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AN EXPERIMENT IN ICT MEDIATED GROUP CREATIVITY

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Abstract: This paper describes an experiment aimed to evaluate the influence of the environment in an "iLab" (Innovation Laboratory) on the divergent thinking of a group of students. The philosophy behind the concept of iLab starts from the assumption that the convergent influence of an "extraordinary environment", a special communication application, and appropriate moderation techniques is capable to foster the creativity of the participants, and to enable a certain "collective intelligence". In our experiment, the group of 20 students was assigned the task to find as many new ideas as possible of ICT solutions for improving the quality of life of people with various disabilities. The ideas produced during the session were recorded and analyzed in terms of originality, feasibility, and utility using the FCA (Formal Concept Analysis) methodology. This paper presents the results of the experiment.

Keywords: iLab, group creativity, assistive technology, Formal Concept Analysis.

1. INTRODUCTION. THE CONCEPT OF ILAB

Historically, the concept of Innovation Laboratory-iLab was first introduced by the Royal Mail in 1997, as a method of team-management based on brainstorm and group communication. It was later used with great success for various purposes such as: strategy planning, summer schools, focus groups, staff development, problem solving, etc.

An Innovation Laboratory is an inspirational facility destined to sustain people's creative-thinking skills and their ability to find original solutions in problem-solving situations.

The iLab concept is based on the idea that human creativity could be significantly increased by three interrelated elements: Environment, Technology and Moderation techniques.

The "Environment" is a physical space specially designed to stimulate creative-thinking and incubation – the temporary break from problem-solving situations that can result in insight. The environment's features are meant "to transport" users into an inspirational mental state.

In the iLab approach, "Technology" include multimedia and software tools to facilitate collaborative work. The software for brainstorming, called "VBS", creates a virtual space where users can freely express their ideas and attitudes. VBS is a Web application that works like a social-group supporting instrument, and it provides specific features as: anonymous involvement, fast discussions, voting and reporting functions.

In an Innovation Laboratory, moderation is done by trained experts who facilitate the creativity sessions. Moderators use group-dynamics and other techniques to manage the group-communication processes, so that the participants get out the most of their ideas.

The iLab features are meant to help users to unlock their potential in problem-solving situations. The iLab space is perfect for any team-based work including facilities for strategic planning, conflict management, mind mapping, etc.

The iLab environment can also offer support for various educational activities. The literature on the influence of the learning environment in education (see Davies et al, 2013; Susnea & Tataru, 2014; Cocu et al, 2015; Susnea et al, 2015) found that this factor

could affect students' attainment, as well as the whole pedagogical communication between teachers and students.

In this context, the iLab approach proposes a new solution, emphasizing several important aspects, such as: flexible use of space and time, the availability of appropriate materials, work outside the classroom, peer collaboration, non-prescriptive planning of educational activities. See (Cocu et al, 2015) for further details on the philosophy of iLabs.

In an attempt to investigate these new educational approaches, a team from the Department of Computer and Information Technology of the Faculty of Automatics, Computer Science, Electrical & Electronics Engineering of the University "Dunarea de Jos" of Galati, Romania, conducted an experiment aimed to evaluate the group creativity in the environment of an iLab.

Apart from this introduction, this paper is structured as follows:

- Section 2 presents the context and the objectives of the experiment.
- Section 3 describes the methodological steps of the experiment.
- Section 4 presents the experimental results, and section 5 is reserved for discussion and conclusions.

2. THE CONTEXT AND THE OBJECTIVES OF THE EXPERIMENT

The instructional objectives, expressed in terms of learning content and outcomes, were as follows:

- make students explore the usage of new Information and Communication Technologies (ICTs) in improving access of disabled persons to information, knowledge and social life;
- make students learn new methods and approaches in seeking solutions to complex technical problems;
- develop the students' behavioral skills associated to group-creativity processes.

The experiment's objectives related to the curricular adjustment and improvement should also be mentioned: (a) connect the learning experiences of students to current social issues; (b) make students aware of the specific requirements in building adapted environments and tools for disabled persons; (c) find new feasible ICT solutions to support and extend the accessibility, i.e. the degree to which an ICT product, device, service, or environment is available/accessible to disabled people.

By using the iLab specific methodology, which includes brainstorming, intellectual mobilization and radial development of ideas, the students were acquainted with the open cognitive style, (Kirton, 1994) , based on specific heuristics, divergent thinking, and flexible reasoning (Sadler & Riding, 1999).

By selecting as brainstorming theme the subject of "ICTs for disabled people – tools and services", we aimed to outline a new direction for the practical assignments of the students. And, equally important, we aimed to experiment new pedagogical methods to stimulate the imagination of students.

The collaborative physical and virtual environments of the iLab allow the development of teamwork and social interaction skills of the students, by means of idea exchange, active listening, analysis, and goal oriented argumentation.

3. METHODOLOGICAL STEPS

The iLab group-creativity experiment consisted in three distinct parts (steps): preparation of the creativity session, the actual group-creativity session and the analysis of the results.

The experiment was carried out in the iLab environment, had a four days duration and included as participants:

- 20 students in the 3rd year of study of a Computer Science and Engineering degree, belonging to the same class and having previous experience in cooperative tasks or team work;
- facilitators, i.e. experts who moderated the sessions;
- educators possessing expertise in the field of ICTs – devices/software systems-, for people with disabilities.

All members of the workgroup - students, facilitators, and experts-, had the possibility to exchange ideas by means of the VBS software application.

The preparation of the creativity session consisted in:

- establishing the objectives and the work methodology;
- defining the subject, creation of supporting materials;
- promotion of the experiment among students, through usual communication channels and social networks;

- establishing the actual students' group composition.

The actual group-creativity work session had three phases:

- a workshop, where the students were introduced with the problem context: ICTs for disabled persons;
- the brainstorming session in the iLab environment;
- scoring the ideas by means of an on-line voting system.

The analysis of the creativity session's results consisted in:

- writing reports on session conduct
- generating of graphical synthesis;
- generating of an classification of ideas by participants' vote and on expert's evaluation;
- selecting the most valuable ideas in order to serve as practical assignments in future student projects.

4. EXPERIMENTAL RESULTS

4.1. The Workshop on Assistive ICTs

The actual group-creativity session included a workshop meant to present the context and the objectives of the pedagogical experiment. The workshop was titled: "Assistive Communication and Information Technologies" (see Federici & Scherer, 2012) and consisted in a lecture presented by experts. The methodology of this presentation was based on knowledge visualization, visual metaphors, diagrams, conceptual maps.

The experts' analysis highlighted the ICT devices and services providing accessibility for several types of disabilities: intellectual-learning disabilities, sensory-visual impairments and physical-mobility impairments. The environmental support needed for all categories of disabled persons has been also emphasized during all debates engaged with the students.
The types of disabilities and the specific assistive requirements have been presented through several mind maps (see figure 1).

The main ideas stressed in the dialogue with the students will be presented in the following paragraphs.

Intellectual disabilities are characterized by limitations in cognitive functioning and in adaptive behavior. Learning disabilities are a group of intellectual disorders that have negative impact on learning. All these may affect ones ability to speak, listen, think, read, write, spell or compute.

The ICTs and the cyber world provide a variety of services and techniques for persons with cognitive disabilities and special education needs, as described below:

- knowledge visualization, i.e. computer presentations techniques using visual metaphors, diagrams, cognitive maps, cognitive graphs or mind maps;
- reading tools, i.e. software applications and/or hardware devices for people having difficulties with reading and comprehension of text-based materials;
- digital storytelling, i.e. tools destined to create visual stories, moving images, collages, cartoons or presentations for persons with intellectual disabilities;
- virtual worlds and associated avatars, that are simulated 3D environments that can help persons with behavioral disorders in building social confidence;
- teaching robots, i.e. conversational agents able to act as tutors, teaching aids or classroom playmates;
- social learning spaces, i.e. virtual environments where persons with behavioral disorders can practice basic social interactions, to acquire the skills needed for understanding oneself and others, or to receive behavior regulation guidance;
- educational games, i.e. computer games meant to support social skills training or practice and educational videos destined to make ideas easy to understand.

Visual impairment is a vision loss of a person to such degree, that it cannot be corrected by conventional means (e.g. glasses). ICT provide various solutions consisting in devices and software applications aimed to assist persons with vision impairment. The most popular are the followings:

- Braille input/output devices: Braille keyboards, embossers and refreshable Braille displays;
- voice recognition/control software;
- magnification software, which works like a magnifying glass for the computer screen;
- scanning/screen reading services, permitting translation of a text to an audio sequence (TTS –Text To Speech using speech synthesizers) or a Braille output format;
- haptic interfaces, devices which allow a user to interact with the computer by receiving tactile feedback.

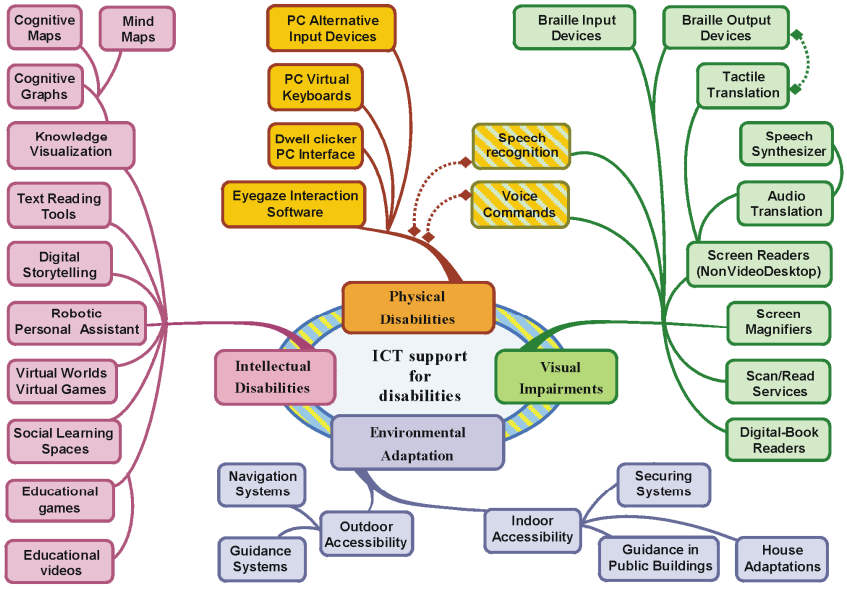

Fig.1. Experts' mind map for assistive ICT devices and software services.

The main categories of ICT devices and software services for persons having physical impairments are as follows:

- alternative input devices: touch screens, joysticks, wands and sticks, sip-and-puff systems (activated by inhaling and exhaling);
- virtual keyboards and "dwell" clicker interfaces, a permitting to move cursor or click mouse buttons;
- speech recognition and voice control software;
- electronic pointing devices, used to control the screen cursor without use of hands (include ultrasound, infrared beams, nerve signals or brain waves);
- eye operated communication and control systems, based upon eye-tracked/gaze controlled hardware/software.

The environmental adaptations are hardware and software products that make the built environment more accessible for disabled persons. The major categories of adaptations based upon ICTs are:

- indoor adaptations: furniture aids, steps/stools securing systems, house automation with voice command;
- outdoor adaptations: surface adaptations, smart walk, accessible signs, navigation and guidance systems;
- vertical accessibility services, guidance in public buildings and places;
- specialties: environmental accessibility plans, safety devices and services.

After the subject presentation and the debates, students were asked to further proceed with an individual study on the state of the art in the field of assistive ICT tools and services.

4.2. The Brainstorming Creativity Session

The actual brainstorming session was carried on over a three days period, when the students had unlimited online access to the VBS software application. The VBS application served as a medium for posting ideas, as a forum for debates on the ideas proposed during the session, and as a voting engine.

A graphic representation (as a "mind map) of the creativity session's results is shown in figure 2. The most voted ideas are highlighted in hatched rectangles. Note the differences between this mind map and the one of the experts: students were mainly interested in solving issues related to the interaction between the disabled and the domestic and social environment.

During the brainstorming session, the students posted 33 ideas of ICT systems for disabled people and formulated 26 comments and additional features to the ideas proposed by their peers. (Table 1).

The ideas' analysis lead to the following general remarks:

- 28% of the total number of ideas generated during the brainstorming session and the most

comments submitted (14 ideas out of 26) were related to ICTs for Environmental Adaptation;

- other categories of ICT solutions proposed addressed the visual and motor disabilities;
- a relative low amount of ideas (6 ideas out of 33) were intended for persons with mental retard, and 4 ideas proposed multifunctional devices for disabled persons.

The conclusions after the collective vote regarding the quality of the proposed ideas were (Table 2).

Table 1 - Statistics of the students' solutions

Type of Disability	Number of ideas	%	Number of comments
Intellectual-Learning Disabilities (**ILD**)	6	17%	5
Sensory-Visual Impairments (**SVI**)	7	21%	3
Physical-Mobility Impairments (**PMI**)	7	21%	2
Disabilities needing Environmental Adaptation (**DEA**)	9	28%	14
Disability - several types (**D**)	4	13%	2
Total	33		26

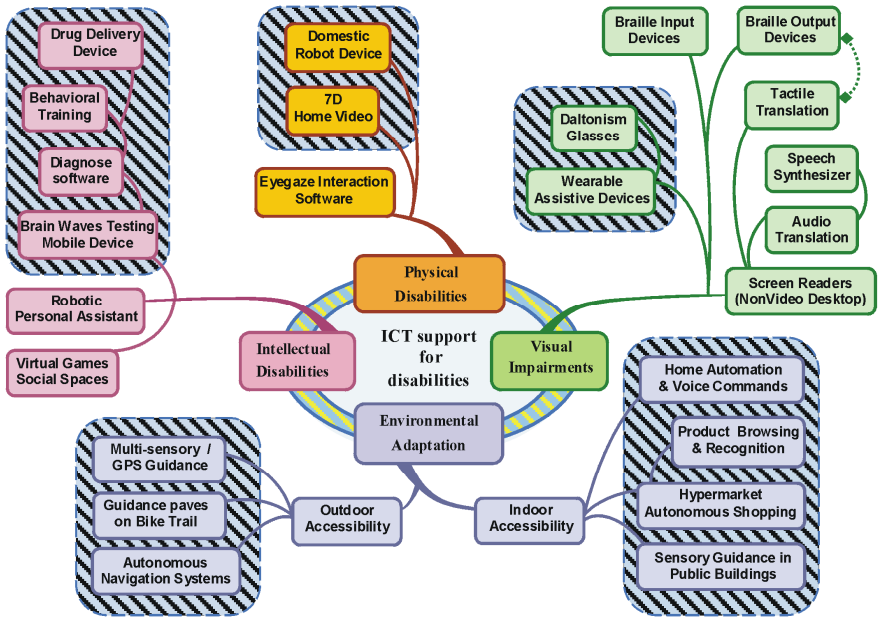

Fig.2. Students' mind map for assistive ICT devices and software services

The attainment of the group of students was later evaluated by the experts with respect to the three criteria: originality feasibility and utility, each having three degrees of comparison:

- for originality - O (original), SO (Somehow Original) and NO (Not Original)
- for feasibility - F (Feasible), PF (Partially Feasible) and NF (Not Feasible – with the Department resources)
- for utility - U (Useful), SU (Somehow Useful) and NU (Not Useful – already realized at large scale)

The results of the expert's evaluation are shown in Table 3.

5. DISCUSSION AND CONCLUSION

In order to obtain a comprehensive classification of students' ideas, we chose a method belonging to the Artificial Intelligence: Formal Concept Analysis – FCA (Ganter & Wille, 2012).

Formal Concept Analysis is a mathematical approach on knowledge representation based on formal contexts and concept lattices, offering a human-centered method to structure and analyze data, and a method to visualize data and its inherent structures, implications and dependencies.

FCA provides a large set of methods, of which a fairly small, but powerful set has so far been implemented in software that is readily available. In our study, we developed a conceptualization in which

the ideas are considered "objects" having certain "attributes". The "attributes" are in this case the ideas scores, originality, feasibility and utility. All these attributes have been scaled in order to be in the same range.

Table 2 - Most popular solutions

Type of Disability	Idea	Votes
Disabilities needing Environmental Adaptation (DEA)	Id14	26
Disabilities needing Environmental Adaptation (DEA)	Id18	11
Disabilities needing Environmental Adaptation (DEA)	Id19	9
Disabilities needing Environmental Adaptation (DEA)	Id22	9
Sensory-Visual Impairments (SVI)	Id9	9
Intellectual-Learning Disabilities (ILD)	Id10	8
Sensory-Visual Impairments (SVI)	Id11	6
Disabilities needing Environmental Adaptation (DEA)	Id5	5
Intellectual-Learning Disabilities (ILD)	Id24	5
Disabilities needing Environmental Adaptation (DEA)	Id16	3
Disabilities needing Environmental Adaptation (DEA)	Id8	2
Disability - several types (D)	Id17	2
Intellectual-Learning Disabilities (ILD)	Id21	2
Sensory-Visual Impairments (SVI)	Id6	2
Physical-Mobility Impairments (PMI)	Id27	2
Intellectual-Learning Disabilities (ILD)	Id29	1
Sensory-Visual Impairments (SVI)	Id3	1
Sensory-Visual Impairments (SVI)	Id13	1
Physical-Mobility Impairments (PMI)	Id32	1

Table 3. Most Voted Ideas and the Experts' Evaluation.

Idea	Votes	O	SO	NO	F	PF	NF	U	SU	NU
Id14	26		x			x		x		
Id18	11		x		x					x
Id19	9	x			x			x		
Id22	9			x	x			x		
Id9	9			x			x		x	
Id10	8	x				x		x		
Id11	6			x		x		x		
Id5	5		x				x	x		
Id24	5			x			x	x		
Id16	3			x			x		x	
Id8	2			x	x					x
Id17	2		x			x				x
Id21	2		x			x		x		
Id6	2			x		x		x		
Id27	2		x			x			x	
Id29	1			x			x		x	
Id3	1		x				x			x
Id13	1		x				x			x
Id32	1			x		x				x

By using the software called "Concept Explorer" - Conexp (https://sourceforge.net/projects/conexp/) based on Formal Concept Analysis (FCA), the results of the experts' classification have been combined with the scores derived from the votes of the students (see figure 3). The best idea found in terms of score, usability, originality and feasibility was the idea Id9: 9 points score, original, feasible and useful.

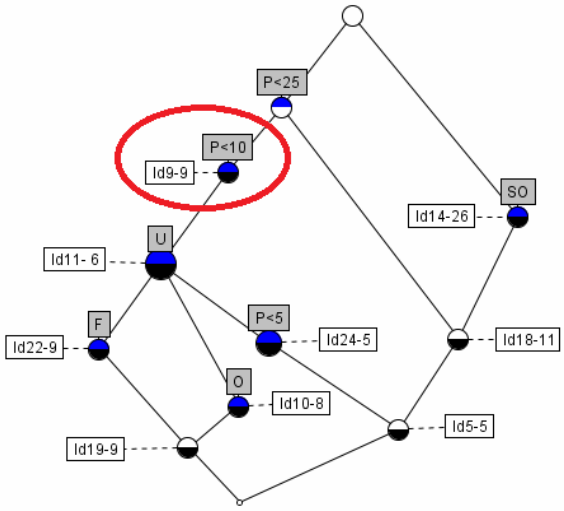

Fig.3. The lattice classification of the students' ideas, after score (P), originality (O), feasibility (F) and utility (U)

The Id9 proposed a mobile device able to read bar-codes of products in a supermarket shelves, i.e. a tool for autonomous shopping for visually or mobility impaired persons, which is a quite new approach in environmental adaptability for disabled persons.

Other well scored idea was Id11: 6 points, and also original, feasible and useful. This idea proposed special glasses able to provide outdoor/indoor guidance for visually impaired people.

By using the iLab specific methodology, which includes brainstorming, intellectual mobilization and radial development of ideas, the students were acquainted with open cognitive style approaches: divergent thinking and flexible reasoning [7].

The collaborative physical and virtual environments of the iLab allow the development of teamwork and social interaction skills of the students, by means of idea exchange, active listening, analysis, and goal oriented argumentation.

By selecting the brainstorming target "ICTs for disabled people – new tools and services", we aimed to outline a new direction for the practical assignments of the students.

The original iLab methodology has been also improved by adding two new steps (phases): context presentation and results analysis through mathematical tools.

Further study and development in this direction are expected, together with new experiments on various subjects, performed by working groups including both students and teachers.

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