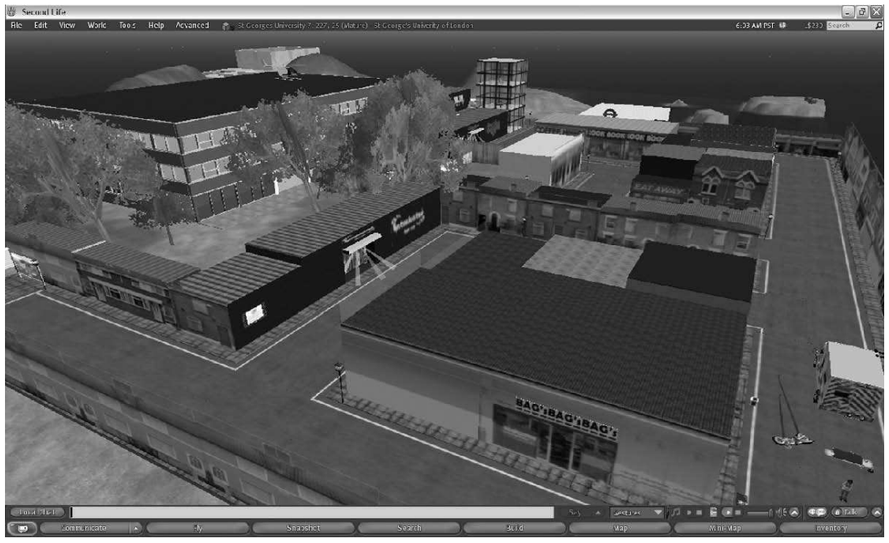
- *Question: Why not use a Web-based collaborative learning environment for this course?*

Learning through constructing in VWs

- 5. **In problem-based learning (PBL)** (Wood, 2008, Hmelo-Silver, 2004)**,** students:
  - Work in groups to address an ill-defined problem related to practice
  - Take responsibility for their own self-directed learning, becoming active learners and exercising deep learning and critical thinking
  - The outcome is a unique solution for each group

Learning through constructing in VWs

- In Conradi, Savin-Baden, et al. (2009):
  - Students at Paramedic Foundation Degree, Second Life (SL)
  - Five virtual patient scenarios
  - Three days to evaluate the scenarios with students, tutors
  - The SL environment engages students effectively in learning, despite technology barriers.
  - Students believed SL could provide a more authentic learner environment than classroom-based PBL.
  - *Question: Why not use a Web-based collaborative learning environment for this course?*



Affordances of Virtual Worlds for learning through constructing

- **Presence:**
  - The "*illusion that a mediated experience is not mediated*" (Lombart & Ditton, 1997)
  - The '*feeling of being there*' (Zahorik & Jenison, 1998)
  - The '*combination of the illusion of being located in the digital space (place illusion), and the illusion that what is happening there is real (plausibility illusion)*' (Slater, 2009)
- Allows tutors/learners to:
  - (Feel that they) **coexist** in the same (digital) environment, rather than that they interact through an external system.
  - Feel **engaged and committed to participate in** / contribute to **learning** processes and tasks.
- Question: Does the environment alone suffice (for feeling present in a learning scenario) or is a need to design the environment and the activity to achieve presence?

Affordances of Virtual Worlds for learning through constructing

- Real-time **Simulation** and expressiveness of 3D graphics:
  - Realistic places – objects - behaviours
  - Role-playing
- Allows tutors/learners to:
  - **Orchestrate/participate** in **real-life learning scenarios**
  - **Test/experience critical processes** and interactions in a safe digital environment
- Question: Does the environment alone suffice or is a need to design the environment and the activity to achieve simulation of activities?



Affordances of Virtual Worlds for learning through constructing

- **Persistence – “the world continues to evolve” :**
  - The Virtual World continues to exist/evolve even after a user exits it…
  - When users log in their in-world they can take up their work from the point they left it.
  - Similar to the real world in which events occur whether or not these are directly or indirectly related to us
    - E.g. things happen, when we are asleep.
- Allows tutors/learners to:
  - **Maintain awareness** about the activities of others’.
  - Quickly **catch up with their work** from the point they left it.
  - Take **their own pace in learning** (to some extent).
- Question: Does the environment alone suffice or is a need to design the environment and the activity to achieve persistence?

Affordances of Virtual Worlds for learning through constructing

- **Open-ended, constructible 3D environment**
  - Numerous possibilities for building 3D content, setting up environmental conditions, etc.,
  - Overcoming physical limitations
    - Gravity → Flying, Travel time → Teleporting, etc.
- Allows tutors/learners to:
  - **(Co-)create** landscapes, artifacts and contexts about learning
  - **Recreate** past and lost landscapes/artifacts to assist learning
- Question: Does the environment alone suffice or is a need to design the environment and the activity to achieve construction?

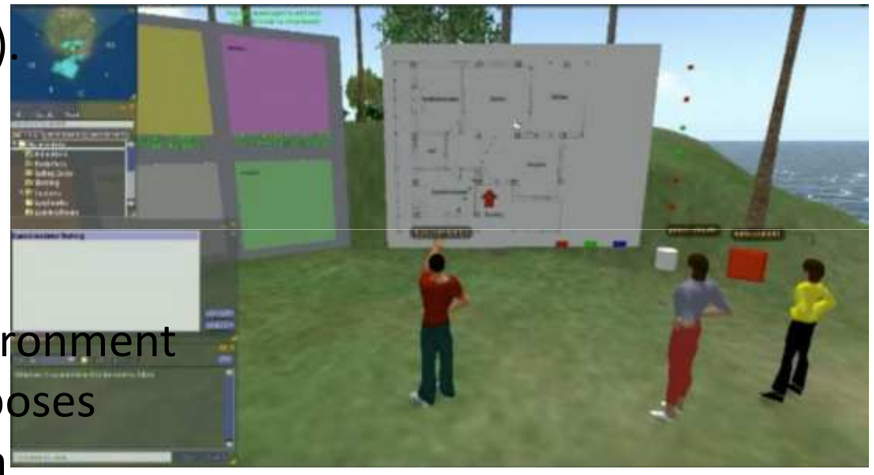


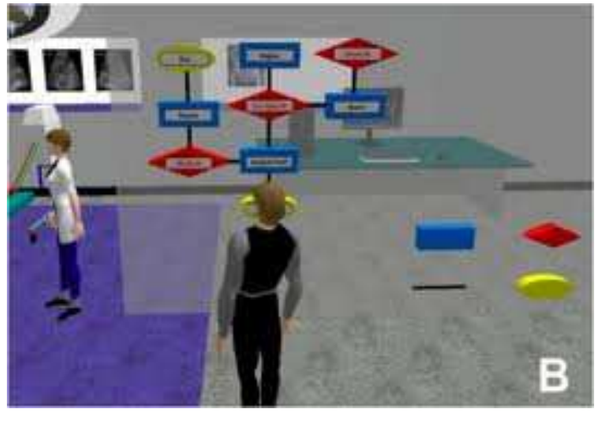
Affordances of Virtual Worlds for learning through constructing

- **Identity (virtual)**
  - Representation through avatars
  - Users (re-)define their own identity
    - A sense of belonging in the Virtual World
  - Tacit communication and awareness
    - Avatar location, activity, posture, gestures, etc.
- Allows tutors/learners to:
  - **Play roles**; - immediate testing of relevant knowledge and skills
  - Affords the **exhibition of high-level skills** (4Cs: Communication, Collaboration, Critical Thinking, Creativity)
  - **Simulate physical interactions** with others and 3D artifacts and environment
  - Better **express thoughts and feelings**
- Question: Does the environment alone suffice or is a need to design the environment and the activity to achieve building/show off your identity?

Affordances of Virtual Worlds for learning through constructing

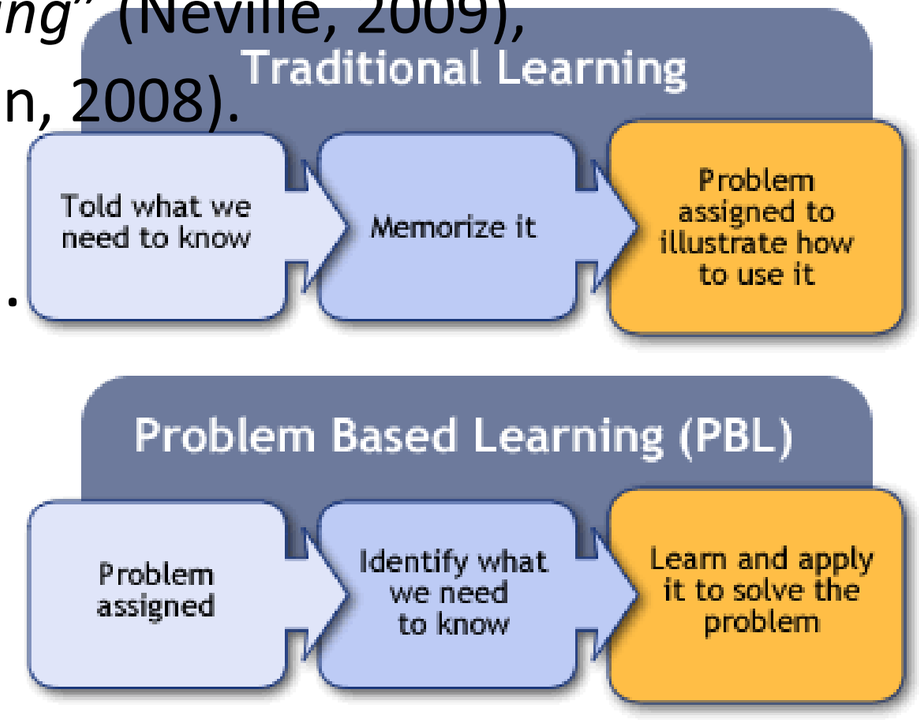
- **Communication**
  - Visual (through avatar position, posture, gestures, etc),
  - Voice
  - Written (e.g. text chat, whiteboards, etc.).
  - Synchronous and asynchronous
- Allows tutors/learners to:
  - Hold organised group **discussions**
  - **Coordinate joint activities**, in similar ways to those of the physical environment
  - **Co-construct** 3D content for various purposes
  - Provide **timely and accurate feedback** on others' activities
  - **Awareness** of others' activity.
  - Can assist the **sense of participating** in a community.
- Question: Does the environment alone suffice or is a need to design the environment and the activity to achieve communication?





Framing of PBL approach

- Foundations of Problem-Based Learning
  - PBL is not simply a method of teaching / learning, but:
    - "a *total approach to learning*" (Barrett & Moore, 2010),
    - "a *philosophy about learning*" (Neville, 2009),
    - "a l*earning strategy*" (Kwan, 2008).
  - Constructivist / constructionist tradition…
  - Situated learning…
  - Practice-based learning…



Framing of PBL approach

- Foundations of Problem-Based Learning – **constructivism / constructionist tradition (Dewey, Vygotsky, Piaget, etc.)**:
  - According to the tenets of constructivism:
    - *"knowledge is not universal, but each person constructs his or her own representation"* (e.g., Duffy & Cunningham, 1996).
    - Learning occurs when learners:
      - uncover inconsistencies between their knowledge representations and current experience
      - develop mental models on the basis of their own backgrounds and skills
  - Papert (1980) has proposed constructionism, that requires learners to:
    - additionally construct tangible artifacts to reflect their learning progress.
    - *''building knowledge structures . . . happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity''* (Papert & Harel, 1991).

one laptop per child

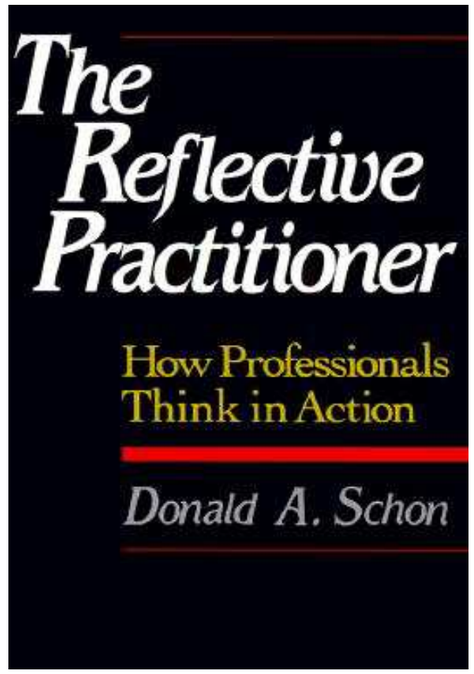
Framing of PBL approach

- Foundations of Problem-Based Learning – **Situated Learning (e.g. Suchman, 1987, Lave & Wenger, 1991; Anderson, Reder, & Simon, 1996)**:
  - the main idea is that much of what is learned is specific to the situation in which it is learned.
  - learning should occur in an authentic context related to practice
  - collaboration between learners and other potential involved partners (such as, for example, project clients) is necessary for one's learning.



Framing of PBL approach

- Foundations of Problem-Based Learning – **Practice-based Learning, Reflective Practice (Schön, 1987)**
  - *"the capacity to reflect on action so as to engage in a process of continuous learning."*
  - Practitioners: architects, doctors, engineers, managers, etc.
    - *''practitioners often reveal a capacity for reflection on their intuitive knowing in the midst of action and sometimes use this capacity to cope with the unique, uncertain, and conflicted situation of practice.''*
  - Iterative process of 'learning by doing' and 'reflection-in-action'
  - Requires from tutor to:
    - Observe, discuss, and review students' practice when it occurs,
    - Intervene at the students' zone of proximal development (Vygotsky, 1978), the point where practice is hard enough to learn without help but not too difficult to grasp through tutor critique, coaching, and scaffolding.

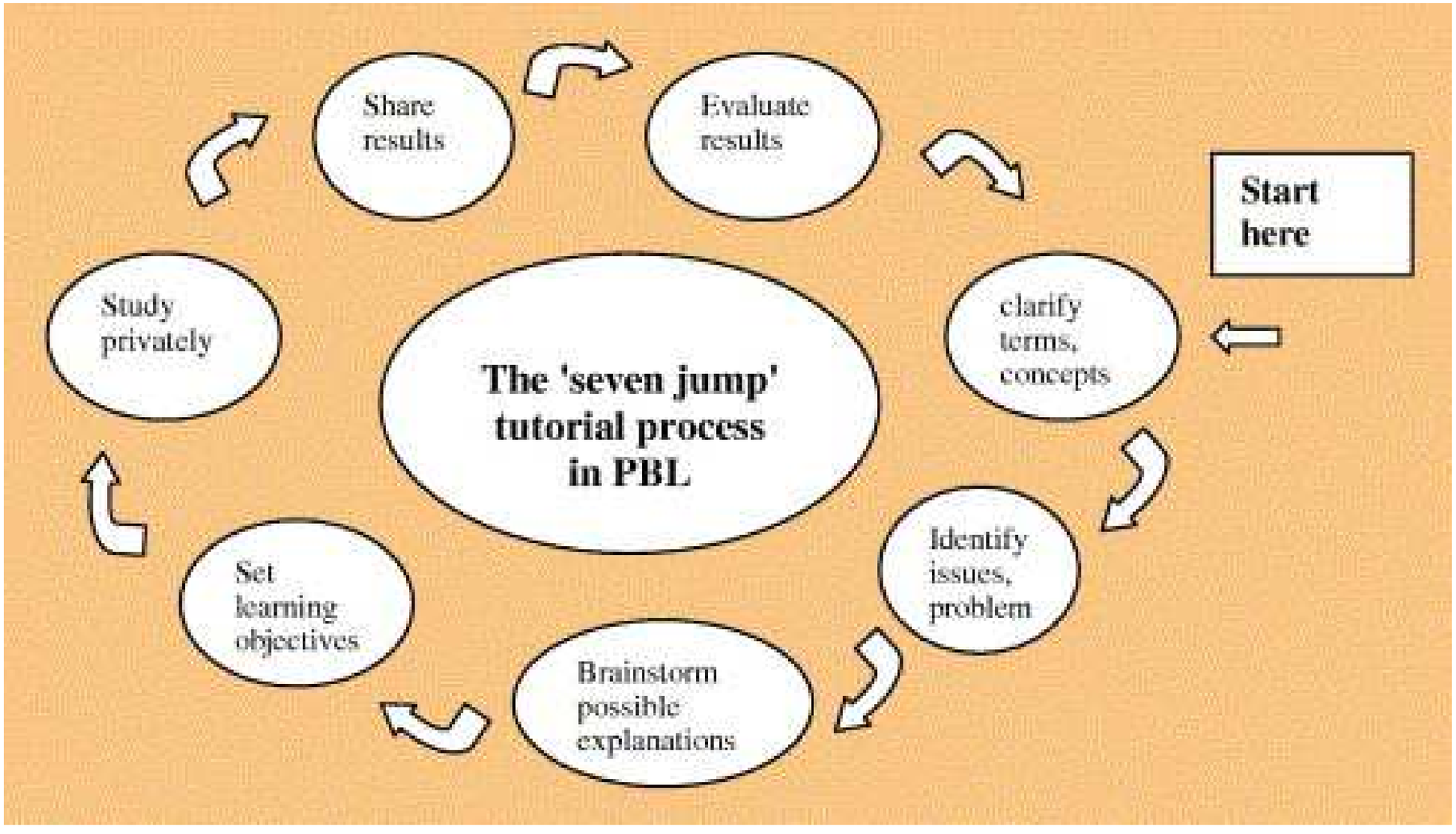


Framing of PBL approach

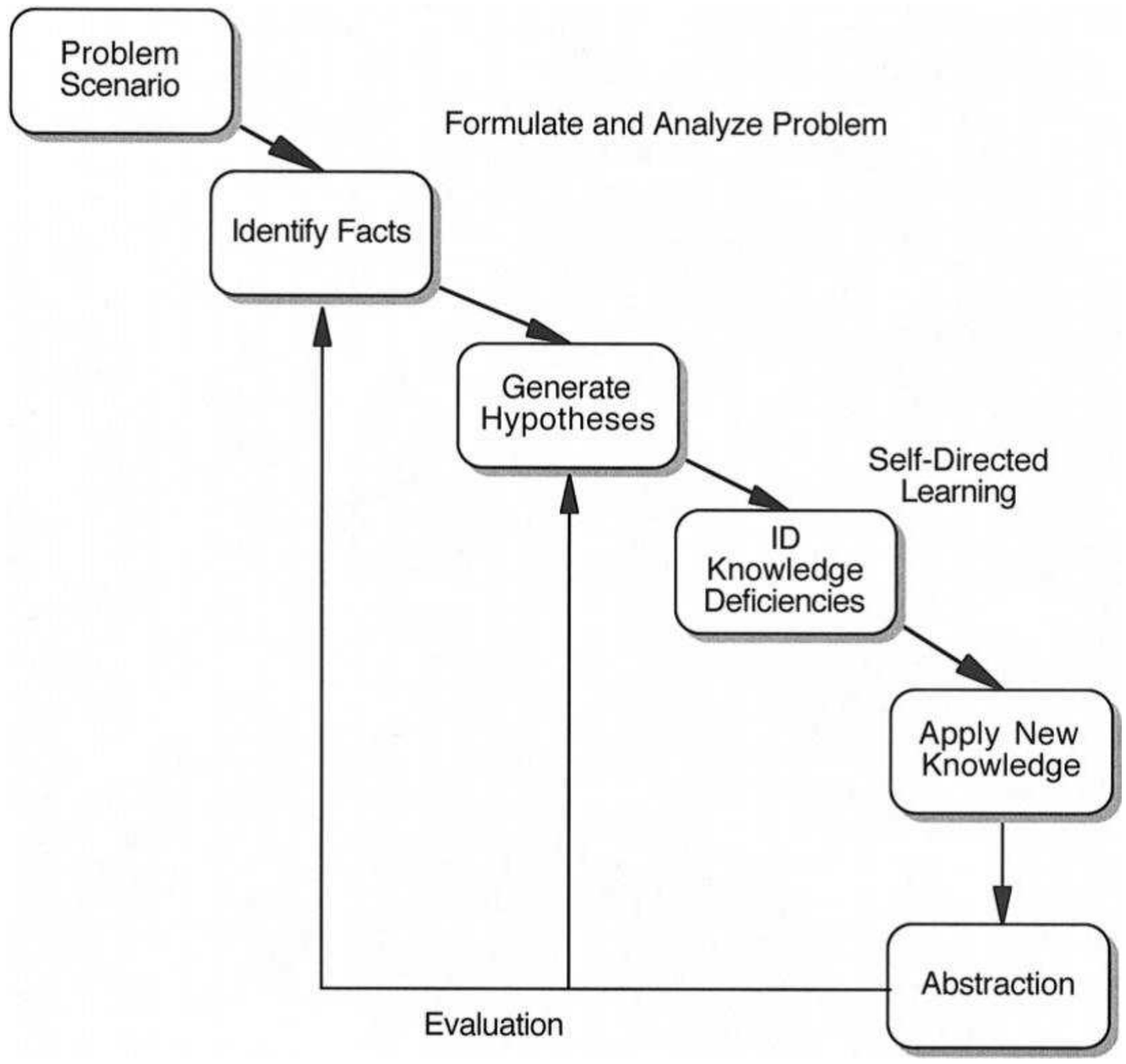
- Historical development of PBL:
  - PBL has a long tradition in academic education:
    - medical schools, engineering, computer science, business, architecture, economics, educational administration and law.
    - a number of universities and schools have adopted it as their principal learning strategy
      - e.g., McMaster Medical School, Maastricht University, and Aalborg University.
  - The worldwide adoption of the PBL philosophy in distinct schools and courses has resulted in various methods to implement a PBL course, notably:
    - seven-jump PBL tutorial applied at the Maastricht University.
    - five-step PBL process proposed by Hmelo-Silver (2004).



Framing of PBL approach



Framing of PBL approach



Framing of PBL approach

- Historical development of PBL:
  - Nowadays, it is widely acknowledged that:
    - the exact steps of PBL implementation may be modified according to particular course requirements provided that the key principles of PBL are followed (Wood, 2004):
      - (a) students are provided with an **authentic problem** that is related to practice;
      - (b) students work in **groups**;
      - (c) **self-directed learning** occurs (beyond group work) and therefore students become responsible for their own learning;
      - (d) the tutor acts as a **facilitator** and is **detached** from student work, pursuing students' deep learning.

Framing of PBL approach…

Key elements of some pedagogical approaches

	Problem-Based Learning (PBL)	Project-Based Learning (PjBL)	Studio-based Learning (SBL)
Main concept	Tackling a problem that is ill-defined and authentic (related to practice)	Carrying out an authentic project following professional practices and methods	Design action with emphasis on creativity, and close interaction and tutor critiques
Central goals	Learn to learn; work in teams; professional research work	Professional quality work; learn to deliver	Professional practice; learn to innovate
Originating schools	Medical (primarily), law and management	Engineering, computer science and management	Art & Design (industrial, product & architectural)
Role(s) of tutor	Detached; devil's advocate; facilitator; emancipator	Depend on project progress: coach, facilitator; project actor (usually client), expert	Expert; judge; coach;
Tutor difficulties / challenges	May face student's mistrust due to detachment; has to cope with unexpected student questions / findings	Coordination of project teams; intense workload for student support (often time is running out; assistants or office hours may be required)	Danger for excessive subjectivity; lack or rigour may cause student mistrust
Role(s) of student	Autonomous learner; a team player, who earns his role; critical thinker	Team player with specific role or expertise; struggles to apply methods professionally; delivers results	Creative practitioner; has to develop skills in expressing, presenting and defending ideas – orally, sketching, with tangible materials
Student difficulties / challenges	Increased motivation is prerequisite; conflicts can arise that hinder team work	Students need coaching for application of methods; student questions may not be enough	Danger to oversell their own work; personality traits may hinder self-reliance;

- *Question: how to orchestrate (identify, design, develop, assess) learning activities in virtual worlds that conform to these key elements?*

Framing of PBL approach…

Key elements of some pedagogical approaches

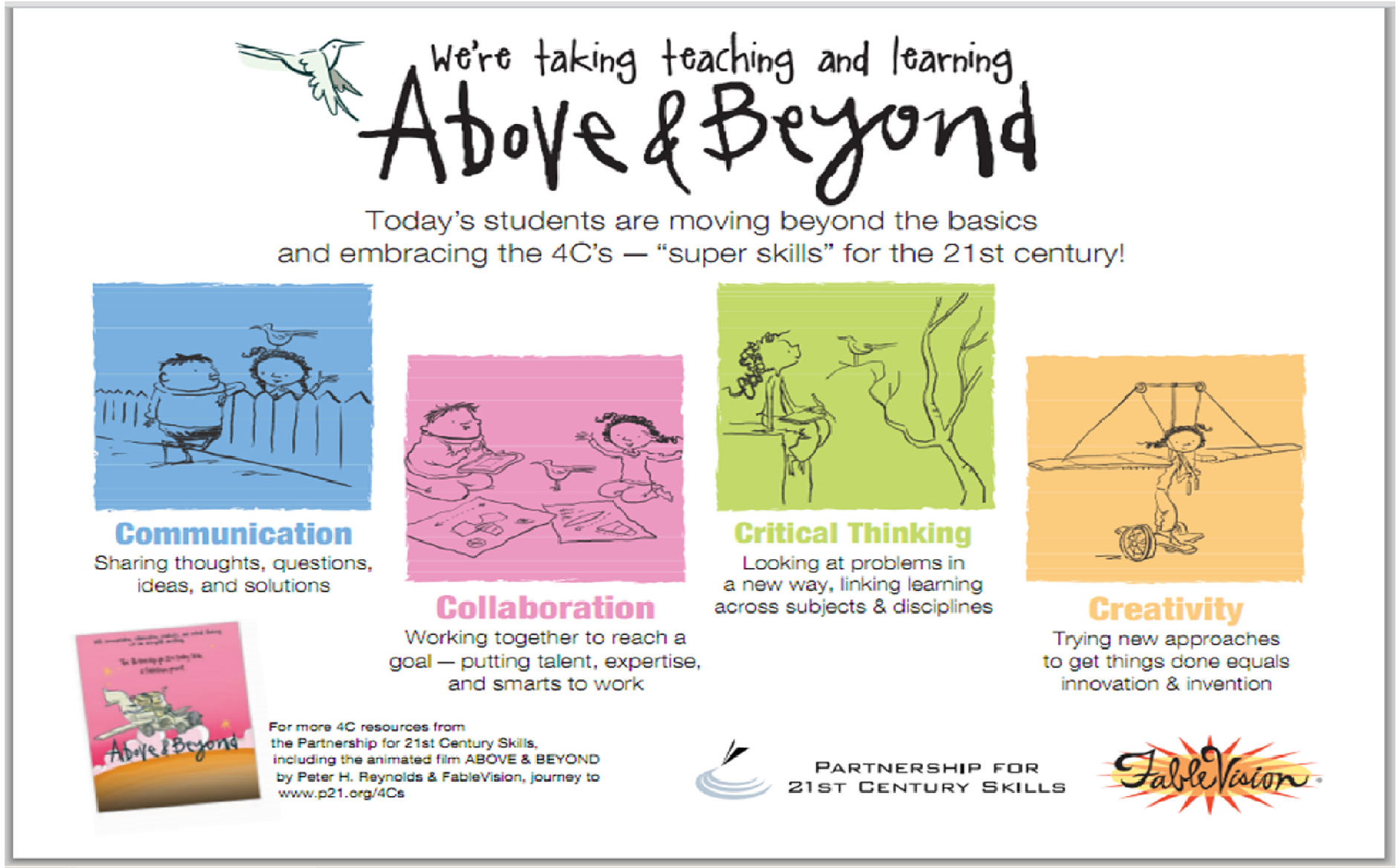
	Problem-Based Learning (PBL)	Project-Based Learning (PjBL)	Studio-based Learning (SBL)
Success criteria	Self-directed learning to occur; soft skills cultivated; problem tackled holistically	Project delivered at quality standards	Innovative creation of a product or service
Who provides the / process / strategy?	Student selected; research methods and bibliography can be suggested by tutor	Provided by tutor at some extent; students can also pick from a given set of methods	Student-selected; thinking strategies may be suggested by tutors
Rigorous use of methods required?	It may be.	Yes.	No.
Group/atomic work	Group work by definition; self-organised;	Either apply, group projects are most often;	Either apply, atomic projects are more often
Lectures?	No in general. Some lectures or scaffolding may be needed	Yes, most usually some lectures are offered.	No in general. Some lectures or scaffolding may be needed
Place	The classroom; (on-line) library: further reading is essential; the field (field studies may be required)	The classroom; the field (field studies are often); the library;	The design studio: a place with available design materials and rooms for atomic and co-located work

- *Question: how to orchestrate (identify, design, develop, assess) learning activities in virtual worlds that conform to these key elements?*

Framing of PBL approach

- PBL helps the cultivation of higher-level skills (21st century skills – 4Cs).
  - Communication (verbal, written, presentations, etc.)
    - Share thoughts, ideas, present own and others' work, etc.
  - Collaboration
    - Work together to achieve goals
  - Critical thinking
    - Pose important questions, looking at problems from multiple perspectives, argumentation
  - Creativity
    - Identifying and trying new ideas and approaches
  - (5th C: Connect, to the Internet!)
- *"While there is no single definitive list of these, skills, most lists focus on expanding traditional concepts of knowledge, skills, and abilities to encompass concepts such as critical and innovative thinking, systems-thinking, interpersonal communication and collaboration skills, digital networking and operation skills, intra- and intercultural awareness and identity, and cross-cultural sensibility."*

Framing of PBL approach



Framing of PBL approach

- We have applied PBL at late graduate and postgraduate courses… some reasons:
  - Increased student motivation
    - To learn, to self-directed learning, to group work, etc.
  - Increased student maturity
    - Especially regarding group work and self-assessment
  - Improved background knowledge and skills
  - Better performance (overall) in authentic situations
  - …

Overview of our studies

- Case 1: VWs in User interface design (short-term (1-day collaborative design activity), exploratory)
- Cases 2 and 3: VWs in architectural and interior space design (medium-term (sessions within a few days) formative/summative assessment)
- Case 4: VWs in HCI design studio (long-term (full-semester) course; formative/summative assessment)

Case 1: VWs in User interface design

- Aim and scope of the study:
  - To explore the suitability of VWs as a platform for hosting PBL activities
  - To explore VWs' affordances for learning, in terms of collaboration support and learning effectiveness.
- Outline:
  - We have designed and developed a number of VW tools that support collaborative learning activities.
  - We have conducted a PBL intervention that required from students to collaboratively design the user interface of a multimedia kiosk.
  - We performed a thorough, formative, multi-method evaluation of the learning activity.

Case 1: VWs in User interface design

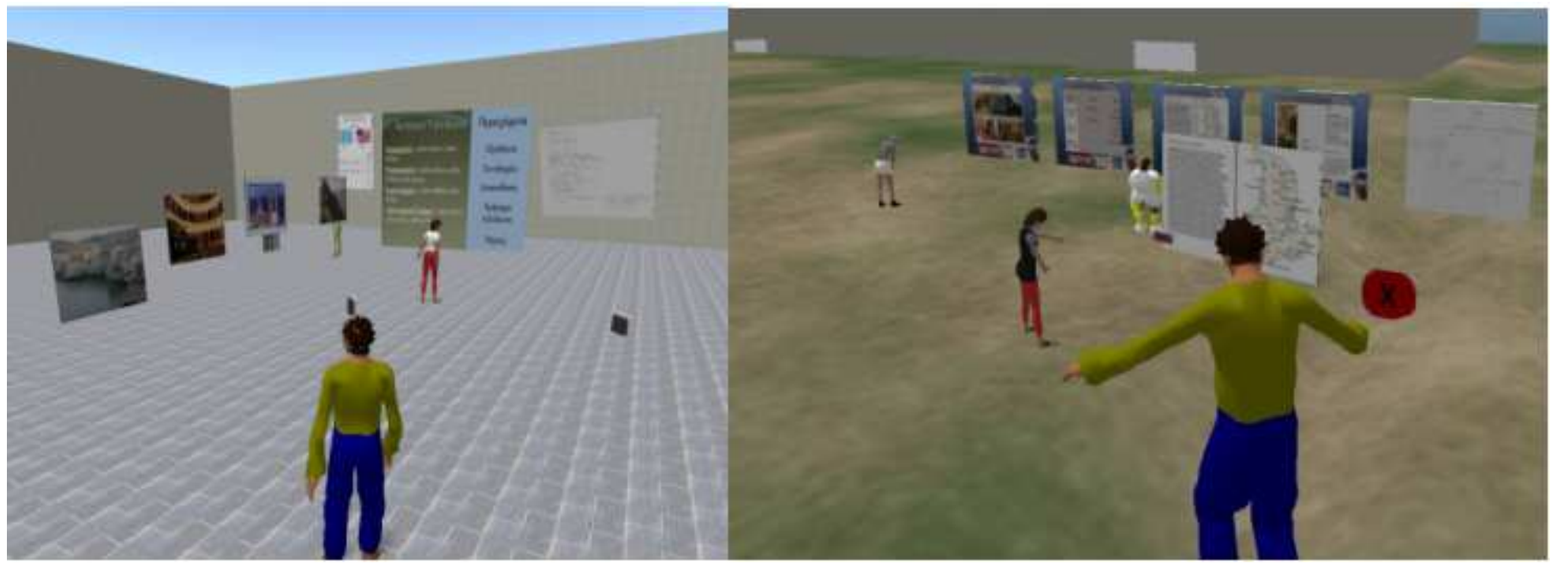
- Rationale:
  - Not many PBL approaches in VWs… - some not really PBL.
  - Most uses of VWs for learning simply exploit resource sharing and conferencing…
    - Common activities: text or voice-based communication, document storage and exchange, group discussions and presentations.
  - Not many studies that exploit the powerful affordances of VW in presenting real-time simulations of custom environments, in which users can actively participate in an experiential and constructivist manner.

Case 1: VWs in User interface design

- Goals of the study
  - (a) **design** a learning intervention for a lecture of user interface design that includes a number of PBL activities;
  - (b) **facilitate** the learning process, while keeping track of students' behaviour and performance; and
  - (c) **evaluate** the learning process with criteria that stem out of the PBL philosophy, as well as the final outcome.

Case 1: VWs in User interface design

- VW environment:
  - Open Simulator server, isolated island (we didn't want to interact with outsiders)
  - Free switch voice server
  - Hippo OpenSim Viewer
  - A single room for each student group to work in.

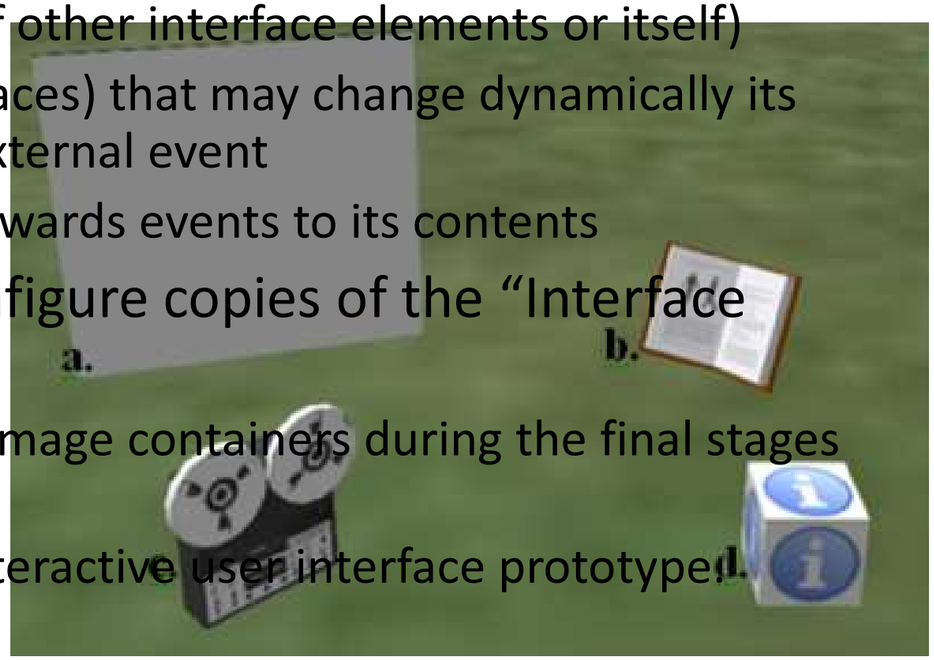


Case 1: VWs in User interface design

- For our study in the area of user interface design we have identified the following user tasks:
  - In the early stages, students **discuss** about the problem, **write down facts** and **reveal aspects for which further knowledge** may be required.
  - Then, they **assign roles** to group members, **search for and share resources**, and **formulate, present and explain their ideas**.
  - Then, they **collaboratively assemble a final solution** and gradually refine it.
  - Finally they **present** it to the class for further evaluation and feedback.

Case 1: VWs in User interface design

- Design and Implementation of VW Tools
  - **a. Interface Element**: an object with scripted behavior that can be used as a user interface component!
    - Its look and behavior can be configured using simple commands
    - It can be configured to:
      - show or hide (as a result of an external event),
      - operate as a button that will generate a batch of events if pressed, (which may affect the status of other interface elements or itself)
      - contain a number of images (faces) that may change dynamically its appearance as a result of an external event
      - operate as a container that forwards events to its contents
- Students can combine and configure copies of the “Interface Element” to:
  - design buttons, windows and image containers during the final stages of the learning activity
  - collaboratively construct an interactive user interface prototype!



Case 1: VWs in User interface design

- Design and Implementation of VW Tools
  - **b. Resource**: an object that links to external web resources
    - It can be used by teachers and students to bookmark and organise Web resources
  - **c. Comment Recorder**: a tool to record and playback user messages
    - notes from conversations during the early collaboration stages
    - record viewer comments during the final evaluation stage.
  - **d. Annotation**: an object that contains a written message
    - asynchronous collaboration between group members (e.g. in the form of comments, notes about assignments, etc.)
    - may be attached to the user interface prototype as further notes or explanations of design choices.

Case 1: VWs in User interface design

- The learning intervention was offered as:
  - An introductory, optional joint lecture for the courses of Advanced User Interfaces and Virtual Reality (9th semester)
- Participants:
  - 10 students (3 male, 7 female).
  - All had attended a number of related lectures like HCI (Human-Computer Interaction), Interaction Design and Multimedia Design.
  - All were proficient computer users, but only three of them had some experiences with VWs.
- 3 groups:
  - Balanced in terms of participants' experience in VWs and their user interface design skills.

Case 1: VWs in User interface design

- Design brief:
  - *"Design the user interface of a multimedia kiosk system for browsing available rooms to let in the island of Syros. The intended users are tourists (Greeks and foreigners), who can access the system at the harbour. You should take into account usability guidelines for multimedia presentations and information seeking. You should design the 5-7 most basic screens of the system, in wireframes*".
  - Learning goals of this intervention
    - a) to discover the usability and accessibility requirements of touch screen interfaces,
    - b) to understand the differences in the design of such interfaces compared to other, more conventional cases,
    - c) to apply this knowledge in a specific practical context.

Case 1: VWs in User interface design

- According to PBL principles, the learning session was applied as follows:
  - 1. The students were given an introductory session in the VW to familiarize with the interface.
  - 2. The supporting tools were presented to the students accompanied by specific use cases.
  - 3. Students worked in groups inside their allocated workspaces.
    - They analyzed the problem, shared ideas and gathered resources.
  - 4. Each group assigned roles and/or tasks to its members.
    - They proposed and argued about concepts,
    - They designed the appearance of the user interface elements using in-world and external tools,
    - They collaboratively constructed their prototype as a proposed solution.
  - 5. Once the group agreed on the final prototype, they attached explanatory annotations to justify their design choices and presented it to the whole class
  - 6. Students and teachers were then free to test each interface prototype themselves and leave comments and suggestions concerning the appropriateness of the solution.

Case 1: VWs in User interface design

Case 1: VWs in User interface design

- Evaluation - Data Collection and Analysis (mixed method)
  - 1. Automated monitoring of student behaviour:
    - this was achieved by video capturing of the activity within the VW, logfile analysis with respect to the use of the tools, and observation of the state of the world during and after the exercise.
  - 2. Dialogue analysis:
    - Voice chat was recorded for most of the exercise and an analysis of utterances
  - 3. Students' self-reporting:
    - questionnaire that investigated several aspects of the problem-based CSCL experience,
    - follow-up discussion.
  - 4. Tutors' evaluation of the outcome:
    - during the activity and also after the experiment taking into account all data gathered.

Case 1: VWs in User interface design

- Evaluation – Interaction Analysis Dimensions and Indicators
  - 1. Task performance
    - Per group and person, for each task, and overall, with respect to tools.
  - 2. Group functioning
    - For each project phase, with respect to background and skills.
  - 3. Social support
    - Participant's actions and behaviour within the group
  - 4. Learning performance and outcome
    - Per group and person, with respect to tasks and final outcome
  - The first three dimensions are those proposed by (Daradoumis et al 2006) while the fourth dimension was added to investigate issues of particular PBL process.

Case 1: VWs in User interface design

Interaction Analysis Indicators	Action monitoring	Dialogue analysis	Self-reporting (question-naires)	Post evaluation (observation, follow-up)
Task performance				
TP1. Problem-solving capabilities and learning outcomes	X	X		X
TP2. Contributing behaviour during tasks	X	X		X
TP3. Performance in terms of self-evaluation		X	X	
Group functioning				
GF1. Active participation behaviour	X	X		X
GF2. Social grounding	X	X	X	X
GF3. Skills that monitor and facilitate the group's well-being		X		X
GF4. Group processing		X	X	X
Social support				
SS1. Commitment toward accomplishment of the common goal	X	X	X	X
SS2. Level of peer involvement	X	X	X	X
SS3. Achievement of mutual trust		X	X	
SS4. Motivational and emotional support to peers		X	X	
SS5. Conflict resolution		X	X	X
Learning performance and outcome				
LPO1. Flexible knowledge about the problem at hand	X	X	X	X
LPO2. Effective problem-solving skills		X	X	X
LPO3. Self-directed learning skills		X	X	X
LPO4. Intrinsic motivation		X	X	X

Case 1: VWs in User interface design

- Evaluation - Results
  - All student groups proved capable of
    - constructing functional user interface prototypes using the in-world tools
    - testing and evaluating their solutions.
  - The prototypes were particularly interesting,
  - All learning activities were conducted in an engaging, enjoyable and satisfactory manner for nearly all users.
  - The learning intervention lasted for a total time of 6.5 hours (1.5 hour more than initially estimated)
    - The first 2 hours were devoted to the tutorial about the use of the VW.
    - A total of 3.5 hours were devoted to the activity of user interface design, presentations and follow-up,
    - A total of 1 hour was allocated to the breaks.
  - Participants responded that they would have carried out the user interface task in a ‘face to face’ situation at the same quality “*at about the same time*”, or “*perhaps an hour less*”.

Case 1: VWs in User interface design

- Evaluation – Results

Table 2. What tools of the VW contributed to the development of your knowledge about the problem? (Bad 1 2 3 4 5 6 7 8 9 10 Excellent)

	Average	Median	Mode	St.Dev.
Resources	5,5	7	7	2,9
Annotations	6	6	6	1,6
Comment listener	4,1	5,5	0	3,7
Interactive objects	6,7	7	7	1,4
Chat (text)	7,5	8	9	1,9
Voice Chat	9	10	10	0,5

Case 1: VWs in User interface design

- Evaluation – Results (Task performance)
  - Students devoted a large portion of their available time to discuss about the understanding of the design problem.
  - These were intertwined with intervals of self-directed learning, which occurred from ‘assignments’ or ‘requests’ by other team mates
    - (e.g. “will you find photos and content about hotels?”) or from individual initiative (e.g. “I can find some text to write about Syros history”).

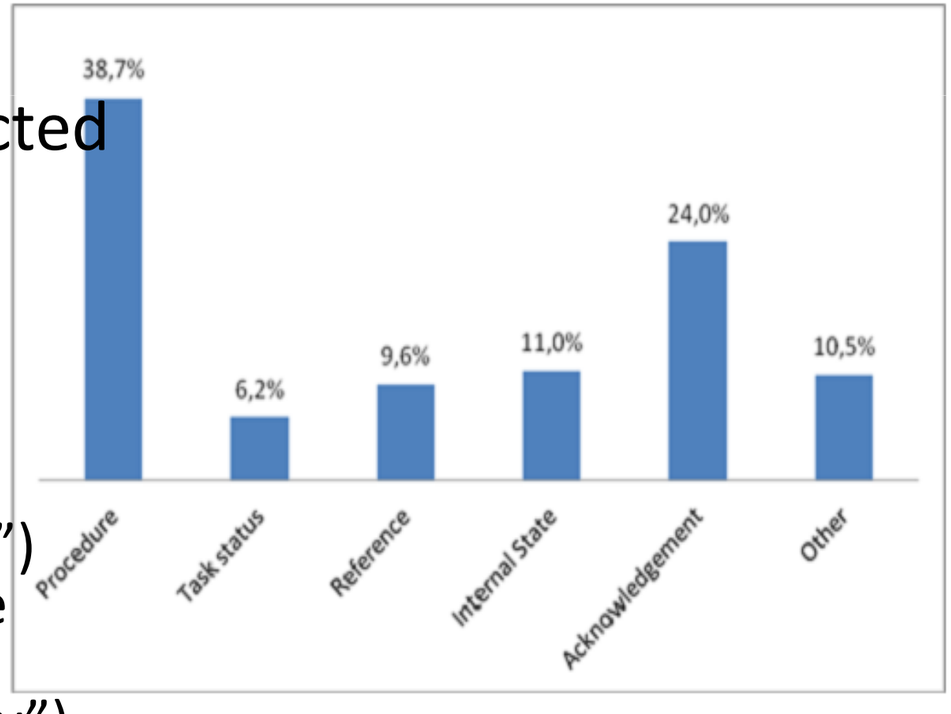


Fig. 4. Types of utterances

Case 1: VWs in User interface design

- Evaluation – Results (Group functioning)
  - Active participation
    - all participants were actively involved in the collaboration and conversations, especially in the first phases of the collaborative activity.
    - 2 students that gradually decreased their contributions (tired).
  - All teams exhibited active interaction skills with respect to monitoring the progress of group work
    - a rather large number of utterances were questions about how to proceed with the activity and specific tasks (14.1%), while there were also a large number of acknowledgements (24.0%) of group work.
  - Each team used a different style of coordination of the work.
    - Team 1 demonstrated a totally balanced coordination scheme without someone taking up a leading role.
    - The other two teams quickly established a leader (in both cases the person who had more experience with the use of the VW) and allocated roles during the collaboration:
      - ‘visual designer’, who also sketched the layout of the screens
      - ‘content designer’ who located and edited content (mainly images and text).
  - All participants reported that the result of their work was a collaborative product and that the environment contributed to their collaboration.

Case 1: VWs in User interface design

- Evaluation – Results (Learning performance)
  - All three teams achieved the goal of the exercise (i.e. to provide the design of the user interface of an information kiosk), at a fairly satisfactory level.
  - All teams demonstrated interesting designs that took related guidelines and content into account.
  - They all reported that they would need more time to elaborate their design solutions.
  - They gradually developed their knowledge about the activity at hand to a considerable extent (an average of 6; 1: Bad – 10: Excellent; st. dev.: 1.2).
  - They devoted about half of the time in self-directed learning: an average of 4.4 (1: None – 10: All; st.dev.:2.3).

Case 1: VWs in User interface design

- Conclusions
  - The experience had several positive aspects.
    - The fact that users shared a persistent workspace was perhaps their most important and recognized advantage of the system.
      - They highlighted the fact that they could easily log off or postpone some of their activities in the world (especially when they performed self-directed learning activities) and they were able to see their other mates' progress
    - All students reported that they felt engaged and motivated to work towards their common goal.

Case 1: VWs in User interface design

- Conclusions
  - The experience had several positive aspects.
    - Discussions about the problem and tasks were easy to carry out in the VW, since they all had their own material uploaded on the shared space.
    - It was natural to compare design ideas and comment on others' work.
    - The environment was fun and kept them occupied all the time, even at times when they had to wait for other team mates to deliver their parts of the work.
    - The increased awareness of others' work and activity and progress was also reported as a positive aspect of the environment, mainly as a motivating factor to one's own work.

Case 1: VWs in User interface design

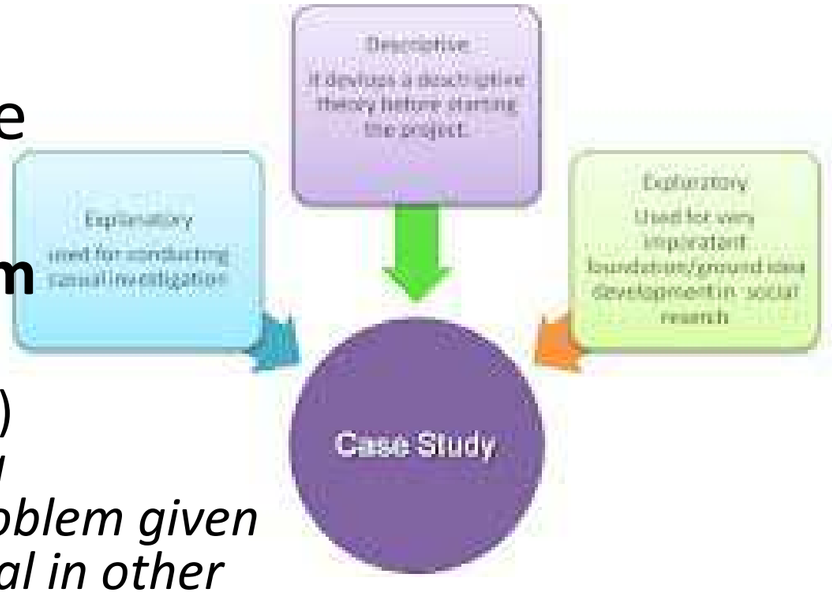
- Conclusions
  - A number of problems and drawbacks were identified.
    - A few users reported that their attention was more on the difficulties of using the environment, especially in the beginning, rather than on the user interface design task.
    - The teams discussed and planned their activities, but they did not manage to keep track of all their coordination decisions.
    - Despite that there were available tools in this respect, some of them found it hard to use them.
    - Some students did not like the fact that the roles of each participant were not visible by their avatars
    - They also wished for more ‘2D functions’,
      - e.g. the possibility to embed applications from their desktop environment to the VW.
    - Finally, perhaps the most important problem for this study was the lack of familiarity with the environment.

Cases 2 and 3: VWs in architectural and interior space design

- Aims and scope:
  - Despite the increasing interest in exploring the affordances of VWs for mediating collaborative design activities, design studies in VWs are still scarce.
    - VWs are a new medium
    - The design community would be interested in pragmatic uses of technologies that add value to existing practices.
  - Collaborative design studies in VWs of:
    - (a) A design review session of the architectural design of a cottage focusing on the quality of communication among the designer and clients;
    - (b) The collaborative design of the interior space of an academic laboratory with focus on situation awareness of collaborating designers;
    - In both cases:
      - Authentic collaborative design projects that involve designers' cooperation and client feedback.
      - Problem-Based Learning context.

Cases 2 and 3: VWs in architectural and interior space design

- Approach: Case study research
- I. Problem, process and outcome of design collaboration
  - A. **Ill-defined or 'wicked' problem** at hand:
    - According to Cross and Cross (1995) '*in design, it is not normal to have a clear and immediately apparent problem given as the task, in the way that is normal in other problem solving studies*'.



  - B. **Design process reflection** ('reflection-in-action') and **negotiation** (among design participants).
    - In practice, the design process is fluid and determined upon the design participants' knowledge and experience.
  - C. **Concrete outcome**:
    - Designing must result to one (or more) concrete outcome(s) that can be evaluated and discussed by design participants.

Cases 2 and 3: VWs in architectural and interior space design

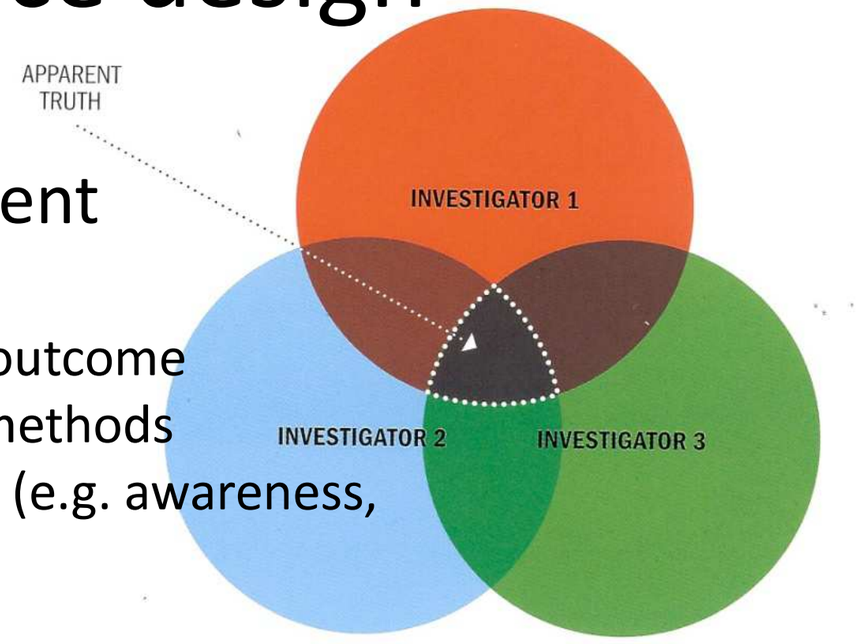
- Approach: Case study research
- II. Participants
  - A. **Pragmatic (or at least authentic) project and participants**:
    - design studies typically concern pragmatic design projects that involve professional designers and stakeholders.
    - when learning and technology research objectives are pursued, authentic projects are also acceptable:
      - Less experienced designers (typically students)
      - Role playing for clients or users
  - B. **Genuine contribution**:
    - Incentives for genuine user involvement,
    - In more controlled HCI evaluation studies ethical issues must also to be considered (Blandford, Cox, & Cairns, 2008).

Cases 2 and 3: VWs in architectural and interior space design

- Approach: Case study research
- III. VW tools and affordances
  - A. **Familiar VW tools and metaphors from design practice.**
  - B. **Exploitation of 3D VW affordances** for digital tool design.
    - Digital places (Harrison & Dourish, 1996) for collaboration.
    - Digital tools for design communication, representation, modeling and documentation.
    - The design space for introducing digital tools is practically unlimited!
      - We do not simply want to transfer 2D tools into the 3D space.
  - C. Design **VW tools** that mediate design activities **at various levels of abstraction**.
    - Most approaches deploy tools for **instrumental** and **communicative** activities.
    - Collaborative design can also be (Vosinakis et al., 2008) :
      - **discursive** in the sense that design goals and actions are negotiated or
      - **strategic** in the sense that it is oriented towards influencing others.

Cases 2 and 3: VWs in architectural and interior space design

- Approach: Case study research
- IV. Data collection and assessment
  - A. Pluralistic assessment about:
    - (a) quality and acceptance of the outcome
    - (b) participants' use of tools and methods
    - (c) aspects of design collaboration (e.g. awareness, communication, etc.)
    - (d) user experience
  - B. Mixed use of behavioural and self-reporting data
    - In VWs it is possible to collect various types of data about user behaviour in the digital space, especially through video, audio, chat, logs.
    - These have to be matched with self-reporting and self-reflection that will explain participants' actions.
    - Qualitative measures require cross examination (triangulation) of data.



Cases 2 and 3: VWs in architectural and interior space design

- VW environment:
  - Open Simulator server, isolated island (we didn't want to interact with outsiders)
  - Free switch voice server
  - Hippo OpenSim Viewer
  - A single room for each student group to work in.
- (same as Case 1)

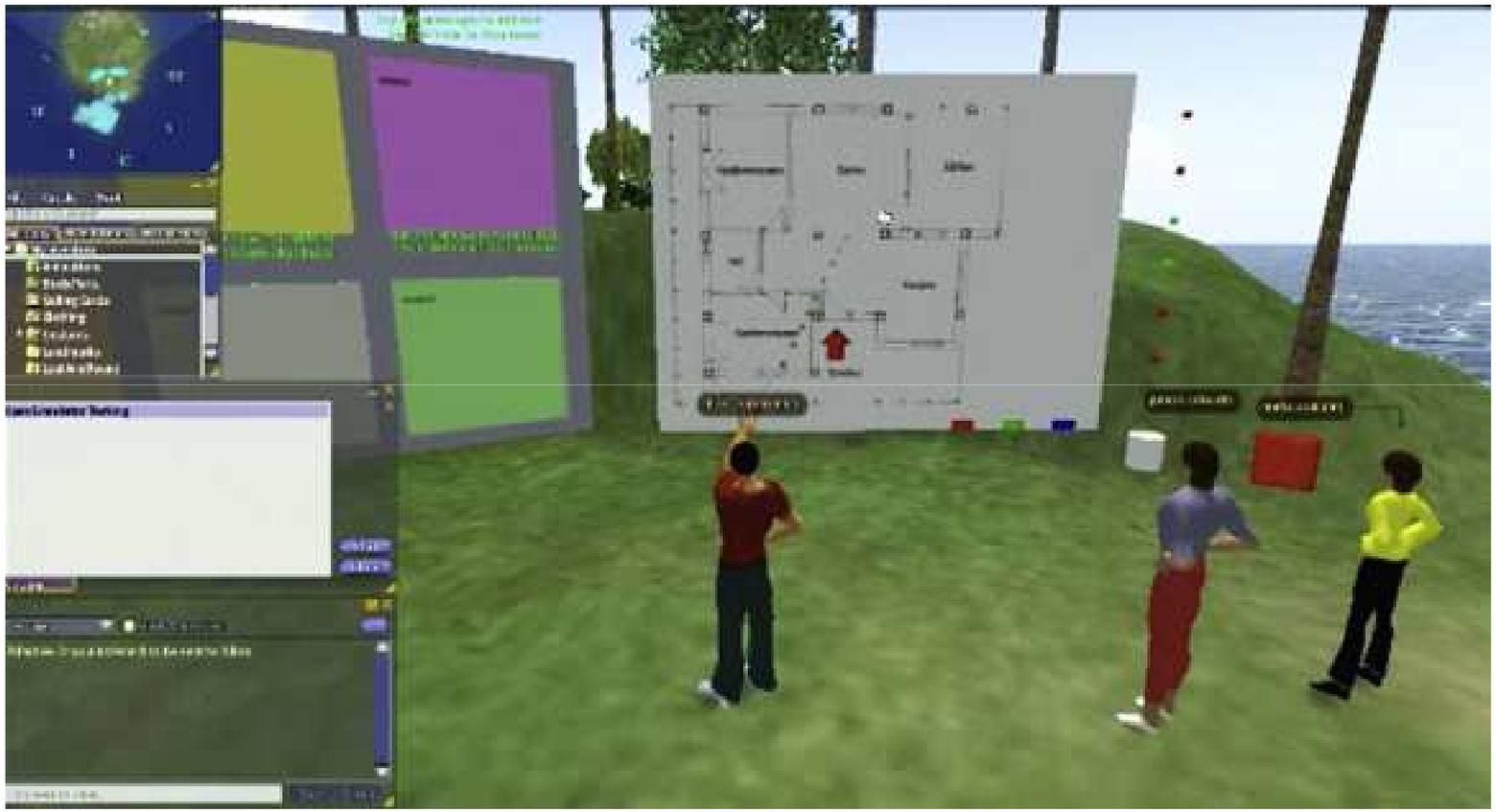
Cases 2 and 3: VWs in architectural and interior space design

- Case 2: designer-client review sessions of architectural design focusing on the quality of communication
- Aim of the study
  - To examine the extent to which VW **communication tools** allow for a comprehensive and efficient **design review of a cottage**.
- Communication tools:
  - **Built-in tools** for communication and information exchange:
    - Text chat, avatar gestures, voice chat, colour palette, texture library, mini-map (for location awareness), and pointing.
  - **We created four (4) additional tools** that fit better to the specific design activity:
    - (a) **annotation** tool for posting comments and requests in specific objects or places;
    - (b) the **area marker** for marking large areas;
    - (c) the **message board** for posting messages;
    - (d) the **note-boar**d for exchanging small notes

Cases 2 and 3: VWs in architectural and interior space design

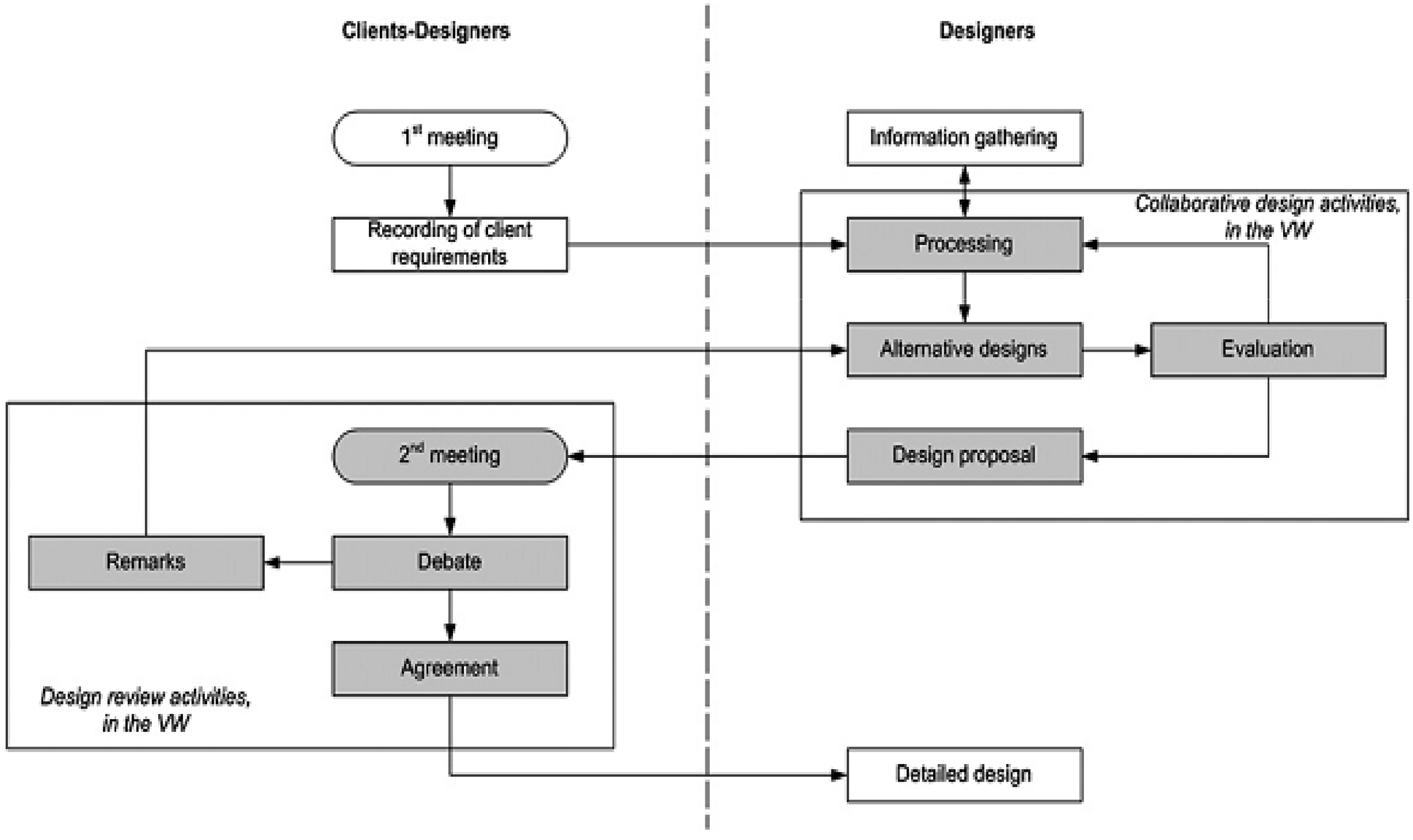
- Case 2 - Participants:
  - A professional architect.
    - In all, three (3) professional architects designed the cottage, at architectural office
      - The chief architect built the cottage in the VW and the other architects approved
  - Two (2) groups (couples of male and female) were the potential clients for the cottage.
    - Real clients in the sense that they were indeed interested for the cottage
    - Each couple carried out the design review process independently

Cases 2 and 3: VWs in architectural and interior space design

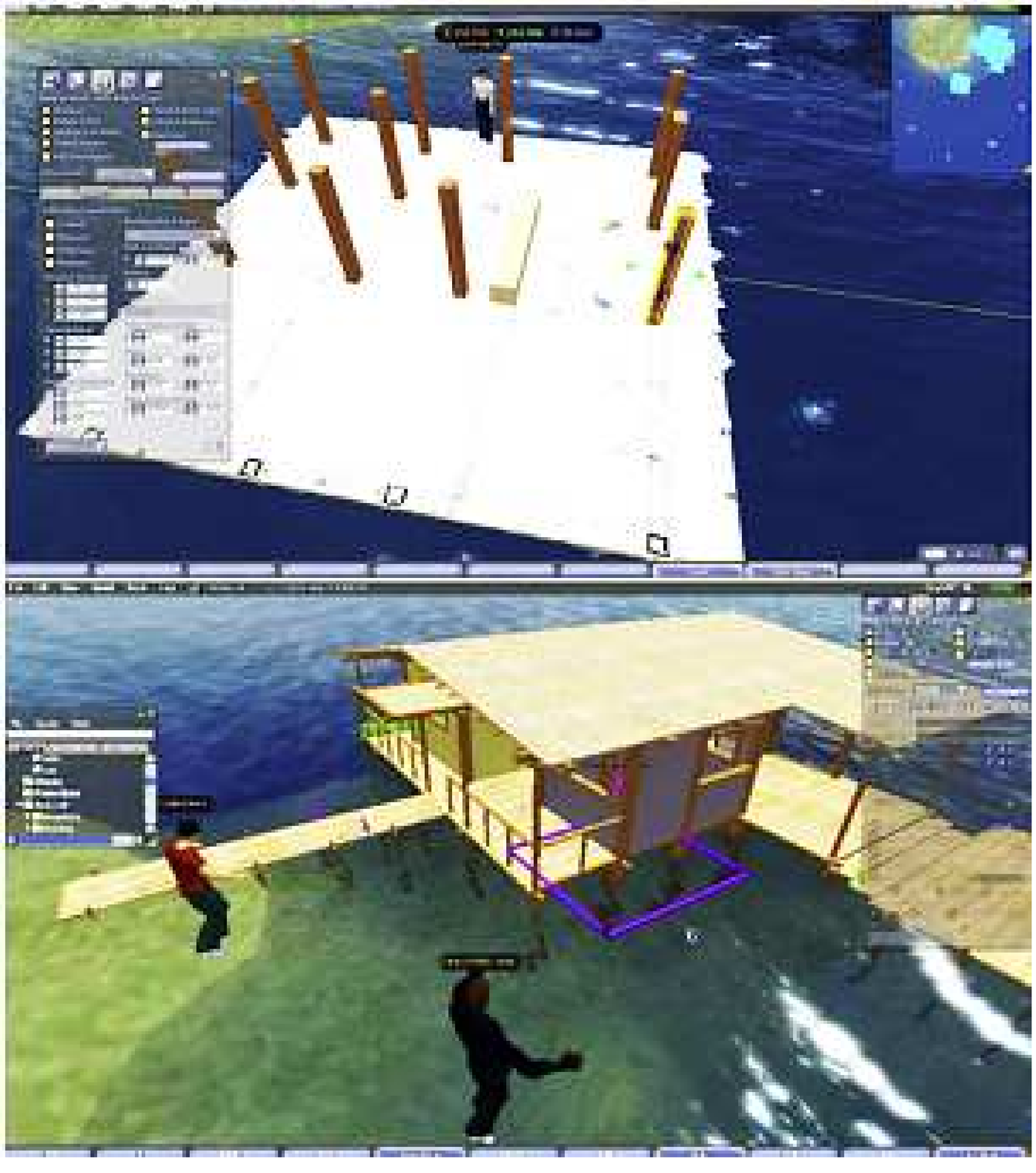


- Figure: the architect and users make use of text chat, area marker, note board, and annotations.

Cases 2 and 3: VWs in architectural and interior space design



Cases 2: VWs in architectural design (design review)



Cases 2 and 3: VWs in architectural and interior space design

- Case 2 - Results and assessment
  - Data collection and analysis: a mixed method
    - Observation and recording
    - Questionnaires
    - Interviews
    - Dialogue analysis
  - Types of assessment results:
    - (a) support of collaborative design review of architectural design in VWs;
    - (b) quality of communication of design participants in the VW (with respect provided VW tools and available affordances); and
    - (c) the user experience.

Cases 2 and 3: VWs in architectural and interior space design

- Case 2 - Results and assessment – (a) Support for design review
  - Both design review sessions produced a considerable number of proposed changes by clients.
    - Simple and complex on the basis of how complicated was the procedure of applying the new solution.
  - Each couple of clients identified quite different sets of changes according to their requirements.
  - For each required change, a detailed list of data was recorded (see table later on).

Cases 2 and 3: VWs in architectural and interior space design

- Case 2 - Results and assessment - (b) quality of communication of design participants in the VW
- The collaborative design review session in the VW yielded important alterations from the client side with the use of various built-in and designed communication tools.
- On the usage of communication tools:
  - (a) The use of additional VW tools provided was much more intensive for complex remarks rather than for simple ones;
  - (b) The collaborative board tool was mainly used during synchronous communication
  - (c) The clients used area marker and note board in asynchronous communication.
  - (d) For simple alterations clients attempted to mark their remarks independently (without consulting one another or the designer),
  - (e) For complex annotations they asked their mate's help and the chief designer's opinion.
  - (f) All users customised their avatar as soon as they logged into the system, though not asked to do so.

Asked alteration	*Alteration complexity*	*Involvement*	*Time*	*Media*	*Total no. of uses*
1st client couple					
Synchronous communication (30′, direct communication time: 15′)					
Additional of railing	Simple	1 client–architect	1:30	Voice chat	17
				Point	6
Place for a boat	Simple	1 client–architect	2:10	Voice chat	7
				Collab. board	2
New kitchen door	Simple	2 clients–architect	2:20	Voice chat	14
				Point	5
				Collab. board	1
Stair at the platform	Simple	2 clients–architect	1:40	Voice chat	5
				Collab. board	1
Storage room	Complex	2 clients–architect	5:10	Voice chat	29
				Collab. board	3
				Point	11
Asynchronous communication					
Bigger balcony	Simple	1 client	–	Annotation	1
				Area marker	1
Change roof type	Simple	1 client	–	Annotation	1
2nd client couple					
Synchronous communication (30′, direct communication time: 15′)					
Change railing type	Simple	1 client–architect	0:40	Voice chat	6
Change door material	Simple	1 client–architect	2:10	Voice chat	4
				Texture library	3
Bigger kitchen	Complex	2 clients–architect	4:00	Voice chat	18
				Collab. board	2
				Point	9
Mezzanine above living room	Simple	1 client–architect	0:50	Voice chat	6
				Point	4
Change wall colours	Complex	2 clients–architect	6:20	Voice chat	32
				Point	7
				Colour palette	5
Move window	Simple	1 client–architect	0.30	Voice chat	4
				Point	3
Change roof material	Simple	1 client–architect	0:40	Voice chat	3
				Texture library	3
Asynchronous communication					
New balcony	Simple	1 client	–	Annotation	1
				Collab. board	1
Change roof type	Simple	1 client	–	Note board	1

Cases 2 and 3: VWs in architectural and interior space design

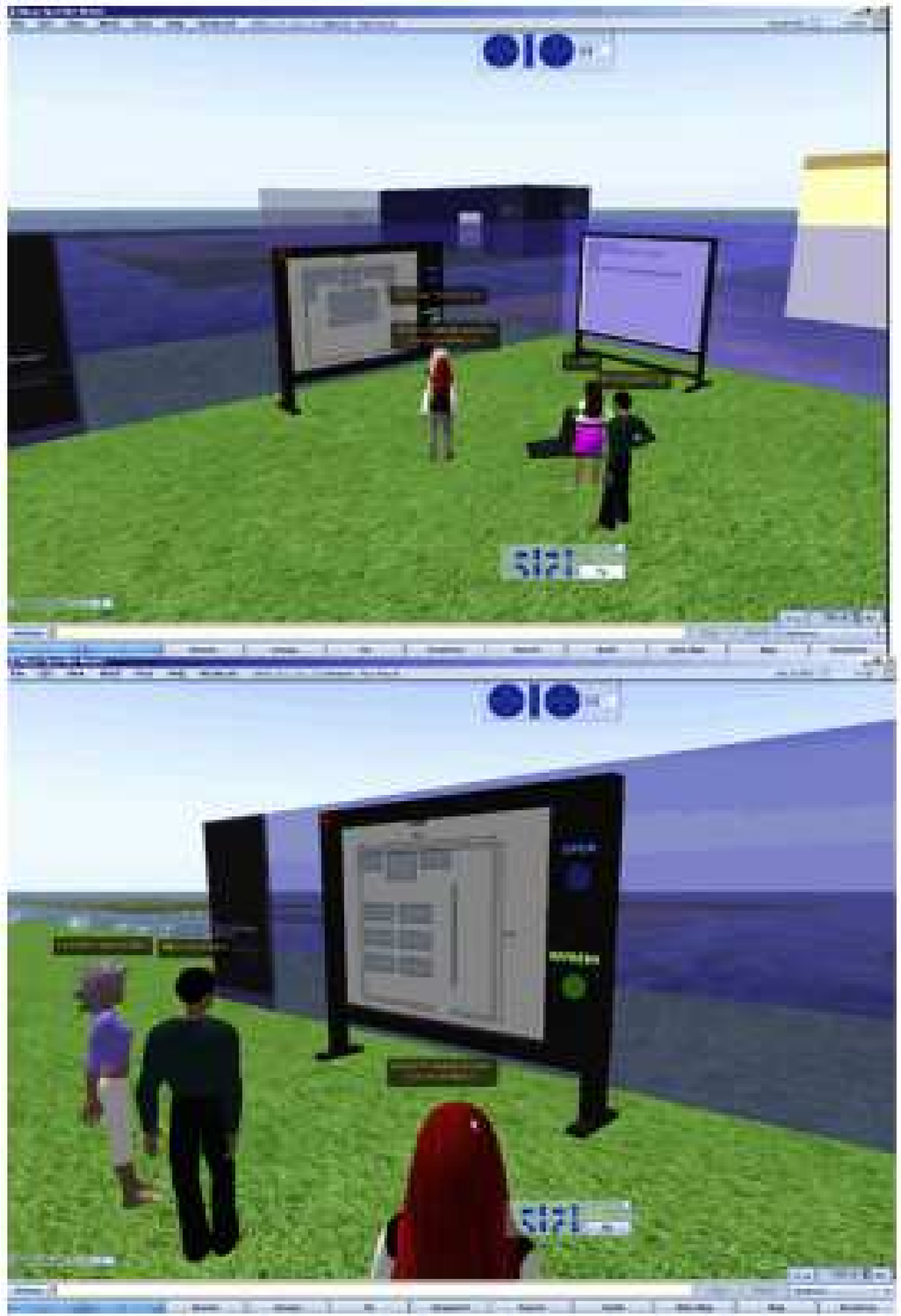
- Case 2 - Results and assessment – (c) the user experience
  - All users were enthusiastic with the environment.
  - They showed a high degree of commitment to the task and engagement to the environment.
  - They all urged to correct their appearance and explore the environment at first,
    - This is a deeply grounded behaviour of all humans when we find ourselves in new spaces and places.
  - Users faced a number of usability problems with the use of the environment.

Cases 2 and 3: VWs in architectural and interior space design

- Case study 3: design team collaborations for the interior space design of an academic laboratory with focus on situation awareness
- Aim of the study: To assess the **quality of situation awareness** mechanisms of VWs for **interior space design of an academic laboratory** (lab of materials in design).
- Situation awareness:
  - *'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future'* (Endsley, 1988)
- Related tools:
  - Built-in tools for creating 3D content
  - Two additional tools were designed:
    - (a) drawing board
    - (b) a message board.

Cases 2 and 3: VV
and interior

- Case 3
  - Two additional tools were designed:
    - (a) drawing board
    - (b) a message board.

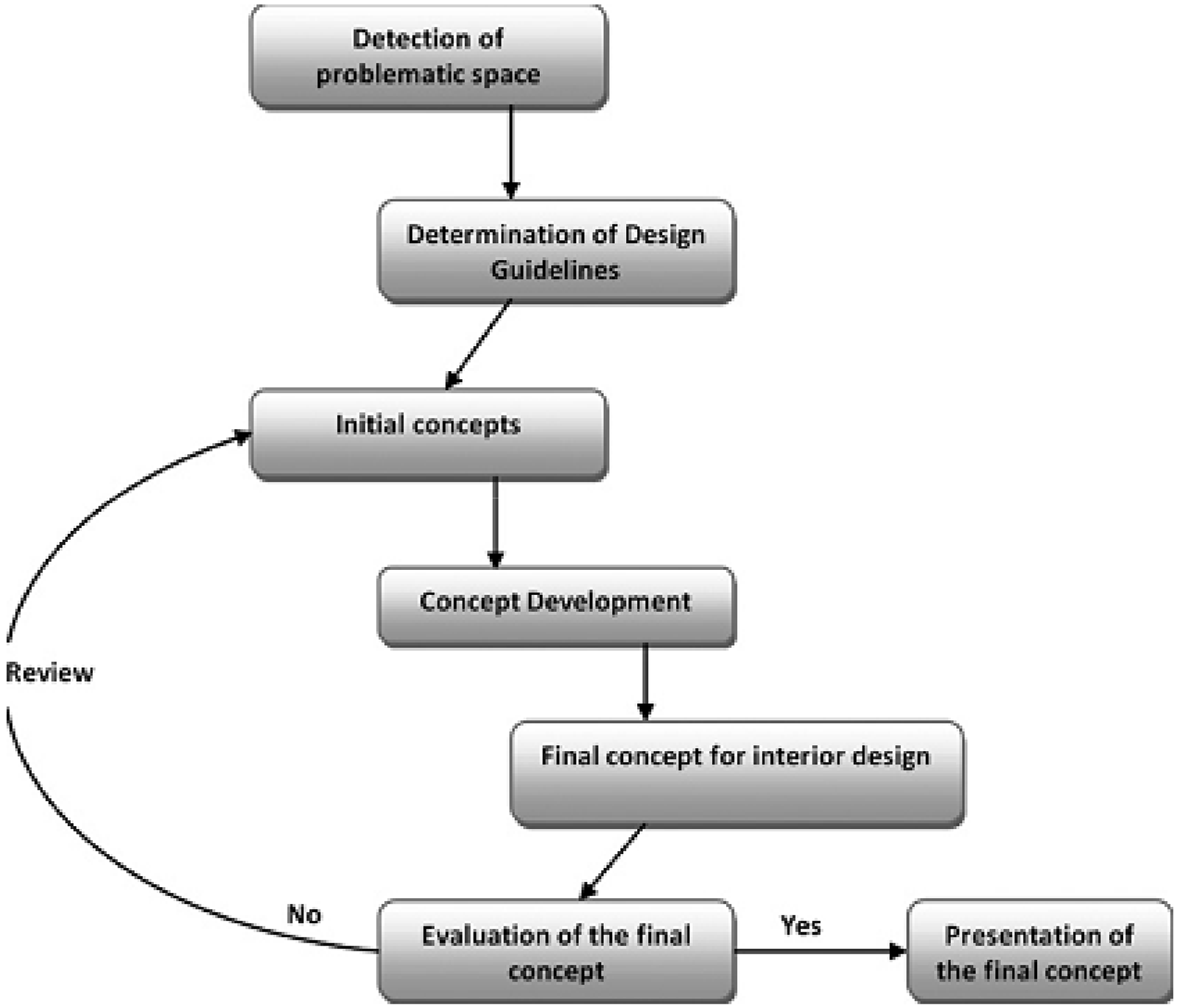


Cases 2 and 3: VWs in architectural and interior space design

- Case 3 – participants: a total of eight (8) persons with the following roles:
  - One member of the research team, who facilitated the process providing help and performing observation and evaluation.
  - Two (2) design teams of three (3), between 24 and 36 years old who carried out the activity independently.
    - One team consisted of professional interior space designers
    - The other of graduates from the Department of Product and Systems Design Engineering, University of the Aegean, Greece.
  - One client, who is a lecturer of the department, participated by
    - (a) providing requirements (outside the VW)
    - (b) in the evaluation of the final outcome of the process (inside the VW).

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 – process and phases (~4h / group):
  - 1. Determination of design guidelines: this happened outside the VW with an interview with the client.
  - 2. Training session in the VW ~30’
  - 3. Carrying out of the interior design process ~2.5 h
    - ‘initial concepts’,
    - ‘concept development’,
    - ‘evaluation of the final concept’ (among the design team)
    - ‘final concept’
  - 4. Observation of the design process (a member of the research team) in parallel to step 3 above.
  - 5. Debriefing and questionnaires (the member of the research team with the designers) ~30’
  - 6. Design Review (the client walked through each academic lab interior along with the design teams and provided feedback and remarks) ~30’


Detection of problematic space
Determination of Design Guidelines
Initial concepts
Concept Development
Final concept for interior design
Evaluation of the final concept
Yes
Presentation of the final concept
No
Review

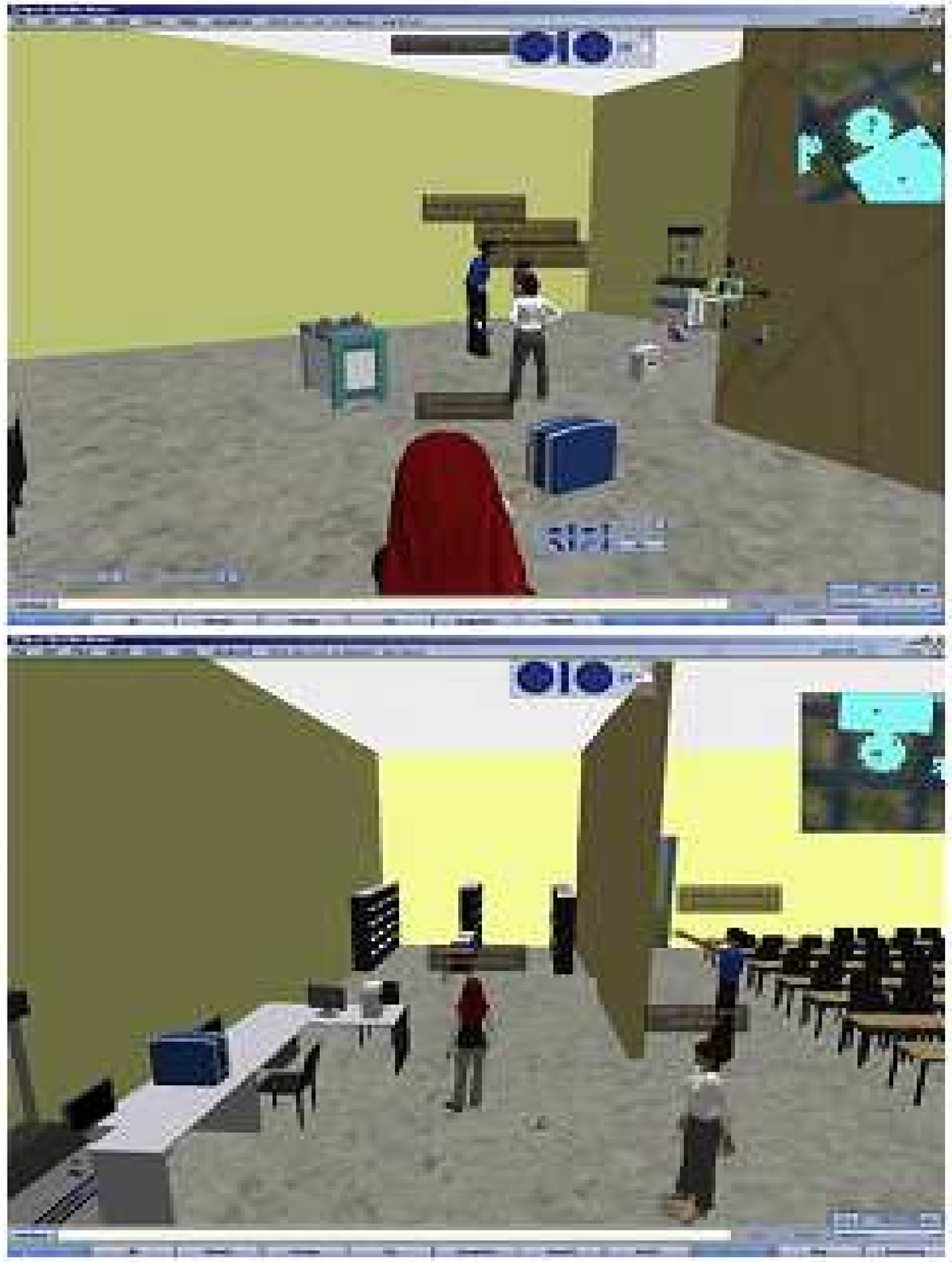


Figure 6 (a) The design team while working (and a member of the research team observing); (b) The academic lab created with rooms for teaching and scientific equipment

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 – Results and Assessment
  - A mixed method for data collection and analysis of collaborative design activity
    - observation, questionnaires and interviews with design participants.
  - The results of can be grouped into the following dimensions:
    - (a) support of collaborative interior space design in VWs;
    - (b) the quality of situation awareness of design participants in the VW, with respect provided VW tools and available affordances.
    - (c) the user experience;

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 - Results and Assessment - (a) support of collaborative interior space design in VWs;
  - VWs can support the collaborative interior design process effectively
    - Both design teams reached to a conceptual interior design of the academic lab within a total time of 2.5 h.
    - Both designed academic lab were well-accepted by the client with not major requests for alterations
  - However the task was not that complex in comparison to other cases of interior design
    - that have intense service design requirements, like for example places offering customer and hospitality services

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 - Results and Assessment – (b) the quality of situation awareness
  - A considerable number of situation awareness issues was identified,
    - For most of them workarounds were quickly applied, with some exceptions for organizational tasks.
    - Some of these issues and recommendations, like the resources and annotation tools (2nd and 12th recommendations in Table 3), have been addressed with additional tool design for other case studies.
  - Detailed view of issues in the next table
    - For each phase of the collaborative design process (column 1) …
    - the major problems of situational awareness are identified (column 2) …
    - with respect to related VW affordances, tools and feedback mechanisms (column 3).
    - Workarounds followed by designers to cope with these problems were tracked down (column 4) as well as …
    - ideas for improved awareness mechanisms (column 5).

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 - Results and Assessment – (b) the quality of situation awareness

Design process phase	*Major problems of situation awareness*	*Related VW affordances, tools and feedback mechanisms*	*Workarounds*	*Ideas for improved awareness mechanisms*
Initial concepts	1. Remember the list of client guidelines and to look at collected resources (e.g. Web documents)	Message board	Voice chat; view documents outside the VW	1. The need for a VW tool that provides links for viewing external documents (knowledge resources) was identified.
Initial concepts	2. What were the previous sketches of an artefact?	Drawing board	Search for this in Google docs versions	2. The 'sketch history' with different editions of the same sketch should be available.
Initial concepts	3. Viewing the sketches of colleagues only after refreshing the screen	Drawing board	None.	3. Automatic refresh of Drawing board.
Concept development	4. Who just edited an object?	Feedback mechanisms for others' actions	Voice chat	4. Subtle visual (e.g. a glowing ray) and audio notifications for others' actions in the VW.
Concept development	5. What is the history of this object? (who created it, who re-designed it, where there different versions, etc)	VW object properties	Voice chat	5. The history about the object's 'design lifetime' in the VW should be accessible.

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 - Results and Assessment – (b) the quality of situation awareness

Concept development	6. To see the dimensions of an object is a tedious and repetitive task	VW affordances for seeing object dimensions	None.	6. Add (keyboard) shortcut or visual indicator for direct access to an object's dimensions
Final concept	7. Uncertain about the accuracy with which the objects were placed in space.	VW affordances for object placing	None.	7. VW enhancement with a grid tool for viewing distances among the 3d objects.
Final concept	8. Lack of support for defining locked and unused space around an object for ergonomic purposes.	VW object properties	Voice chat	8. Enhancement of the VW with function about the definition of unused space around an object.
Final concept	9. The true scale of objects and space makes them look small in the VW	VW environment	Adjust avatar height; view VW in first person view	
Final concept	10. Uncertain of whether subsequent (part of) objects were tangential to each other.	VW affordances for assembly tasks	Walk around and/or tediously inspect objects	9. VW enhancement with 'locking' and 'match' functions in the VW for assembly tasks
All phases	11. Vague mini-map of others' positions and activity	VW mini-map	Walk/fly to see or voice/text chat	10. Re-design of the mini-map to inform in real time about others' identities and activities.

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 - Results and Assessment – (b) the quality of situation awareness

Design process phase	*Major problems of situation awareness*	*Related VW affordances, tools and feedback mechanisms*	*Workarounds*	*Ideas for improved awareness mechanisms*
All phases	12. Uncertain about coordination of their own actions with respect to others' tasks (what do I have to do next?)	VW/Drawing board	Voice chat	11. Some type of coordination chart in which designers record their duties and follow up has to be developed
All phases	13. Hard for participants to make use of gestures for their avatar.	VW affordances for gesturing	Voice chat	
All phases	14. Not visible role of others during particular tasks	Drawing board/Avatar appearance in the VW	None	
All phases	15. Notifications about text chat, when collaborators where far away (text chat range is geographically limited)	VW text chat	Voice chat or 'shout' VW function	

Cases 2 and 3: VWs in architectural and interior space design

- Case 3 - Results and Assessment - (c) the user experience
  - Designers reported that they had a satisfactory awareness of the VW environment after the collaborative design activity.
  - They perceived and understood their other mates' actions in the VW fast,
    - this allowing them to coordinate their moves and actions as well as in taking the initiative to communicate and ask questions.
  - They reported that the VW helped monitor others' progress which motivated them to progress with their own responsibilities.
  - When designers focused on their own tasks in their digital places, it was easy to return to the collaborative space and catch up with their other mates' work progress.

Case 4: VWs in HCI design studio

- A long-term application of VWs in education (blended course)
  - During a whole semester (13 teaching weeks, ~4 months)
- Postgraduate course on Human-Computer Interaction (HCI) Design Studio:
  - At the MSc program of Design of Interactive and Industrial Products and Systems, at the University of the Aegean, Greece.
  - A transformation postgraduate program that
    - Includes students from a wide variety of disciplines related to design (e.g., computer science, engineering, and architecture)
    - provides them with the skills that enable them to make creative use of technology, scientific methods, and the arts in order to contribute to the design of functional and usable products and services.
  - Offered at the 2nd semester of study, just before students begin their MSc thesis.
    - At that point or in parallel to this, students are attending courses related to HCI theory and methods, informatics, ergonomics, and advanced user interfaces.

Case 4: VWs in HCI design studio

- Case 4 – Goals of the course: 1. Knowledge and Skills, 2. Design project, 3. Use of technology.
- 1. Knowledge and skills.
  - 1.a. Students have to make justified use of HCI and design methods in their projects
    - (a) Design research methods
    - (b) Conceptual and detailed design methods
    - (c) Evaluation and assessment methods
  - 1.b. To cultivate higher-level skills to students
    - (a) to develop critical thinking through reflecting on their (group) work as well as on the use of methods found in HCI and design literature,
    - (b) to learn to work in groups,
    - (c) to develop intrinsic motivation and responsibility about work and learning, and
    - (d) to learn how to learn through the practice of self-directed learning.

Case 4: VWs in HCI design studio

- Case 4 – Goals of the course: 1. Knowledge and Skills, 2. Design project, 3. Use of technology.
- 2. Design project (student learning is centred to this)
  - Has to be developed from ideation to user evaluation
  - Can be added to students' portfolio as well as a design report.
  - Authentic and related to practice
  - Requires field research and design work.
  - Has neither a single correct line of inquiry or methodology to be followed nor a unique solution.
  - Students work in groups
    - To identify what they need to learn in order to solve a problem
    - Come up regularly with presenting their progress to get feedback and criticism.

Case 4: VWs in HCI design studio

- Case 4 – Goals of the course: 1. Knowledge and Skills, 2. Design project, 3. Use of technology.
- 3. Use of technology
  - (a) the VW design studio developed for this purpose;
  - (b) a wiki space for communicating texts and documents;
  - (c) other tools like online survey tools, online prototyping tools, usability evaluation tools, card sorting tools, etc.,
  - In HCI design studios it is important that students gain digital design competence,
    - "*the ability to confidently and critically design digital media for other people's confident and critical use of that media in their fulfillment of certain socially relevant purposes*" (Arvola and Hartman, 2008)

Case 4: VWs in HCI design studio

- Case 4 – the design brief
  - *Design a (multi-) touch interactive table or kiosk for a public place like a cafeteria, cinema or theatre. Consider alternative installations, e.g. on top of cafeteria tables or cinema seats, at the entrance, etc; the location of the installation will affect the utility of the installation and goals of the software multimedia application. Type of services of that application may be "business services" like browsing/searching the product catalogue and ordering/booking, and "entertainment services" like web browsing, games and communication with others (e.g. other tables in the cafe). The design should take into account "tangible requirements" like table form, table dimensions, etc.; however it should focus on the aspects of the software user interface and user interaction techniques. You should make careful and justified use of design methods to deliver a brief design report that will show off the design models created and an evaluated prototype of the designed artifact using some HCI evaluation method and/or the VW.*

Case 4: VWs in HCI design studio

- Case 4 – Course schedule
  - Introduction (1 week)
    - To explain the approach and technology and to provide context to the design project for each group.
      - An information kiosk for the theatre
      - A multitouch table for a specific cafeteria, which is a popular student haunt
    - A total of 10 students participated in the course
      - Two groups of 5, with ranging backgrounds
  - Research and inquiry (~3 weeks).
    - Requires use of HCI research and requirements methods, like:
      - Interviews and related strategies, observation (strategies), contextual inquiry, models of contextual design, user segmentation strategies and personas, content inventory tools and methods, competitor analysis strategies (Garrett, 2003), mood boards, designing brand identity, and goal-setting methods, etc.

Case 4: VWs in HCI design studio

- Case 4 – Course schedule
  - Design (conceptual and analytic) (~5 weeks).
    - Requires the use of HCI and design methods for articulating design concepts and solutions, like:
  - (a) “design process” methods: brainstorming (Cross, 2008); scenario-based design (Carroll, 1995); interpretation sessions (Beyer & Hortzblatt, 1998);
  - “design modeling” methods like: visioning (Beyer & Hortzblatt, 1998), concept modeling (Brown, 2007), and storyboarding and information architecture methods;
  - prototyping methods: paper prototyping (Snyder, 2003), wireframes, screen designs, and virtual prototyping.

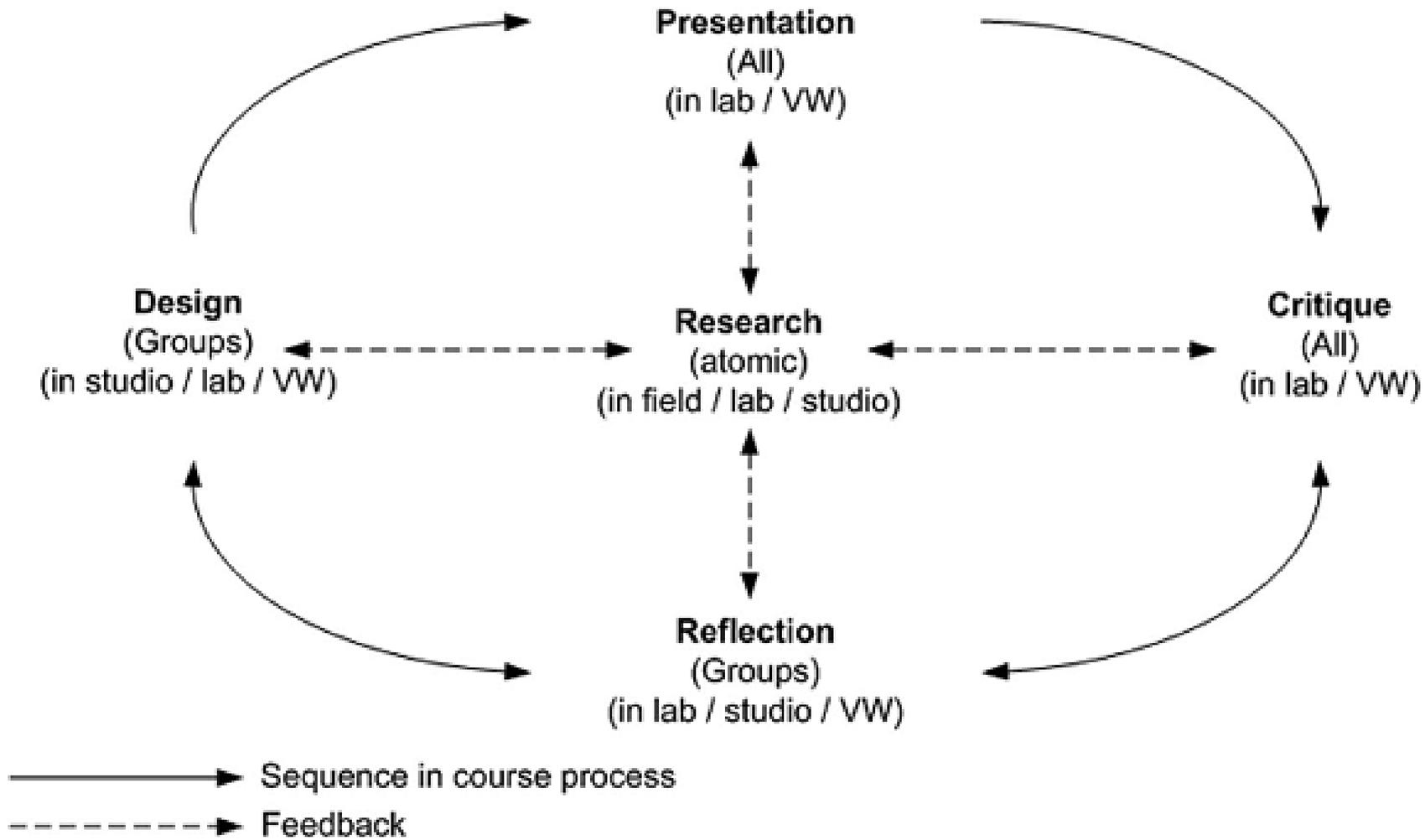
Case 4: VWs in HCI design studio

- Case 4 – Course schedule
  - Evaluation (~2 weeks).
    - Methods like: prototype walkthrough in the VW, paper prototyping (Snyder, 2003), prototyping with online tools, and user testing methods in the case they had devoted time to reach to a fully working demo.
  - Final presentation and assessment (1 week).
    - final project presentation as well as course and peer assessment.

  - The main phases of the project development during the HCI design studio course were considered as problems of HCI and design methods use.
    - A considerable time of each session was devoted to collaborative work on the identification of areas of further study and the assignment of atomic research and learning tasks for each student by all group members.

Case 4: VWs in HCI design studio

- Case 4 – course activities



Case 4: VWs in HCI design studio

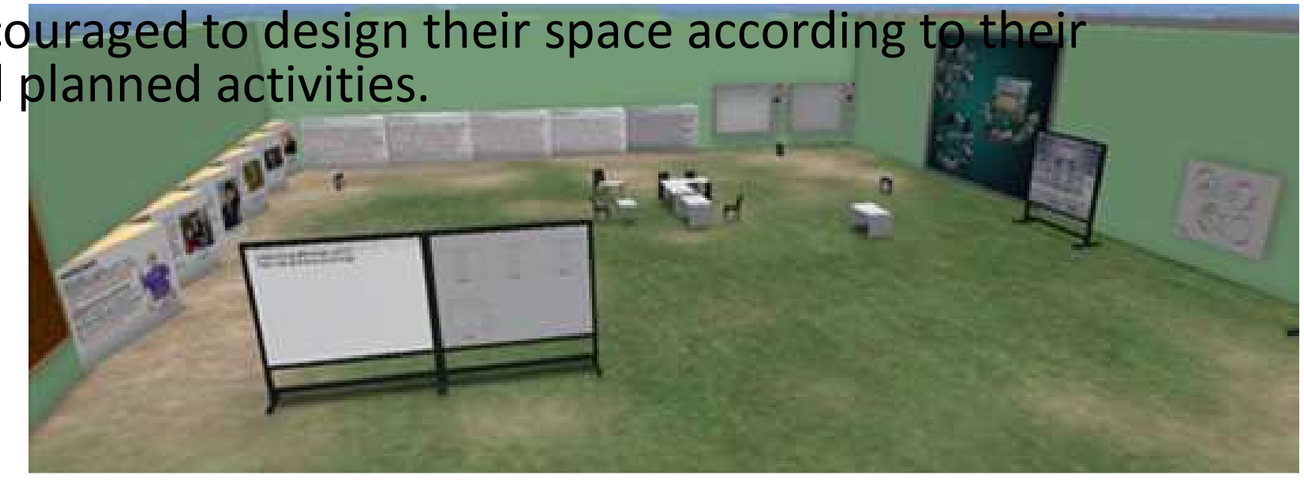
- Case 4 – The Virtual HCI Design Studio
  - VW environment:
    - Open Simulator server, isolated island (we didn't want to interact with outsiders)
    - Free switch voice server
    - Hippo OpenSim Viewer
    - A single room for each student group to work in.
  - (same as previous Cases)

Case 4: VWs in HCI design studio

- Case 4 – The Virtual HCI Design Studio
- We constructed a number of places to be used for student activities:
  - **Classroom**.
    - One single classroom for class activities,
    - Designed as a meeting space with a display screen on one wall and a large table with chairs,
    - In the entrance there is a space for tutors' announcements about the course and the projects.
    - Any notes created by the tutors during class presentations and any drawings on the physical whiteboard of the labs are added as digital content in the classroom space
  - **Private rooms**. Each student
    - Has exclusive control of the entrance
    - Can bring their own resources and freely develop their own ideas and concepts before presenting them to the rest of the group.

Case 4: VWs in HCI design studio

- Case 4 – The Virtual HCI Design Studio
  - **Group collaboration rooms**.
    - One room for each of the groups to be used for collaborative design and learning activities.
      - To support group meetings,
      - To be used as places to collaboratively construct and present sketches and models,
      - To store resources (web pages, papers, etc),
      - To place comments and notes on the project's progress, etc.
- Initially, equipped only with appropriate interactive tools and sample furniture objects (tables, chairs, etc.),
- Groups are encouraged to design their space according to their own needs and planned activities.



Case 4: VWs in HCI design studio

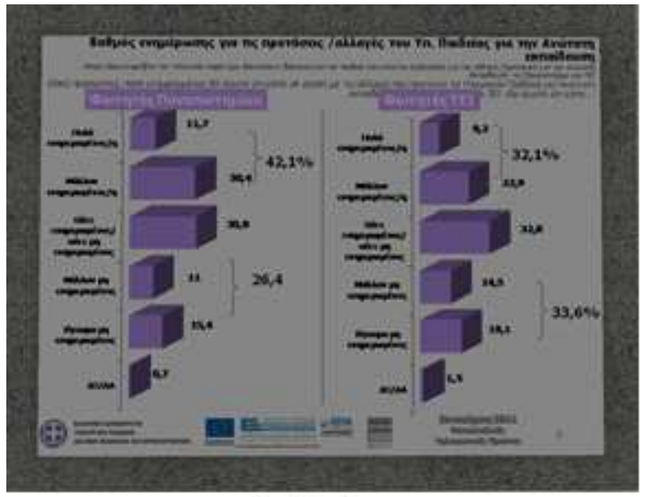
- Case 4 – The Virtual HCI Design Studio
  - **Prototyping rooms**.
    - One room for each of group,
    - The room is initially empty and students are asked, using the appropriate tools, to construct a functional prototype of their designed concept and to place it in a realistic context.
    - This prototype is then evaluated by other users that interact with it as avatars.

Case 4: VWs in HCI design studio

- Case 4 – The Virtual HCI Design Studio – Tools
  - 1. The **Projector** and the **Projector Controller** were used to prepare and show presentations in the VW.
  - 2, The **Annotation** stores notes or comments in the 3D environment and others can click on it to open the note.
  - 3. For simpler one or two-line notes the **Short Annotation** object could also be used, which displays the message floating.
  - 4. The **Message Board** is a collaborative text-only whiteboard, and it could be used for storing ideas, facts or simply group meeting notes.
  - 5. The **Sketch Board** allowed free form sketching (with the mouse) on a white surface and allowed students to quickly present concepts to each other.
  - 6. If more sophisticated and accurate drawings were required, students could use the **Drawing Board** that displays Google Docs drawings in the VW (they had to edit them outside the VW).

Case 4: VWs in HCI design studio

- Case 4 – The Virtual HCI Design Studio – Tools
  - 7. The **Post-it Board** was used to add new text messages.
  - 8. The **Chat Recorder** allowed students to record chat sessions, play them back, or save them as annotations.
  - 9. The **Resource** allowed students to store a short description of a Web document including a hyperlink in a new browser window when clicked.
  - 10. The **Interface Element** tool was designed to be used as a building block and simulation object for the implementation of a functional user interface prototype.
    - Using multiple copies of this object, students can progressively construct windows containing elements such as buttons and images and define their behavior using simple commands.
    - Thus, the Interface Element could be designed by students
      - (a) as a button (which can send events to other elements (or to itself) when clicked),
      - (b) as a Window, which can contain other elements, and be visible or hidden and (
      - c) as an Image Container.

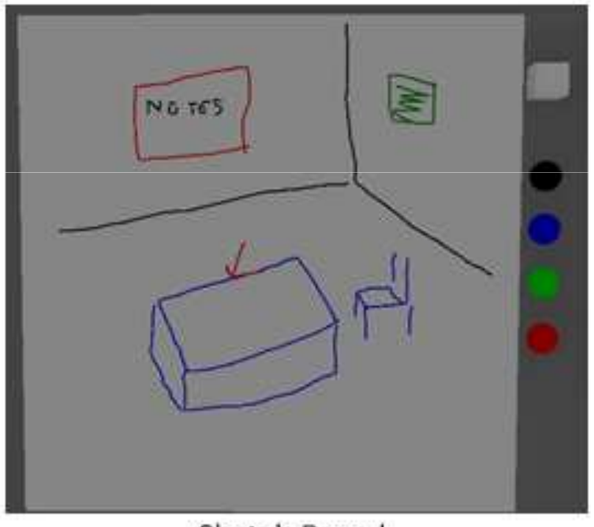


Projector

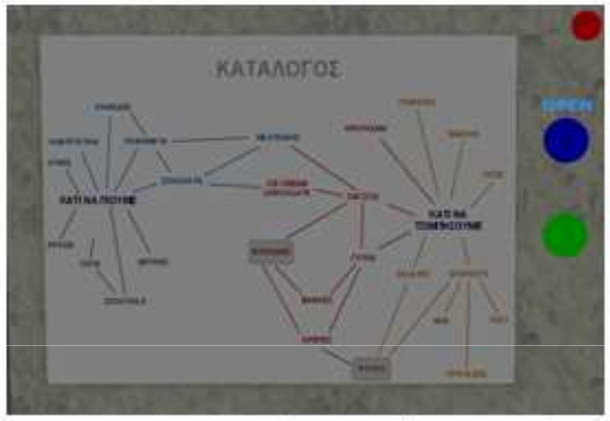
Projector Controller

Resource

Interface Element



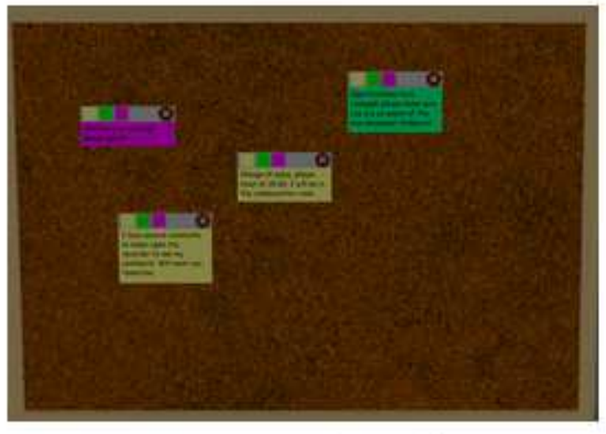
Sketch Board



Drawing Board

Message Board

Annotation



Post-it Board

Chat Recorder

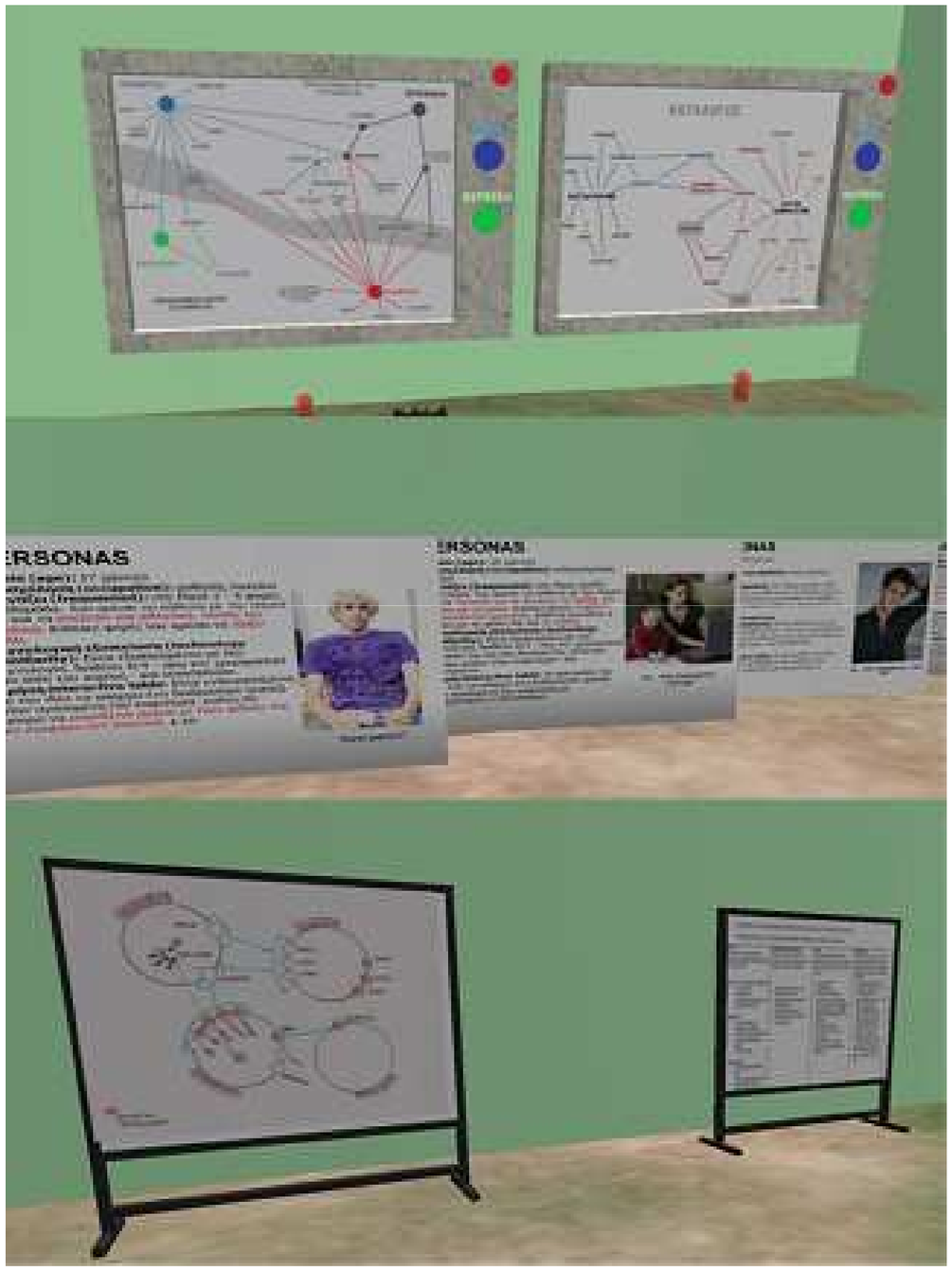
Short Annotation

Case 4: VWs in HCI design studio

Activities	Actions	Tools	Places
Research	Collect and organize resources	Resource	Private Room
	Share resources	Resource	Group Collaboration Room
	Discuss about findings	Chat Recorder	Group Collaboration Room
Design	Communicate ideas	Sketch Board, Message Board, Post-it Board	Group Collaboration Room
	Create and refine concepts	Drawing Board, upload images	Group Collaboration Room
	Present solution	Projector, Projector Controller	Group Collaboration Room
	Explain proposed solutions	Annotation, Short Annotation	Group Collaboration Room, Prototyping Room
	Construct prototype	Interface Element, 3D object building	Prototyping Room
	Discuss/comment on (aspects of) proposed solution	Annotation, Short Annotation, Chat Recorder	Group Collaboration Room, Prototyping Room
Presentation	Present solution	Projector, Projector Controller	Classroom
Critique	Comments on presentation	Annotation, Message Board, upload images	Classroom
	Comments on concepts/solution	Annotation, Short Annotation	Group Collaboration Room
	Critique of prototype	Annotation, Chat Recorder	Prototyping Room
Reflection	Discuss about critique	Chat Recorder	Group Collaboration Room
	Fill PBL whiteboard	Message board, upload images	Group Collaboration Room

Case 4: VWs in HCI design studio

- Case 4 – Evaluation of the PBL Activity
  - **Formative evaluation** occurred periodically in every lecture by both teachers and students,
    - The aim was to facilitate the PBL process mainly in terms of asking questions about students' progress and providing resources.
  - Overall, students were very pleased with the process followed:
    - The PBL approach enabled students to take responsibility for their own study and follow different routes to their learning and project development.
    - These routes allowed students and groups to contribute with different methods to the course content corpus.
    - There were some complaints at the first sessions about the 'lack of guidance' and 'lack of corrections' on their work;
      - however they got used to the approach especially after they saw their team mates to cope well.


ΕΡΣΟΝΑΣ
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ΘΕΑΤΡΟΝ ΑΠΟΛΛΩΝ

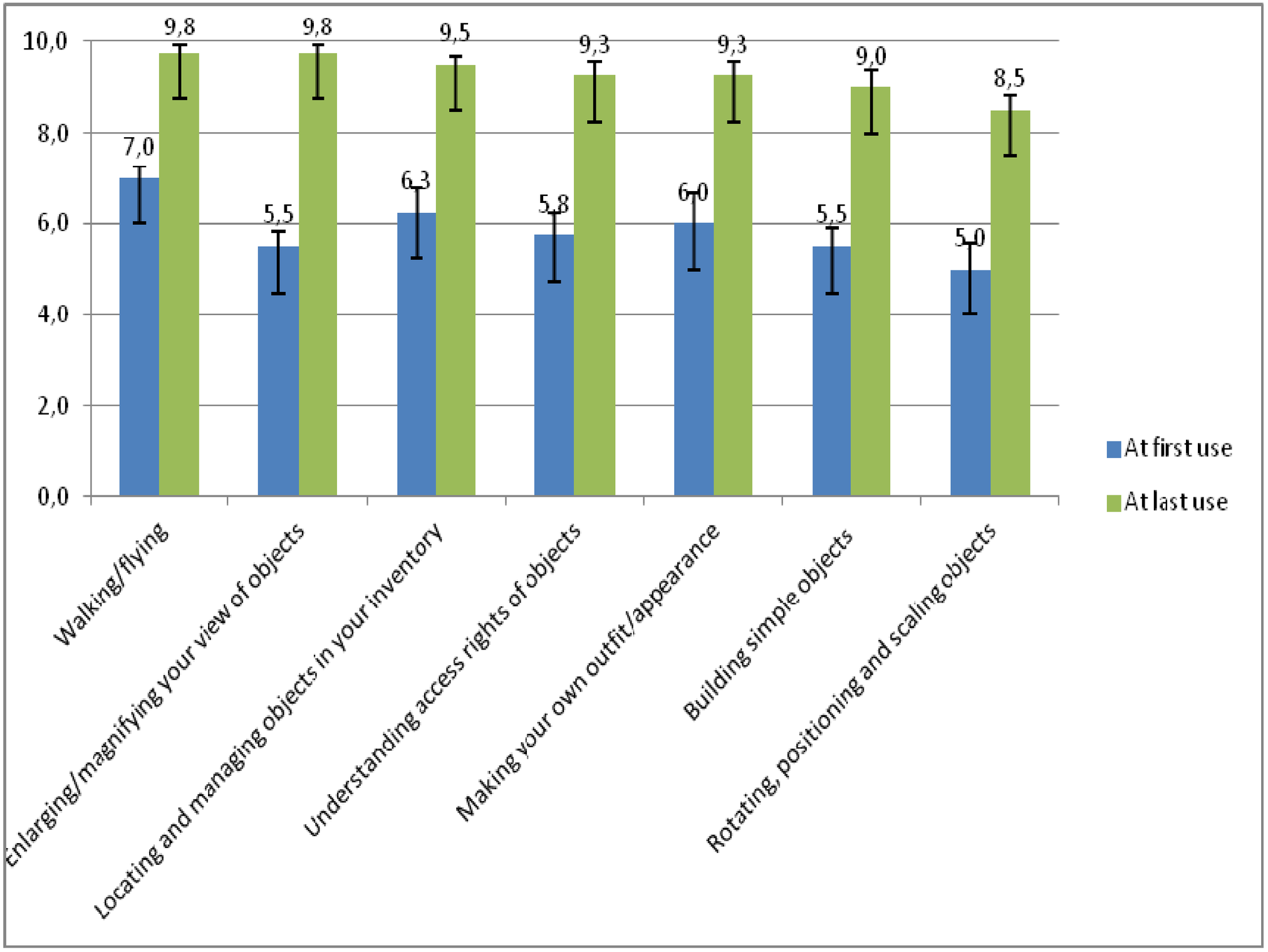

ΘΕΑΤΡΟΝ ΑΠΟΛΛΩΝ
1 Επιλογές Παράστασης
Owner of group?
Zoi Koutkalaki

Case 4: VWs in HCI design studio

- Case 4 – Evaluation of the PBL Activity
  - **Summative evaluation** of the PBL course at the end of the course
  - Project assessment (60%)
    - Provided by the tutors
    - On the the basis of a weighted set of criteria reflecting the whole process, method use and outcome with qualitative explanations.
    - Students receive a final written review of their work on the basis of these criteria from each tutor.
  - Assessment of individual student skills and attitudes
    - Provided partly by the teachers (10%) and largely (30%) by the students themselves (peer assessment)
    - Assessment of high-level skills cultivated by PBL
      - critical thinking, self-directed learning and group work.
      - Students and teachers filled in a PBL rubric of qualitative criteria adapted from (Yip & Ghafarian, 2000).
      - Only the summary assessment was provided to students, not the detailed responses of peers.

Case 4: VWs in HCI design studio

- Case 4 – Evaluation of the VW Environment: Perceived Usability of VW Tools and Affordances
  - Formative evaluation throughout the lifetime of the course
    - Answering students' questions, observation, providing technical support, etc.
  - Questionnaires about perceived usability at the end of the course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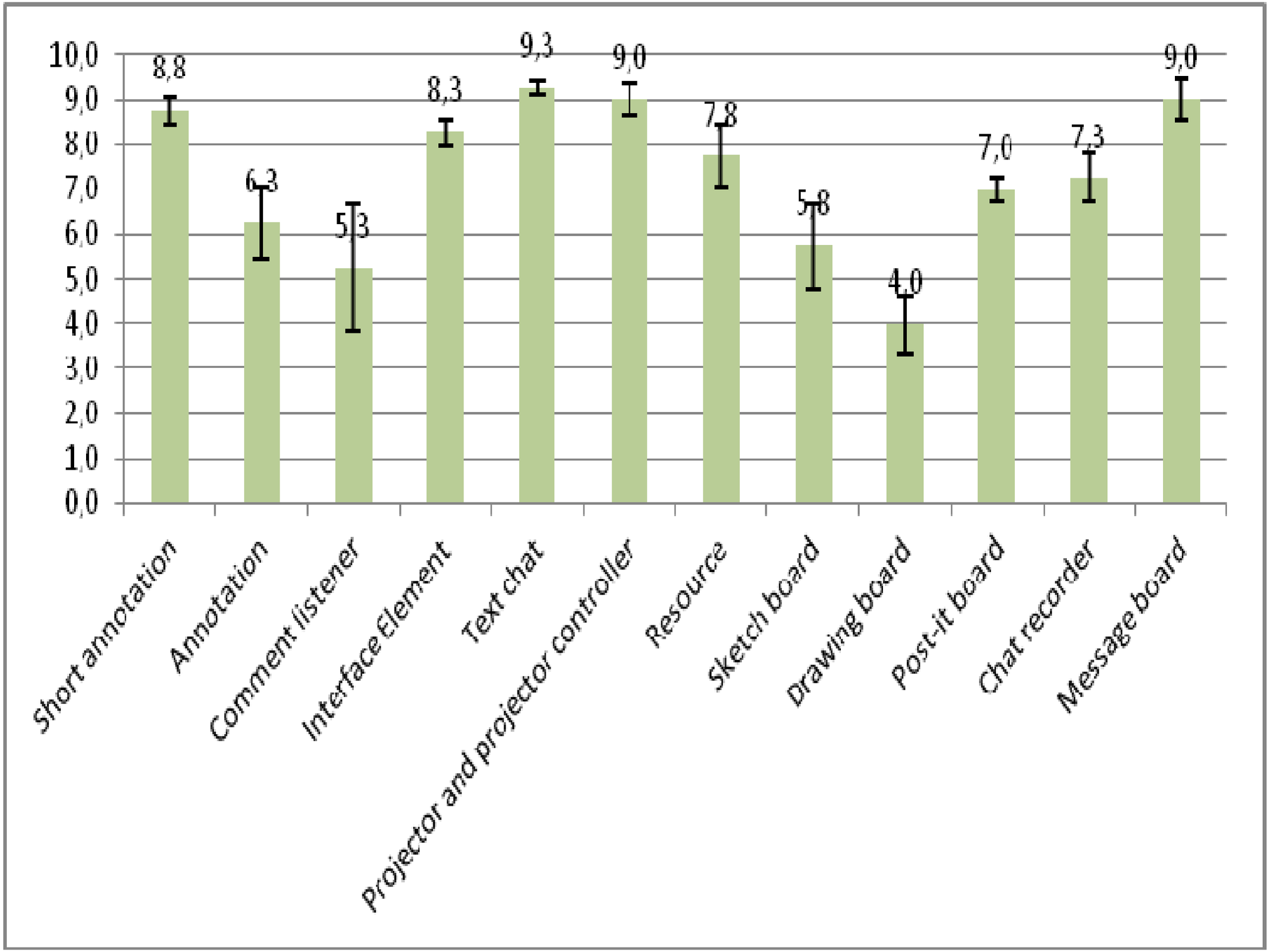
At first use
At last use
Walking/flying
Enlarging/magnifying your view of objects
Locating and managing objects in your inventory
Understanding access rights of objects
Making your own outfit/appearance
Building simple objects
Rotating, positioning and scaling objects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Short annotation
Annotation
Comment listener
Interface Element
Text chat
Projector and projector controller
Resource
Sketch board
Drawing board
Post-it board
Chat recorder
Message board

Case 4: VWs in HCI design studio

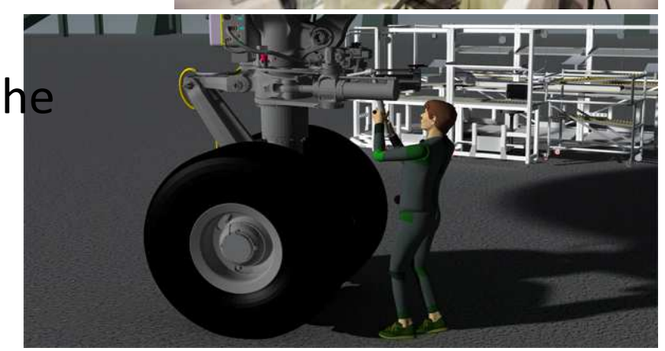
- Case 4 – Discussion and experiences
- Course results
  - The PBL approach enabled students to take responsibility for their own study
  - Different routes to research, study, and development emerged in-groups and between-groups
  - Contribution with different methods and projects to the course content corpus
- Administrative issues
  - Tight coordination is required (session timing, effective process with outcomes)
  - Some additional sessions in the VW we inevitable.
  - Significant resources are required to develop and maintain the VW
    - The staff of current computer labs does not typically have the knowledge to provide related support.

Case 4: VWs in HCI design studio

- Case 4 – Discussion and experiences
- Use of the VW:
  - As a prototyping tool
  - As a collaboration environment.
  - Integrated environment:
    - high awareness of others' progress, the groups can decide about the tools to use
- Usability issues:
  - The 3D modeling capabilities of the environment were not as sophisticated as in commercial applications, and the rendering quality was significantly lower, as expected.
    - This difference caused some frustration to the more experienced students with a background in the arts or architecture.
  - Some students felt that it was an extra burden to convert and upload to the VW the documents that they created using familiar applications, such as Powerpoint and Photoshop
  - They would like to have a less complicated interface between the VW and external applications.
  - Finally, some users found the Interface Element object quite difficult and time-demanding to use

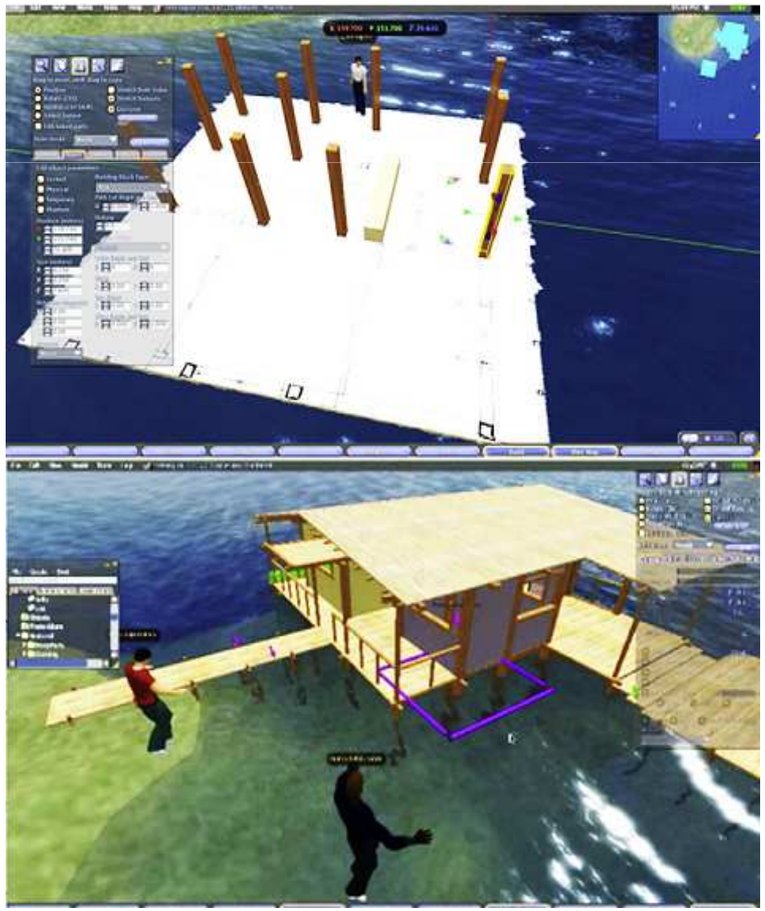
An approach of employing PBL in Design & Engineering Education

- Much of what is taught in D&E disciplines is related to examples from professional practice presented by their teachers
  - in the classroom and
  - to problem-solving in the form of exercises in the lab.
- *"Learning to solve classroom problems does not necessarily prepare engineering students to solve workplace problems"*
- If we place design engineering students into an authentic problem situation,
  - they immediately encounter complex decisions
    - about (among others) form, function, materials, mechanics, software, ergonomics, and usability, etc.
  - They are immersed in unique conditions
    - related to the particular knowledge and skills of the design team, client requirements, user group characteristics, time constraints, and costs.

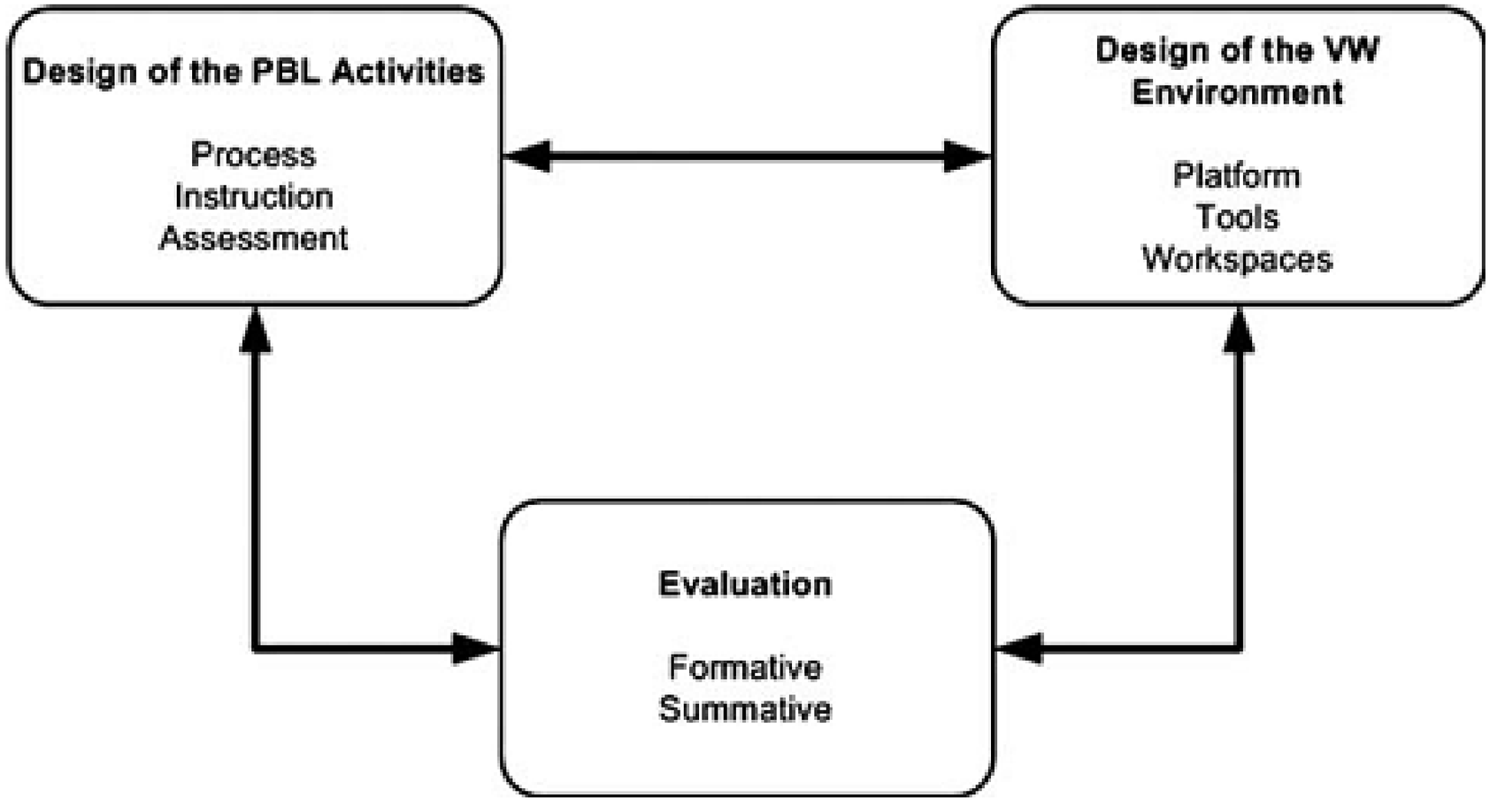


An approach of employing PBL in Design & Engineering Education

- Students are expected to apply their theoretical knowledge in problems that they will encounter in their professional life.
- Students should be capable of developing tangible (digital) artifacts (prototypes) that reflect their decisions and skills
  - These artifacts are subject to multiple evaluations and experimentation with objective and subjective criteria
  - This requirement is unique with respect to other practice-based disciplines (e.g., medicine and law)
    - in which rational decision making is more important,
    - there is limited, if any, room for construction and experimentation of solutions or prototypes.

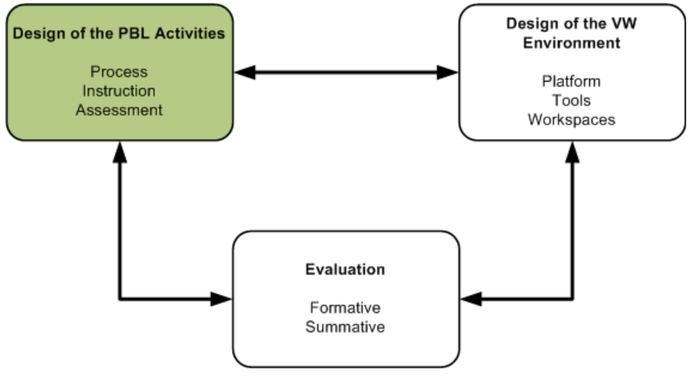


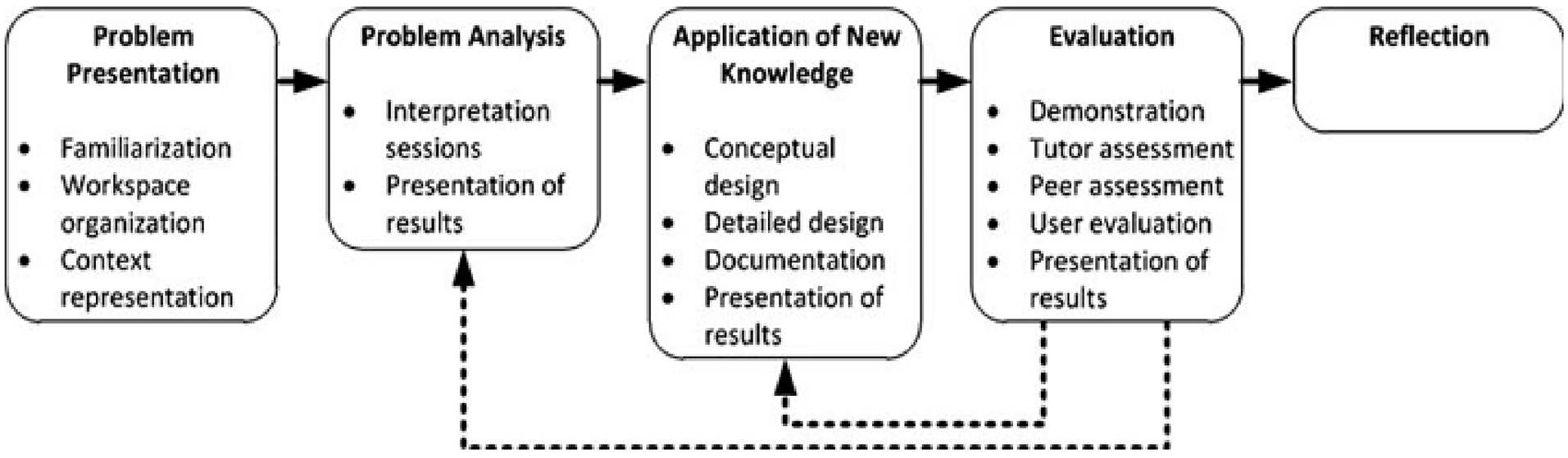
An approach of employing PBL in Design & Engineering Education



An approach of employing PBL in Design & Engineering Education

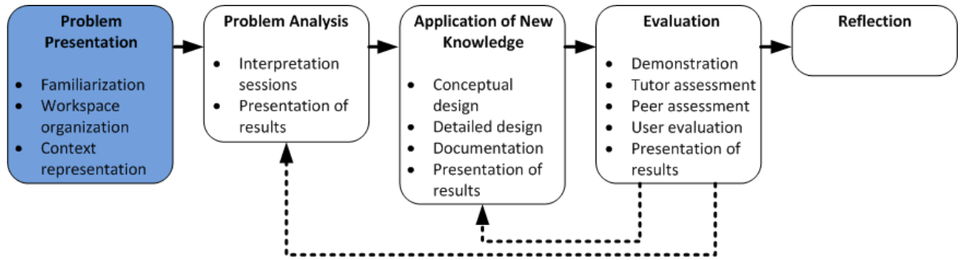
- 1. Design of the PBL Activities.
- 1.1. The Process





An approach of employing PBL in Design & Engineering Education

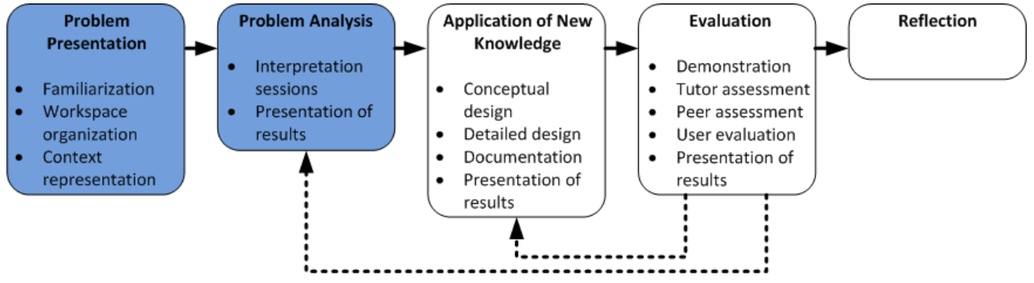
- 1. Design of the PBL Activities
- 1.1. The Process
- 1.1.1. Problem Presentation
- **Familiarization**
  - The VW platform is introduced to the students and they familiarize themselves with the provided tools and places.



- **Workspace Organization**
  - Students organize their personal and group workspaces by
    - adding the appropriate collaboration tools
    - arranging the places to host group meetings and to publish the deliverables.
- **Representation of Problem Context**
  - The physical (3D) and abstract space (e.g., specifications) describing the problem context is further constructed and specialized based on students' understanding of the problem brief.

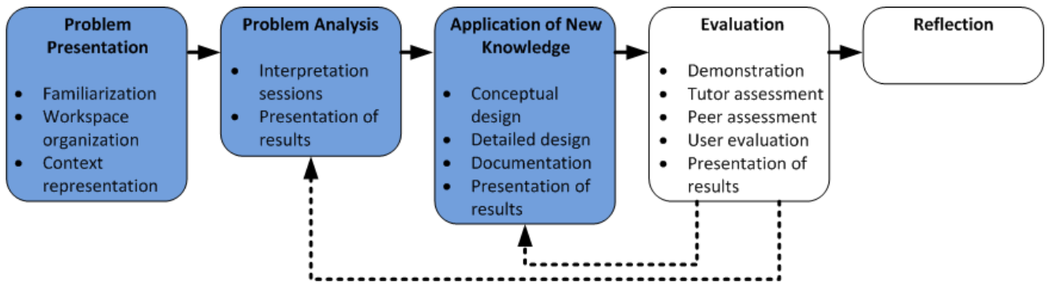
An approach of employing PBL in Design & Engineering Education

- 1. Design of the PBL Activities
- 1.1. The Process
- 1.1.2. Problem Analysis
- **Interpretation Sessions**



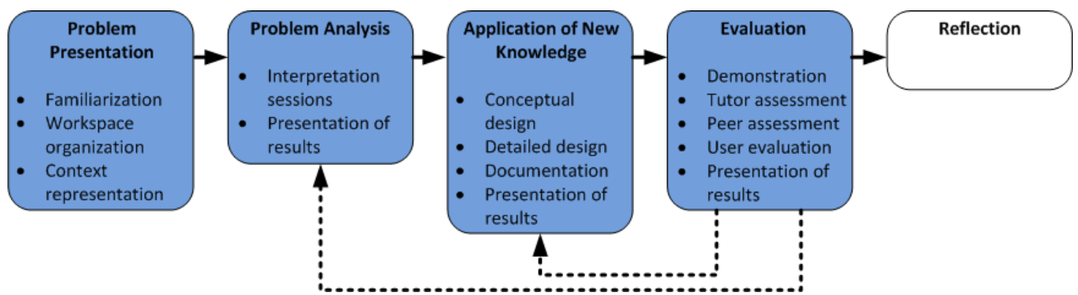
  - Group meeting for problem analysis, in which students
    - Interpret and analyze the problem,
    - Identify issues that need to be further explored and researched
    - Plan future actions including self-directed learning assignments.
- **Presentation of Results**
  - Deliverables and resources in the VW
  - Action planning

An approach of employing PBL in Design & Engineering Education



- 1. Design of the PBL Activities
- 1.1. The Process
- 1.1.3. Application of new knowledge (in both self-directed learning and group work)
- **Conceptual Design**
  - Collaborative creation of concepts (sketches, drawings, scenarios, etc.);
  - machinima may be also used for scenario-based design.
- **Detailed Design**
  - Collaborative construction or assembly of candidate solution using the tools provided.
- **Documentation of the Design Rationale**.
  - Publishing of design choices and methods used for respective parts of the solution.
- **Presentation of Results**.
  - Grouping and organization of deliverables in the workspace.

An approach of employing PBL in Design & Engineering Education



- 1. Design of the PBL Activities
- 1.1. The Process
- 1.1.4. Evaluation
- **Demonstration of Solution**
  - The proposed solution with its rationale and the intermediate design stages are publicly presented.
- **Tutor Assessment**
  - Tutors go through proposed solutions and provide questions and comments to facilitate deep student learning.
- **Peer Assessment**
  - Students inspect fellow groups' solutions and post comments and questions.
- **User Evaluation**
  - Users interact with the designed system or artifact to evaluate its usability.
- **Presentation of Results**
  - Students publish evaluation results and plans for further actions, if required.

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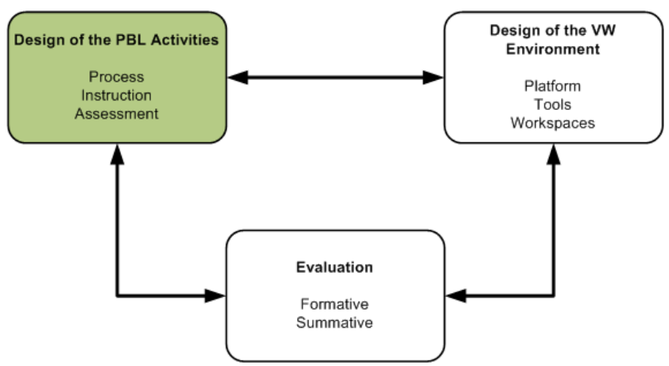

- 1. Design of the PBL Activities
- 1.2. Instruction
- **Whole-Class Meetings**
  - Regular meetings in the VW, where instructors or groups make presentations and discussions
- **Building Resource Lists and Showing Examples of Problems and Solutions**
  - Instructors may direct students toward specific resources or collections and by presenting examples.
- **Group Meetings of Students with Instructors**
  - To be informed about role assignments and planned actions
  - To make sure that the groups are collaborating without problems
- **Asynchronous Reviews of Student Work**
  - By inspecting messages, drawings, and solutions and attaching annotations.
- **Technical Assistance**
  - For all activities, it is important to schedule specific hours on a regular basis for technical assistance.

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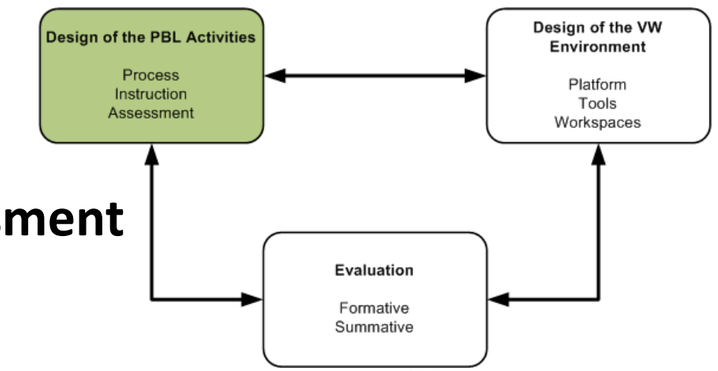

- 1. Design of the PBL Activities
- 1.3. Assessment
- **Review of Problem Solution and Quality Assessment**
  - By the instructor, empirically, with the use of synchronous and asynchronous tools.
  - By peers according to a particular method, for example, remote usability testing.
- **Action/Work Planning**
  - To keep track of work progress and milestone achievement.
- **Collection and Processing of Comments, Annotations and Presentation Logs about Individual and Group Effort During the PBL Process**
  - It is important for instructors to inspect the quality of these data in order to provide assessments about students/groups.
- **Traditional Assessment Methods**.
  - Oral and written examinations can also be set up and conducted in the VW.

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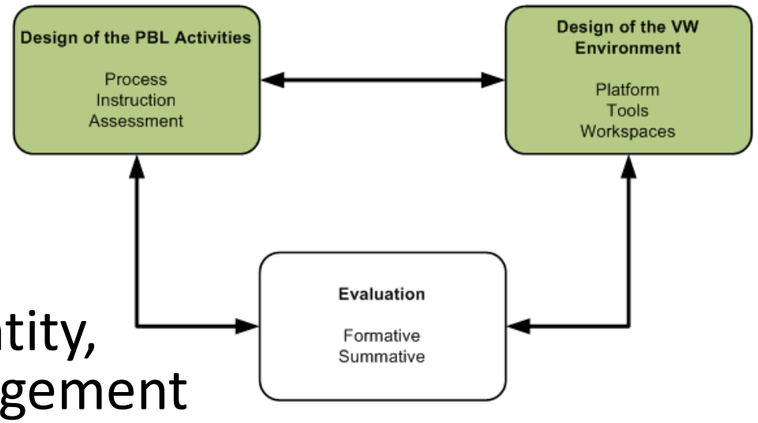

- 2. Design of the VW Environment
- 2.1. Selection of VW Platform
- **Avatar Customization**
  - To let students develop a sense of identity, which can enhance presence and engagement (Junglas et al., 2007).
- **Verbal and Nonverbal Forms of Communication**
  - Features such as text and voice chat, pointing and performing gestures, are essential for supporting distant real-time communication between learners (Davis, et. al. 2009).
- **User-Generated Content**
  - This will help students restructure their space, explore creative ways to present and communicate knowledge, and to collaboratively construct problem solutions.

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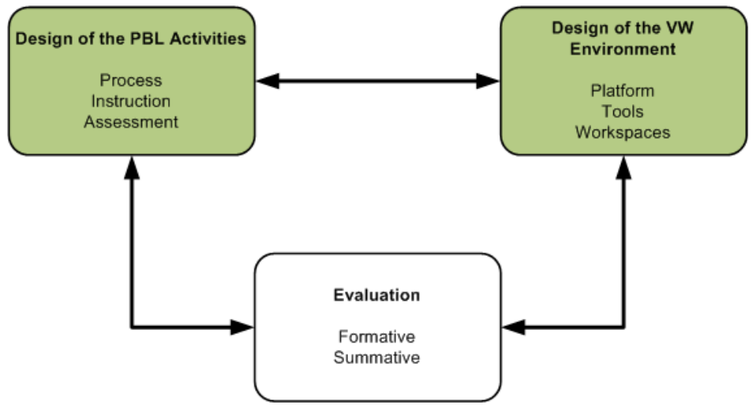

- 2. Design of the VW Environment
- 2.1. Selection of VW Platform
- **Public and Private Spaces**
  - The existence of private (restricted access) spaces will allow individuals to organize their own resources and test and develop their own ideas before presenting to the community.
- **Programming/Scripting Language**
  - The ability to program the real-time behavior of the world's objects is essential for implementing simulation environments and interactive tools that will be used during the problem-solving processes.

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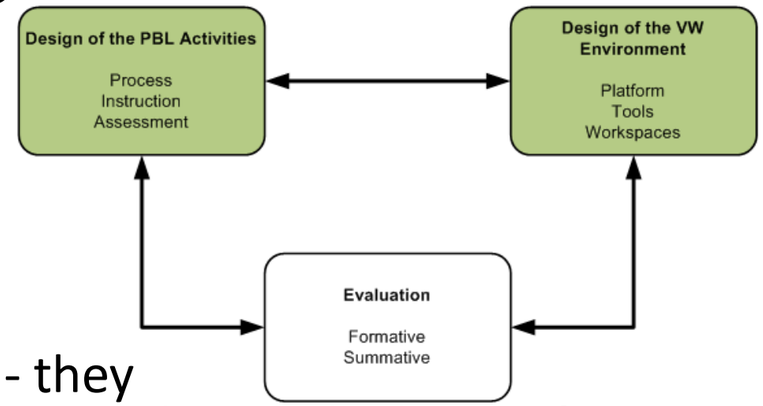

- 2. Design of the VW Environment
- 2.2. Design of the VW Tools (suggested tools:)
- **Resources**
  - Objects that point to or contain resources - they might provide links to external URLs or allow reading and editing of documents in the VW.
- **Message Boards and Drawing Boards**
  - Tools to collaboratively post and edit messages and create sketches and diagrams.
- **Building Blocks**
  - Primitive objects related to the problem domain (e.g., mechanical parts in an engineering problem), which learners manipulate to construct new concepts, artifacts, or systems.
- **Simulation Objects**
  - Objects with scripted behavior that can be used to simulate the functionality of a system

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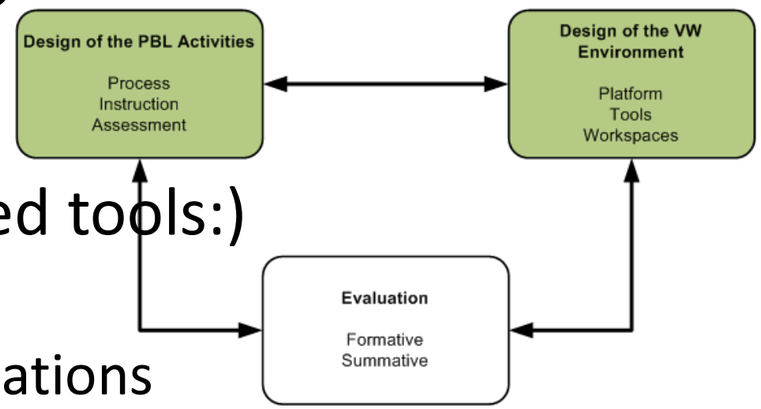

- 2. Design of the VW Environment
- 2.2. Design of the VW Tools (suggested tools:)
- **Annotations**
  - Tools for adding comments and explanations on constructed objects or parts of the environment.
- **Discussion Logs**
  - Tools for storing and reproducing discussions.
- **Interactive Presentation Boards**
  - Tools for presenting in-world during remote meetings.
- **PBL Whiteboard**
  - An object presenting the facts, ideas, learning issues, and action plan of the problem-solving process

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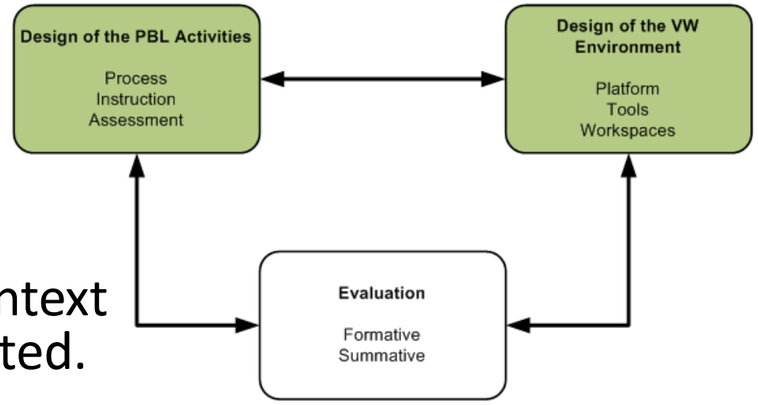

- 2. Design of the Environment
- 2.3. Design of the VW Workspaces
- **Simulation Place**
  - The environment in which the problem context and the candidate solutions will be presented.
- **Group Collaboration Place**
  - The workplace for each student group that will be used for resource sharing, group discussions, collaborative design of the solution and posting of intermediate deliverables.
- **Class Meeting Place**
  - A formal place for class presentations, discussions with the instructors, common resource sharing and announcements.
- **Personal Place**
  - A personal workspace for each student to collect and organize resources and to try alternative solutions.

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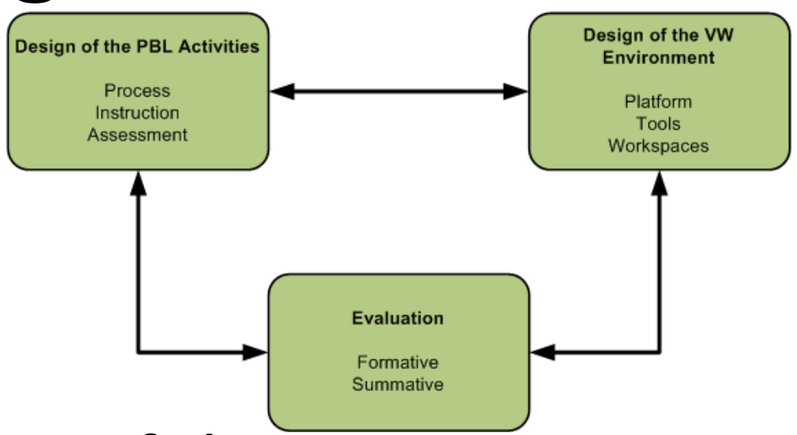

- 3. Evaluation
- 3.1. Formative Evaluation
  - Occurs throughout the lifetime of the course.
  - The focus is on the PBL process as facilitated by the VW:
    - Do tutors challenge student thinking?
    - Do students exhibit high-level skills (critical thinking, active learning, group work).
    - Do VW tools empower tutors and students

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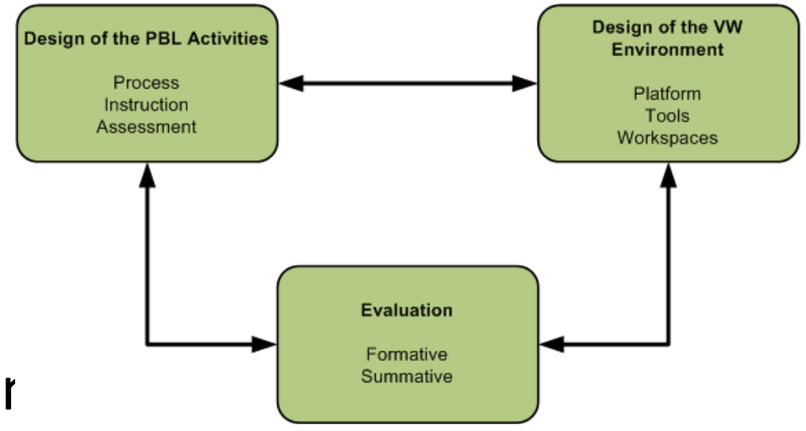

- 3. Evaluation
- 3.1. Summative Evaluation
  - Occurs at the end of the course.
  - The focus is to reach to conclusion effectiveness of the learning process and the quality of the final outcome :
    - Previous assessments can be aggregated in this type of evaluation, which concerns both groups and individual students.
    - Tutors' assessment is usually based on a set of criteria for quality, and an assessment report is produced for students.
    - Often peer assessment occurs based on assessment rubrics.
    - Summative evaluation also examines the use of VW tools for mediating PBL activities.
      - In this case, usability is the primary focus of the evaluation that can take place with user testing methods.

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- Discussion
  - VW are open-ended, networked digital spaces,
    - something like the Web in 3D
  - VWs are not learning environments per se! They need to be designed as such!
  - The proposed approach aims to provide a reference framework or methodology for:
    - Instructional designers, who are interested to incorporate a constructionist, PBL approach into learning in VWs
    - Educators, who want to make use and exploit VWs as constructivist interactive learning environments
    - VW/VR researchers and designers, who want to prepare the VW learning environment and provide appropriate supporting tools
  - The approach is inevitably influenced by our own experiences in design & engineering problems and courses

Reading material

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