Informatics in Education, 2002, Vol. 1, 61–72



# Kids' Club as an ICT-Based Learning Laboratory

Pasi J. ERONEN, Erkki SUTINEN, Mikko VESISENAHO,
Marjo VIRNES
*Department of Computer Science, University of Joensuu*
*P.O. Box 111, FIN-80101 JOENSUU, Finland*
*e-mail: {peronen, sutinen, mvaho, mvirnes}@cs.joensuu.fi*

Received: June 2002

**Abstract.** Kids' Club is a research laboratory where school children of age 10 to 14, in collaboration with university students and researchers, apply and create novel information and communication technologies (ICT) for learning. The technical environment includes visualization and concretization tools, such as a visual programming environment, control technologies, and programmable bricks. As of pedagogical models, the laboratory makes use of problem-based learning (PBL), creative problem solving, and group processes. Preliminary results show that the environment provides a promising platform for developing educational technologies by getting immediate and constructive feedback from potential users. In addition, visual and particularly concretizing tools offer an attractive learning environment for learning abstract skills, like programming.

**Key words:** ICT in education, problem-based learning, constructionism, concretizing tools, Kids' Club, technology education.

## 1. Overview of Kids' Club

Kids' Club is a technically oriented club for school children between 10 and 14 years, held twice a month at university. The reason for launching the Kids' Club project at the Department of Computer Science (CS), University of Joensuu, was to arouse young pupils' interest in information and communication technology (ICT), especially from the research and development point of view. It was also recognized that the regular schooling system lacks time, teaching and technological resources to give such specialized teaching.

The Kids' Club project began at the Department of CS in fall 2001. The main idea of the Kids' Club project is related to technology education and K-12 programs (K-12, 2002) run in the United States, where children interested in academically flavored topics are encouraged to join clubs run on university campuses. In those clubs children have an opportunity to study skills of their interests in a playful, non-school like environment, where there is room for innovative ideation and alternative approaches. Thus, the concept of Kids' Club belongs in the wider picture to the field of educational technology, which provides the technological means to overcome various barriers for learning (Eronen *et al.*, 2002).

In Kids' Club there are three types of participants: children, tutors and tutor-researchers. The *children* have a dual role, they receive education in ICT and personal development, but they are also contributing to the research done with them. The *tutors* are mainly undergraduate students, who voluntarily take part in club activities helping the children with their tasks. The *tutor-researchers* work as instructors. In addition, they carry out their research tasks, related to educational technology, with the children.

From the *children's point of view* Kids' Club is a club, where they learn new technical skills, that is using computers, programming them, browsing the Internet and creating activating gadgets, like interactive Java animations. They also get acquainted with basic robotics by building and programming LEGO Mindstorms (LEGO, 2002) sets. Robots serve as concretizing tools with which the children are able to reflect their progress as the robot – invented and constructed by the children – gets its shape and behavior. In addition to the skills mentioned above, they learn how to handle modern digital media equipment by taking photographs and storing their activities with video cameras. All these skills combined together create the basis with which the children can participate actively in the modern information society. But it is noteworthy that not only the way things are done is important, but how they should be done might be even more essential. Gaining comprehension about ethical issues surrounding the usage of technology is one of the key elements in Kids' Club's participant's development process.

The children are encouraged to express their ideas and opinions openly during club sessions. During club activities, for example using programming interfaces or being taught how to program with Java, the children develop and possess ideas and viewpoints of their own. Those children's notions serve adults by widening their way of thinking and refreshing their comprehension over the issue at hand. Some of those views presented by children may have earlier been overlooked or not foreseen by adult experts, who designed the systems or planned teaching. One example of such a novel approach was the comments that the designers of Instructive Portable Programming Environment (IPPE) received from the children, which helped the designers to improve their design (Jormanainen *et al.*, 2002).

The key elements that the club participants learn include collaborative work, self-guidance and problem-based tasks. Collaboration takes place in pairs or in small groups. While working collaboratively the children learn to recognize their own strengths and their partners' strengths and to combine their efforts and skills in order to achieve the goal set beforehand. To achieve the goal, the children have to solve the problem set for them. This is done in a self-guided manner, learning while doing and being helped by hints and tips from the tutors. While the children develop their skills, the similar development is happening among the tutors, who reflect their own actions in the club as tutor and as researcher, leading to development in their areas of expertise.

Contrary to most K-12 programs, Kids' Club is an *open, living laboratory*, where research results can be tested or, more interestingly, novel innovation can be found. While being tutors for the children, the researchers also pay attention to the response generated by the children. The children are not considered to be merely stimulus-reaction contributors; on the contrary, research is considered to be done *with* them. Children and their contributions – comments, opinions and ideas – are taken seriously. This close co-operation between researchers and club participants is probably the most important and notable



difference between regular K-12 programs and the Kids' Club project at our department. Kids' Club is also considered to play an important role in the research field of educational technology. The idea is that the Kids' Club project forms a *piazza*, a sort of market square for research and communication, for researchers, where they can meet, test their ideas, collaborate and communicate with colleagues in the same research field or even from industry.

The research methodology we have applied in Kids' Club is based on the ideas of action research. We carry out our research in a highly turbulent environment, which is in constant change. Temporary results can be described as "snap-shots" of a certain phase in that environment. Achieved results form the basis for the next iteration, which is anticipated to be an improvement in comparison to the earlier one. It is also important to realize the fact that research in the area of ICT has two dimensions: the research concerning the pedagogics and the research concerning the technical aspects. As of pedagogics, research methods we have applied include observation, video recording, interviews, reflection, and note taking. As of technical research, we emphasize tool design and implementation, for example programming environments, like IPPE.

The research questions of the Kids' Club project are tri-dimensional, related to the children, tutor-researchers and technical innovations in the field of educational technology. We have further included four categories of objectives into each dimension to clarify the span of the results we aim at (Table 1). Those categories are: skills, attitudes, values and cognition. Results that belong to the skill category are concrete and shown in one's actions, for example improvement in the children's ways of using ICT. Attitudinal changes are manifested in one's inner motivation for acting, for example, a researcher may find herself more open-minded towards new ideas. Values create the basis for all the actions that one does, therefore results in this category affect also all the other categories.

Table 1

The goals for the Kids' Club project

| | Children | Researchers | Technical Innovations |
|---|---|---|---|
| **Skill** | Programming, robot construction, and computer usage skills | Instructional development, development in methodological skills | Know-how to build such technical innovations |
| **Attitudinal** | Engagement to information and communication technology | Openness towards new research aspects, respect for the children as collaborators in research | Open minded new approach with attractive creation and design process |
| **Value** | Ethics, collaboration | Tolerance and meeting with specialized group of learners | Ethically sound technology |
| **Cognitive** | Comprehension over the principles of ICT | Knowledge over efficient usage of educational technology, increase in domain knowledge | Understanding over the technical aspects, insight in criteria needed for building gadgets for educational technology |

A good example of this kind of category is creating an ethically sound technical tool; this belongs to technological innovation dimension. Results in the cognition category changes the way of thinking, as an example a researcher may find meta-knowledge over her work, which helps her to restructure it.

## 2. Learning: Theories and Concepts

### 2.1. *Learning Theories*

When dealing with the basics of learning and teaching, we should start from the line behaviorism – cognitivism. The first of these concepts refers roughly to learning by repeating and the second one learning by thinking. Constructivism is a learning theory mostly based on the ideas by Jean Piaget. In constructivism learning is process, in which people actively construct their knowledge from their experiences in the world (Resnick, 1996). We often speak about constructivist-cognitivistic learning. *Constructionism* (Papert, 1993) enhances the idea: constructing knowledge is particularly effective when learners are engaged in actively constructing meaningful products. This means constructing something concrete while learning. Constructionism is at the same time a theory of learning and a strategy of education. The theory of constructionism is essential when we speak about technology and learning, that is ICT in education.

We have conceptualized teaching and learning in an instructional setting as (Table 2):

Table 2
Learning in three different settings

| | Traditional learning | Learning in a virtual environment | Using robotics and concretizing tools in learning |
|---|---|---|---|
| **Didactic approach** | Theory | Diverse | Cognitive conflict and joyful learning |
| **Learning strategies** | From detailed to general information | Learner specific | From general to detailed information |
| **Goals of learning (knowledge, skills, opinions, values, motivation)** | Learning goals are usually certain knowledge or skills. | Learning goals are usually certain knowledge or skills. | Influencing one's opinions and motivation, deeper adoption and understanding of knowledge or skill |
| **Instruction** | Teacher-controlled learning | Self-directed learning | Self-directing learning, Collaborative learning, Problem-Based learning |
| **Role of ICT in education** | Topic-specific tolls and materials supporting a given curriculum | Virtual learning material, self-assessment | Concretizing, cognitive tools for hands-on exploration and experimentation |



- traditional learning,
- learning in virtual learning environments and
- robotics and concretizing tools in learning.

This categorization makes sense when investigating learning and technology.

Most organized *teaching* is quite *traditional*. It is very theoretical and abstract. Information is shared in small pieces, which are rarely related to each other. The teacher's control is essential and the learning outcomes are assessed in tests. Teaching takes place in a concrete place at a certain time (Bennet, 1976).

In *virtual learning environments* the classroom for learning is much more extensive and far from concrete. Learning is not bound to place or time, which gives new possibilities as well as requirements. There are many chances for misunderstanding, the learner has to be relatively self-directed and the communication has to work well (Looms, 1993).

Technology facilities learning with *robotics and concretizing tools*. Novel challenging ways to learn include self-directed learning, collaborative learning and problem-based learning (Koschmann, 1996). Learning could be innovative and concrete and needs cognitive strive. Technology offers versatile ways to construct deeper knowledge (Järvelä, 1996).

### 2.2. *Concepts*

*Self-directed learning* has been defined in terms of learning process or a state (Brockett &Hiemstra, 1991). Knowles (1984) argues that everyone is at least partly self-directed when taking care of his own life. A person has a background, orientation and reason to study as well as a certain state of motivation. And of course he is aware of his own learning needs and has a goal. Mezirow (1985) proposes that self-directed learning is like going in a new direction; getting away from traditional ways to do things. It is like critical reflection, which leads to new learning.

In problem-based learning and collaborative learning there are many possibilities for self-directed learning. Self-direction gives possibilities for "good" learning, but it raises big needs for the educational system (Vesisenaho, 1998). According to Fischer and Scharff (1998), the educational system should be user directed and supportive, open-ended and complex, offer possibilities for users, support a range of expertise and promote collaboration.

When using computers in a *collaborative learning* setting we often speak about computer-supported collaborative learning (CSCL). Basically, we deal with collaborative learning supported by technology. We could ask how we can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distribution of knowledge and expertise within the learning community. The importance is in cooperation as a part of learning. Thereby, collaboration is a process of participating in knowledge communities. The goals are shared in a situation where no one knows everything. Therefore, to construct meaningful knowledge, a true contribution from each and every member of the group is needed (Lipponen, 2002).

We can no longer speak about teachers and learners as separate groups. Even teachers become investigators and learners to understand how to use technology to learn effectively. Teachers even participate in the collaborative learning process (Fischer&Scharff, 1998).

*Problem-based learning* (PBL) can be considered as a collaborative, case-centered and learner-directed method of teaching or actually instruction. At first, it was an educational method designed to health sciences, but now it is widely used in various fields of science and even at schools in secondary and elementary levels. Problem-based learning is a way to a high quality learning process (Koschmann *et al.*, 1996).

According to Koschmann, there are five components in a PBL-model: problem formulation, self-directed learning, reflection, abstraction and application of knowledge (Fig. 1). In the beginning there is a problem to solve, possibly some background data and a hypothesis. In self-directed learning, the group collects more information and examines the problem. The group applies knowledge even in the starting part of the learning process or later. In appropriate case the group will abstract and reflect. Abstracting is articulation of the knowledge they have achieved. It is like re-examination and applying to different cases. Reflection means that the group evaluates its own works for future improvement. All the components are in constant interaction and may be used at any time. The PBL-model has a shape of a learning circle.

The role of the teachers, who work like tutors, is to facilitate the learning process. The tutor monitors the group process and guides it by questioning and encouraging the development of metacognitive skills. The last one especially leads to students' own reasoning and understanding.

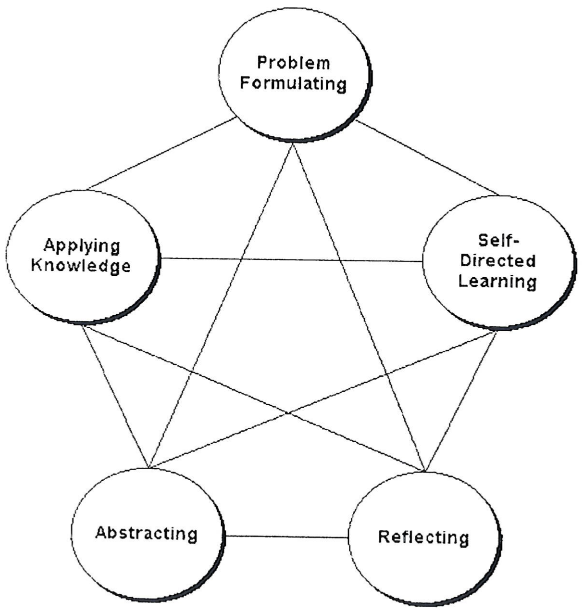


Fig. 1. Components of problem-based learning (Koschmann *et al.*, 1996).



## 3. Activities in Kids' Club

The Kid's Club began in October 2001 with a group of five children and a new group of ten children started up in February 2002. Tutors who are undergraduate and graduate students in CS and education act in co-operation with children in Kids' Club. Kids' Club is held every other week with a total number of 15 children participating in the activities. All the children are volunteers, who applied to participate in the club. The ages of the children are between 10 and 14 years.

Children work in pairs that they have formed themselves. For each meeting the tutors have set certain targets or tasks that children realize at their own pace: one pair might be testing their program on the robot, whereas another group has just got their robot constructed. Children set the goal for the project in the beginning and approach it by building and testing the robot, planning the future of the project and presenting outputs of the project on the group's web page. In the reflection each child needs to think individually about how she succeeded in the task and how she would like to develop the robot. This helps children to plan their activities in programming and building but also to evaluate their own skills.

Tutors do not mainly teach, apart from using the IPPE-environment and some general topics in programming, for example basic control structures, but they support and guide children in problem situations and do their own research. The IPPE programming environment is a tool for learning the basics of programming visually with LEGO robots (Jormanainen *et al.*, 2002).

In this kind of environment, the technical equipment offers tools all the way from working out preliminary ideas up to presenting final products. Thus, Kids' Club appears to children as a fun environment where they can build robots, learn to program them, implement the desired tasks and have the robots play with other groups' robots. Children are encouraged to design and create things starting from their own interest and learn in their project at their own speed. Then learning occurs in the most effective way according to what is needed in a certain situation.

The activities of Kids' Club (Fig. 2) consist of building LEGO robots, programming them with IPPE and creating web pages for presenting their projects and sharing experiences and achievements with the rest of the group. Children may also use pictures and video material taken by the tutors or children during activities in reflection and reporting. In addition they use Empirica Control (Lattu *et al.*, 2002) to measure the speed of robots that they built and programmed with light gates. In fact, skills in programming are needed also in Empirica Control when implementing an algorithm for measuring the speed.

The use of different tools, like LEGO Mindstroms and Empirica Control together, gives the children a challenge to choose an appropriate tool for a given task. Diversity in the use of different tools in different situations makes children self-guided active *doers* with equipment and software; this is a highly needed skill in the information society. The opportunity to choose the right tool makes children critical. For example, at certain stage some learners started to consider the IPPE environment too restrictive. As a result they continued programming with Java and made some small Java animations.

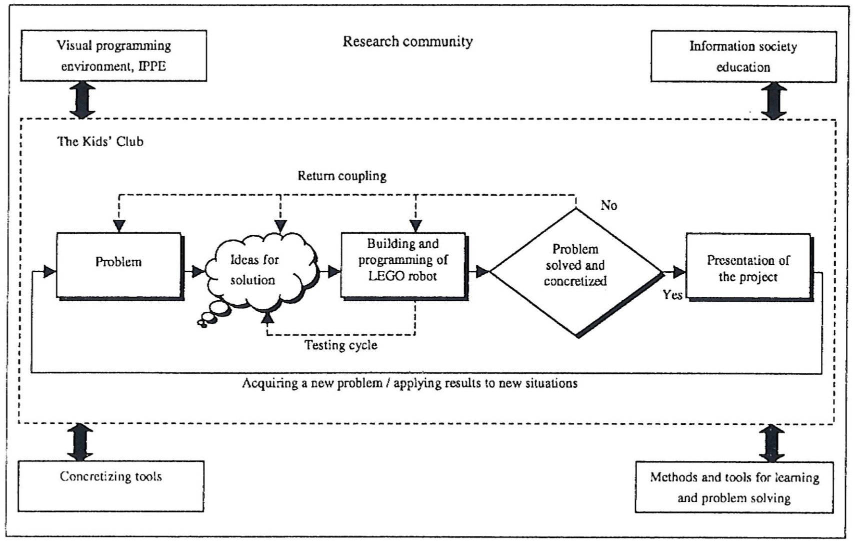


Fig. 2. Research topics of the surrounding academic community are elaborated in Kids' Club.

One indication about the quality of learning outcomes in Kids' Club is the win in the RoboCup Junior one-to-one Soccer Competition in Japan in June 2002 that is an international research and education initiative. Its goal is to foster artificial intelligence and robotics research by providing a standard problem where a wide range of technologies can be examined and integrated. This is for example soccer playing robots that children have built and programmed themselves (Robocup, 2002).

In April 2002, the children got a problem to solve for the last three Kids' Club meetings. One task of Kids' Club was to build and program a LEGO robot that can go through a certain winding route on a floor. Children worked in pairs and used LEGOs and the IPPE programming environment (Fig. 3). This case describes a typical Kids' Club meeting. At the end of each meeting children reflect their learning and actions by filling out a web form. Information obtained from these answers is used in this case description. The reflection stage is important not only for children but also for the tutors for developing the Kids' Club.

The theme of the meeting was to build and program robots according to a given task. Each group continued working at their own pace and got instruction from tutors when needed. There were ten children and three tutors in this Kids' Club. The majority of groups were mainly working in the phase of programming but rebuilding was also needed especially in problem situations.

When using LEGOs for learning to program, the relevance of the concrete dimension can be easily seen. When children have built their robot, created the first program and transferred it to the robot, they enter in an iterative process (Fig. 2). The function of the robot becomes real as the children engineered their robot and programmed its behavior.



Fig. 3. The children in the middle of a problem solving process.

In this meeting turning the robot to a certain course was the most difficult part to many pairs. When the robot did not move according to the wanted course, one of the pairs identified problems in the bumper. Thus, they returned to the building phase and created a new bumper. However, there were usually more problems in programming in comparison to problems in the design of the robot. The use of LEGO robots helped children to understand and locate mistakes in the code. They were able to concretely see the mistake, which created a kind of "force to learn" and hunger to solve the problem.

## 4. SWOT Analysis of Kids' Club

After the first year, each of the tutors evaluated Kids' Club action using the SWOT analysis and wrote down their thoughts about the strengths, weaknesses, opportunities and threats of Kids' Club.

The recorded opinions mainly discussed the idea of Kids' Club, the role of children and tutors, material resources and the learning process and environment. Both children and tutors showed a real interest to act in Kids' Club. Thus, it is easy to understand the tutors' trust in the idea and wish to work in an innovative environment generating novel approaches education. The tutors also felt that their own group is heterogeneous and their expertise consist of both technical and pedagogical skills. Multidisciplinarity among tutors was considered to be a particularly significant strength. LEGOs helped children to learn programming and also developed their logical thinking and problem solving skills.

Almost all tutors volunteered in Kids' Club; this was experienced as weakness. Sometimes too few tutors appear in Kids' Club meeting; some show lack of motivation after a full working week, even though motivation and enthusiasm was among tutors considered as strength. An ideal situation could be one tutor for each pair so that instruction could be more intensive and available when needed. Also observation of the pair's learning process would be easier and a heterogeneous group of children would get more focused help. It was also noticed that preparations for a Kids' Club meeting needs more time in terms of both arrangements and persistent planning. Some of the tutors felt that they do not have enough skills and knowledge either in education or in technical issues.

According to the SWOT analysis there are a lot of opportunities that can be achieved in Kids' Club. Because of the eagerness of children and tutors, several new ideas could be found and good results achieved in the understanding of learning of information and communication technology. The tutors felt Kids' Club as a unique research environment where they can do their own research and studies. In learning Kids' Club creates interest and new learning situations where children can learn, e.g., to program, skills of co-operative learning and problem-solving skills.

The most notable threat in Kids' Club is a possible lack of tutors in future that can affect additional work to tutors. Also tutors' limits to create new challenges to children and adopt new information themselves were recorded as a threat in the SWOT analysis.

## 5. Conclusions

Already after the first year's experiences, the concept of Kids' Club has shown to be a success. It has gathered both school children and enthusiastic students and researchers to joint activities, lasting over a few weeks' periods. These activities have not been limited by regular restrictions stated by most educational institutions, namely those of time, place, or a given topic.

When analyzing how Kids' Club, in its first form, met the objectives given in the introductory section, one can note the following. All the four categories of learning in the three-dimensional research space have been dealt with, as opposed to most of today's narrow, or too clean, learning environments. It is of particular interest that Kids' Club also offers natural ways to overcome conventional boundaries between attaining cognitive results, skills, attitudes, or values. Members in a group have to pay attention to their partners, and by sharing their views on the knowledge they build related skills as a side-effect.

The future potential of Kids' Club concept is far from limited. First, it serves as an inspiration for developing new tools for learning. This is because technically aware, real users can discuss opportunities with researchers who know how to design these.

Secondly, we have identified several specific learner groups who might benefit extensively from the kind of collaborative activities described above. These include learners with cognitive or social disabilities.

Thirdly, the concept is easy to transfer or contextualize in diverse settings. The basic ingredient is the openness beyond traditional boundaries of a learning process. In a way, we are going back to basics where children could learn straight from and within



their environment. Fortunately, the modern learning environment can be embedded with intelligent plug-ins, which can even be constructed by the learners themselves.

Last but not least, in the era when technology is an increasingly important factor of our global society, there is a constant need to attract new students into the area. However, more and more students seem to choose a non-technical career. Starting from the early days of learning, universities might engage their future students in a phase when they are more open to get excited of technology, but in their own way.

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**P. Eronen** works as a research amanuensis and is a graduate student in the Department of Computer Science in the University of Joensuu. In addition to his studies in computer science he has accomplished minor studies in computer-aided instruction. Since he has been working for the Department of Computer Science in Thinking Tools for the Net project, he has been a co-writer in several publications concerning the field of educational technology. Furthermore, he has been actively participating in the Kids' Club project since the beginning of the project.

**E. Sutinen** is a professor of computer science at the University of Joensuu. After receiving his PhD (Approximate pattern matching with the q-gram family) from the University of Helsinki in 1998, he has been working also at Purdue University, USA, and University of Linkoping, Sweden. Currently, his main research focus is educational technology from the computer science point of view: how to design functional ICT tools to overcome learning barriers in areas like special education, developing countries, diverse cultural contexts, and ICT education. He is a Director for Thinking Tools for the Net Project, funded by the National Technology Agency, Finland. He is also involved in applications such as Jeliot for program visualization, Woven stories to support collaborative learning by writing, and virtual approbatur for teaching university level computer science to high school students over the web.

**M. Vesisenaho**, master of education (thesis 1998, The development of self-direction in distance education), works at the University of Joensuu as a lecturer for University Practice School and Department of Computer Science. Before he has been working as a lecturer and a project coordinator in Research and Development Center for Information Technology in Education at the University of Joensuu Faculty of Education. Research interests are culture contextual IT-education in developing countries, computer supported problem-based learning with children, and teachers' and teacher trainees' skills in computer supported learning.

**M. Virnes** works as research amanuensis in the Kids' Club project at the Department of Computer Science in the University of Joensuu. Her educational background is in educational technology in the field of computer science. She is writing her master's thesis about creative problem solving in programming from the perspective of the Kids' Club.

## Vaikų klubas, kaip laboratorija, kurioje mokomasi remiantis informacinėmis technologijomis

Pasi J. ERONEN, Erkki SUTINEN, Mikko VESISENAHO, Marjo VIRNES

Straipsnyje aptariama vaikų klubo veikla. Vaikų klubas – tai tarytum tyrimų laboratorija, kurioje moksleiviai 10–14 metų drauge su universiteto studentais ir tyrinėtojais, diegia ir kuria naujas informacines technologijas mokymuisi. Naudojamos vizualios ir programavimo priemonės: vizualiosios programavimo aplinkos, valdymo technologijos ir programuojami konstruktoriai. Laboratorija naudoja problematinį mokymą, kūrybišką problemų sprendimą ir grupinius procesus kaip pedagoginius modelius. Mokymosi aplinka teikia perspektyvių galimybių plėtojant mokymo technologijas, gaunama konstruktyvių atsiliepimų iš potencialių vartotojų. Vizualios priemonės siūlo patrauklią aplinką lavinant abstrakčius įgūdžius, kaip, pvz., programavimo.