SCHOLA LUDUS: New Eyes for Science Beauty

Three e-learning formats based on scientific visualisation and pro-science teaching

Katarina Teplanova[1]
Faculty of Mathematics, Physics and Informatics CU
Bratislava, Slovakia
kteplanova@scholaludus.sk

Marian Zelenak[2]
SCHOLA LUDUS
Bratislava, Slovakia
mzelenak@scholaludus.sk

***Abstract* - There are presented three unique e-learning formats, the BlackBox, the ComplexCase and the e-E-Exhibition designed for SCHOLA LUDUS Virtual Science Centre. A brand new educational approach is assigned for authentic co-constructivist learning. The formats are intended for discoveries of real processes by scientific approaches via scientific visualization, utilization of recent IT and digital display technologies. Examples from educational conceptions of pilot e-learning cases are given. The formats are set for non-formal learning but they can be adopted also for formal education.**

Key words: pro-science e-learning, scientific visualisation, real world experience, e-portfolios, new learning models and applications

1 HOW TO TRANSFER EDUCATION

Mark Prensky [1] is right. Essential for kids is to ´Find information you think is worthwhile anywhere you can. Share it as early and often as possible. Verify it from multiple sources. Use the tools in your pocket. Search for meaning through discussion.´

We agree with the physicist and Nobel prizewinner Carl Wireman that "science must be thought by scientific approach" [2].

And we share fears with Jane McGonigal, the virtual games´ guru, who said: "Gamers are super-empowered hopeful individuals who believe they are individually capable of changing the world. The only problem is, they believe they are capable of changing virtual worlds and not the real world..." [3].

But, can we apply scientific approach in science education and, at the same time, left learning on kids? And, how can we assure that next generation will use virtual games and will be realistic?

Below, we present three of the e-learning formats and e-learning Entities designed for the SCHOLA LUDUS Virtual Science Centre SLVSC [4], considered as our contribution to answer the upper given question.

2 SLVSC E-LEARNING FORMATS AND ENTITIES

The below described BlackBox (BB), ComplexCase (CC) and e-Exhibition (EE) denote special SCHOLA LUDUS formats for e-learning, and also e-learning Entities built up in those formats, and e-tool for development of e-learning Entities at the back-end of the SLVSC [4].

The formats were constructed by tools of SCHOLA LUDUS pro-science learning and teaching assigned for authentic complexity-creative learning and teaching science [5, 6].

The different formats were constructed for different goals:

- At BB to broke users deeper into the particular case.
- At CC to expand the users´ views from complex reality into simplicity and back to reality of higher order complexity.
- At EE to benefit from general scientific concepts and identify conceptual analogies and/or principal differences at parallel cases seeing what was on the first glance unseen.

The different goals are achieved via different learning procedures applying different SCHOLA LUDUS Strategies for Authentic Learning by Playing:

- spontaneous authentic learning by playing,
- guided authentic learning by playing,
- authentic big creation by playing.

The respective e-learning Entities are intended for effective systematic discoveries in sequels.

In any case, the users are expected to recognize and adopt the problem for themselves what is a necessary assumption for authentic learning by playing.

In common, each e-learning entity that is built up in one of the respective formats, starts with pictures and videos of real processes [7] to evoke surprise, fascination, curiosity and, of course, mental conflicts, questions and personal interest to go on deeper in the matter.

The user proceeding in any e-learning Entity is considered as very interactive, should depend significantly on user's ideas and there is broad space for user's activities outside the PC. The users are asked to prepare own real and/or thought experiments related the problem. The experiments are usually simple for preparation but complex for understanding.

However, there is pre-defined direction of user's proceedings by scientific approach supported by scientific

[1] Katarina Teplanova is the author of the SCHOLA LUDUS methodology and educational conceptions

[2] Marian Zelenak is the author of the SCHOLA LUDUS visualization by digital display technologies and responsible also for utilization of recent IT in the frame of the project

978-1-4577-1746-8/11/$26.00 ©2011 IEEE 21–23 September 2011, Piešťany, Slovakia

visualization, utilization of recent IT and digital display technologies.

Users can confront own ideas with pre-defined opinions of others collected during the pilot live and virtual realizations of the respective e-learning Entity case (see [4]), and via Commentaries.

Technically, operations in the frame of each BB, CC and EE are realized via the respective Operational Board with access buttons into the Stages that have been already solved by the user, and into the space for inputs at the current Stage.

3 SLVSC LEARNING ENVIRONMENT

The three e-learning formats - were developed for SLVSC [4] but can be used also independently. However the complex environment of the SLVSC - manifold learning contents and conceptions, applied methods and formats, and mainly the mutual links between the e-learning Entities are considered as very important for users learning, thinking, and working.

3.1 MUTUAL LINKS

There are mutual references between all e-learning Entities referring to the Key Words. The links are dynamic, realized on the front-end of the portal via Lexicon and/or Maps containing both, concepts and picture substitutes of respective BB, CC and/or EE. The Maps are centered round a concept. Pointed out another concept, the map is re-arranged.

By solving the respective e-learning Entity the user's e-learning Portfolio is filled out on the back-end of the portal. The user can open also her/his individual Map, containing only concepts from the e-learning Entities that s/he already solved and/or those e-learning Entities.

3.2 VISUALIZATION OF REAL PROCESSES

Although video allows us to see the whole process, there is only a certain segment of the recorded process visible at the certain point of time. By using the Stack Frame Technique made by the post-processing method a complete view of the process is achieved and the individual parallel processes can be analyzed (Fig. 1).

Figure 1. Example of stack frame technique. Rice grains falling to the plate. 900 stacked frames

The Stack Frame Technique simulates the use of stroboscopic shooting [7], whereby instead of a powerful camera flash or other suitable intermittent light source, camcorder and post-processing software are used.

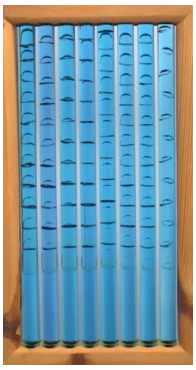


Figure 2. Bubble tubes in parallel

The stack frame technique (similar to the stroboscopic shooting) is also used in the other example (Fig. 2). Images of ´one bubble in one tube´ are joint together at intervals of 0.2 seconds; there are joint 12 images in total. Intervals between frames have been chosen as to make behavior of bubbles obvious in a substantial length of the tube.

Here, not only differently modified bubbles coexist in parallel (different amount of air means different shape of bubbles) but due to the stack frame method elaboration we can observe their exposure effects in motion. The method allow us greatly facilitate understanding of the functioning of a highly dynamic complex system by simple comparison of successive stages of the process development.

4.1 BLACK BOXES FORMAT

The BB format is dedicated for discoveries related the development of one real process. At the BB the user is asked to build up hypotheses regarding the hidden part of the presented process. There are only three possible tasks at BB,

- to deduce the development of the complex system between two shown states
- to deduce the starting phase of the complex system from successive phases of the process
- on the base of the first part of the process to deduce its end,

but there are potentially unlimited number of processes that can be presented as the Key Case of the BB, by use of formed and/or unformed pictures and videos, and at the beginning with a hidden development phase of the process, or with a hidden starting conditions (all or any ´small´ but significant detail), resp. with the hidden end phase.

There are four Stages of the user of the BB. The user of B is always invited, and hinted,

1. to make own hypotheses to the Key Case
2. to compare own hypotheses with hypotheses of others
3. to rethink her/his hypotheses after appearance of new details or circumstances
4. to learn the whole process.

At 1-3. Stages the user can combine and/or order given pictures and videos, realizes choice, exclude improper, focus on a part of the pictures and also add own pictures - photos, drawings, sketches, schemas, graphs etc., and or slow down a part of video.

Only after active passing those Stages, the user can follow records of the whole process and exemplary explanation at the 4th Stage. At disposal are links to other learning cases at the SLVSC relevant to the respective case.

4.2 COMPLEX CASES FORMAT

The CC format is designed for systematic heuristic exploration over the one Key Case and by support of several parallel cases. The adjective heuristic is used as ´heuristic improvement of problem-solving and performance´, ´improving efficiency of problem-solving´ and/or ´heuristic connections´ [8]. I.e. several possibilities are searched at each Stage of the cycle.

Complete proceeding of the CC requires the user to pass 11 Stages of the respective CC. The activities within the Stages are in common aimed as follows:

0. To identify the strangeness of the observed Key Case; make pre-conceptions on the Key Case process.
1. To describe the Key Case in narrative way; to find out and define the Key Problem to be solved.
2. To map the Key Case in order to approach the Key Problem; find out the whole process facts and details, conditions of the unique processes, aspects and attributes related the problem (on the key case and by help of parallel cases, in different environments etc.
3. To create models in order to discover functional relations between observed phenomena and the parameters of the key case at conditions related the problem.
4. To abstract the real condition of the model in order to get principles of the complex system and its dynamics expressed by basic scientific concepts.
5. To embed the results into the Key Case and identify the gained conceptual changes (embedding).
6. To appreciate the gained novelty by design of new solutions.
7. To evaluate the own proceeding at Stages 1-6.
8. To recapitulate the thinking process realized at Stages 1-6.
9. To play with Key Words of the CC.
10. To find out e-learning Entities with cross connections to the just finishing CC.

The Stages 1-6 represent the SCHOLA LUDUS pro-science learning cycle [5, 6]. Inevitable part of their settings and solving are visualization and formulation of questions, views, notes, hypotheses, standpoints, definitions etc. with respect to the Key Case and the Key Problem.

The outputs of Stages 1-6 concern the Focus of the realized proceeding, the leading Concept, the developed Ideas and Values of the proceeding. The outputs enable the user to follow back the way of the learning - thinking - working process.

The Operational Board of CC contains currently only the actual buttons for access

- into the Stages that have been already solved,
- into the ´Outputs Card Repertory´ related to the respective working Phases of the current Stage,
- into the ´Pictures Card Repertory´ given by the case creators and those given by the user,
- into the ´Videos Card Repertory´.

4.3 e-EXHIBITIONS FORMAT

The e-Exhibition is another format of the SLVSC. An e-Exhibition consists of a collection of e-Exhibits. And each e-Exhibit consists of a set of photos and videos of real processes. The sets must enable the users to observe the performance of the whole process from different sides; to observe details of the process; to observe similar processes realized in the same system.

The standard users´ task in the e-Exhibition is to create Sets of e-Exhibits to the defined set of the Key Concepts or vice-versa, to identify a set of Key Concepts related the Set of e-Exhibits. In both cases, the Sets of e-Exhibits can be used also for self-assessments of users and tests of their understanding the science behind the exhibits.

There can appear also other tasks, for example, to draw the course of similar processes.

5 EXAMPLES OF e-LEARNING ENTITIES

The conceptions and content of e-learning Entities differ in the scope, language, demands on users etc. Next are given main ideas for one BB, one CC and one EE, making use of the well-approved SCHOLA LUDUS exhibition SURPRISES IN LIQIUDS. Inter alia the examples show that repeated utilization of the same case (process, demonstration, experiment) in the frame of different formats can touch different levels of cognition and expand understanding of matter.

The scope of the below examples relates fluid dynamics, and can be linked to meteorology, aerodynamics, environmental issues etc.

5.1 AN EXAMPLE OF BLACK-BOX: AN AIR BUBBLE IN THE TUBE WITH WATER

After turning the frame upside-down there starts to go up one bubble in each tube. But the user can not see the whole process. How did the bubble get from down to up? (Figs. 3, 4, 5)

<u>What can be evident from observations</u>: The bottom of each bubble is during the rise unquiet. (while there is formed always the same number of fine rings under the dome of each bubble. The bigger the bubble the more rings and the finer the rings (Fig. 3).

<u>Questions that can arise among others</u>: Is the motion of the bubbles´ bottoms chaotic or regular (Fig. 4)? Are rings a kind of resonance on bubbles? Can we consider motion of bubbles in the same way as we consider solid bodies? Is it right to consider only bubbles? Shouldn't we consider motion of water first, or mutual motion of water with small amount of air (Fig. 5)? And, what is the role of the tube? How are the geometry, the size of the vessel, and the ratio between the amount of fluids and the proportions of the tube important? Etc.

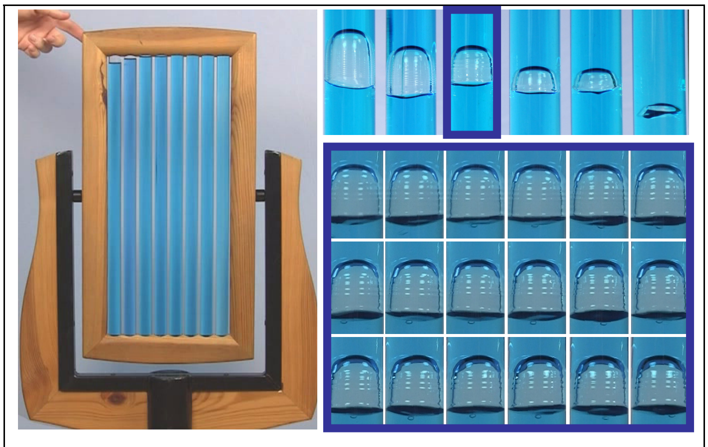


Figure 3. After turn upside-down an air bubble in each tube goes up. Right down: A sequence of successive states: 1/25 sec per frame.

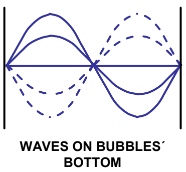


Figure 4. Hypothesis: Waves on bubbles´bottom.

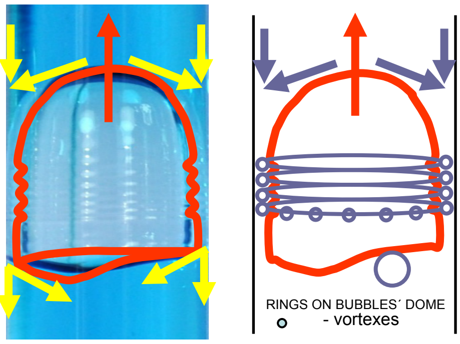


Figure 5. A model to the origin of waves on bubbles, both, fine rings on the bubbles´ dome and on the bottom. (The rounds point out the presence of vortexes.)

5.2 AN EXAMPLE OF COMPLEX-CASE: WAVING

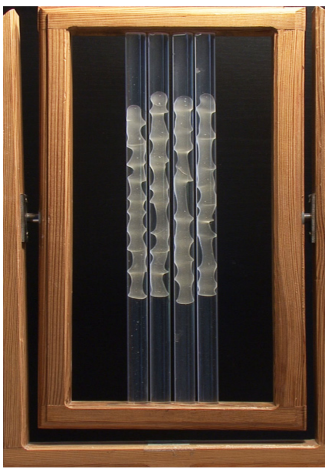


Figure 6. CC Key Case: After turn upside-down the dynamic oil bodies are rising up in each tube with water.

Key Case (0. Stage): After the turn of the frame there start to go up a strange oil body in the tubes with water (Fig. 6). The similar dynamic structures of the neighbours are fascinating. Their heads are round, their rise casually, each with the same speed, and they wave also in similar way. But not in the same wave.

Search of the Key Problem (1. Stage): There is oil body in the tube with water Fig. 6), and there is a bit of air that goes up through water (Fig. 7).

Look, single sections of the caterpillar keep their position until they exists! (Fig. 8)

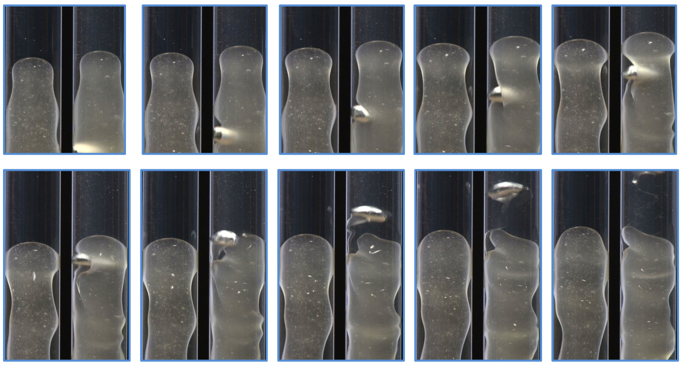


Figure 7. Parallel observation of processes in two tubes: One bubble in each tube passing the oil (also the oil body rises up but slower); 0,08 sec.

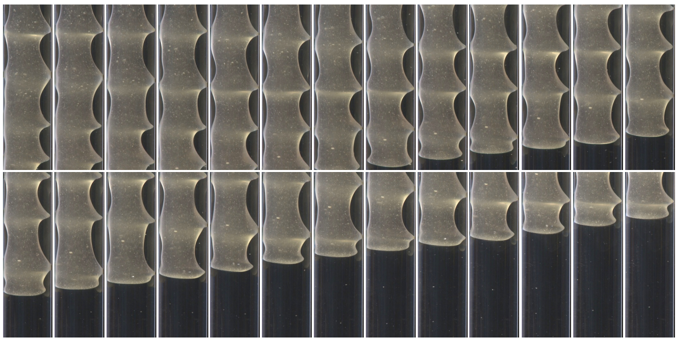


Figure 8. Observation focused to one segment of the tube: While oil flows slowly up, water falls quicly and swirls, producing waves on the boundary. with ´plastic´ oil. – Key Problem!

Hypotheses with respect to the Key Problem (2.Stage): During the oil flowing to the top, it moves from side to side similarly as the swaying bubble hurries to the top. Let’s study the motion of a bubble in the tube.

Model 1 (3. Stage): The track of the continuous motion of a small bubble (Fig. 9) is like a caterpillar (Fig. 10) with denser knees, just as at the oil caterpillar (Figs. 6 and 8)!

Figure 9. Observation of motion of bubbles in tubes with falling sand

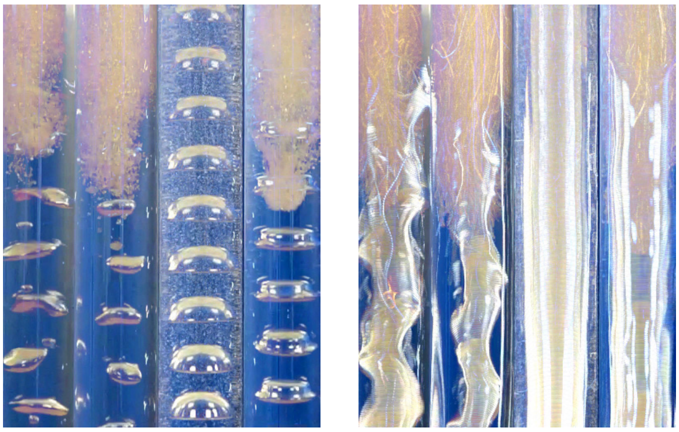
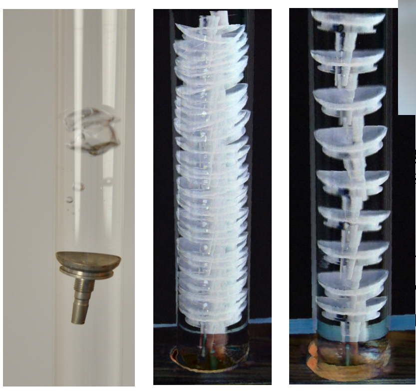


Figure 10. Model 1: Visualisation of bubbles´ tracks. Unique pictures are achieved from the slow motion video (300fps) by use of Stack Frame Techn.

<u>Model 2 (3. Stage)</u>: Simulation of the oil caterpillar motion by solid body in the tube with water, using the Stack Frame Technique (Fig.11). - The solid body is waggling between walls just like air bodies (bubbles), oil bodies and any pendulum. They stop and turn at the wall each time.

Figure 11.
Simulation of the oil caterpillar by a "pendulum" (Model 2).



<u>Other models and proofs.</u> For example, a small flat stone (of appropriate size with respect to the diameter of the tube) falling in the tube with water, will regularly clinking.

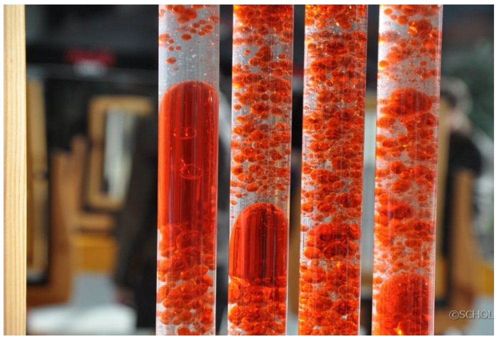
<u>Physics behind waving (4. Stage):</u> The oil, with rather high viscosity, is flowing up slowly inside the „oil body", while the frisky water with much less viscosity runarounds.

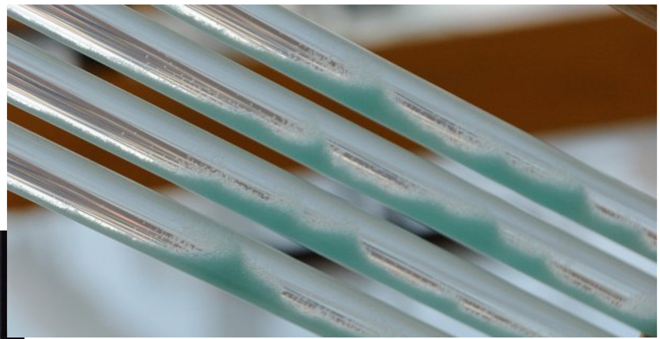
<u>Hypothesis (4. Stage)</u>: There must be vortexes between the wall of the tube and the „plastic" oil body! - The rolling vortexes push into the oil. The surfase tension at the boundary of water and oil (Fig.s 6 and 8) is big enough to keep together the oil, in contrast for eample to the case at the Fig. 12. But, the force caused by water whirls is big enough to deform the oil body!

<u>Generalization (4. Stage):</u> The waves are dynamic structures created in fluids at different physical conditions but by similar mechanism – by mutual bumps of flows resp. flows and solid walls, creating vortexes, that pull in into bigger vortexes that can roll on boundaries (Fig.13).

<u>New challenges (6. Stage):</u> Our oil caterpillars (Fig. 6) are "only" study cases, but surely relatives to a number of processes from Nature and the world of technology. Let's consider fluxes in atmosphere and oceans, aerodynamics of vehicles, or material technology, e.g. production of glassy metallic alloys.

Figure 12.
At lower surface tension the water whirls can have power to breake the liquid body in parts.





gure 13. Visualization of "waves mechanism" by glass sand. While sand slides on the bottom, the water swirls creating waves on the "sand body".

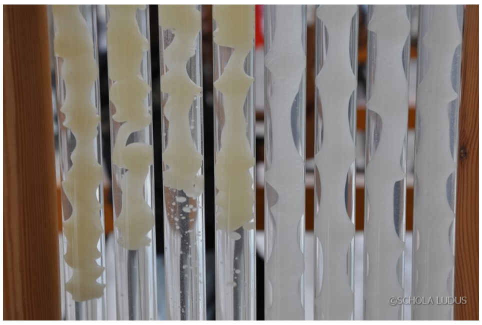
<u>Embedding (5. Stage):</u> What is known at present and was t know before, i.e. could not be discussed previously? - For velopment of vortexes and waves there must be suitable nditions (Figs. 14, 15, 16).

Figure 14.
To the process conditions: The same tubes and immescible liquids as in the Key Case .

5.3 AN EXAMPLE OF e-EXHIBITION: SUPRISES IN LIQUIDS

The EE Surprises in Liquids origin is in performance of parallel dynamic processes that occur always in 4-8 tubes of 30 and 48 cm height, filled by liquids and small bodies, built together in frames. The processes in parallel tubes start after turn of the frame at once.

Figure 15.
To the process conditions: Similar processes but in differen liquids, at the same temperature, but probably different than was in the case of the process at Fig.6.



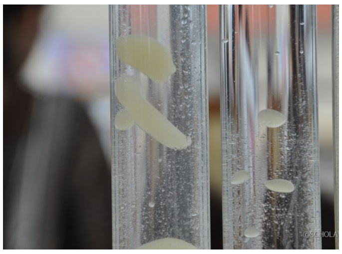


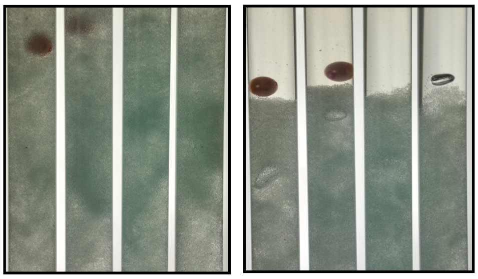
Figure 16. Where come these small dancing bodies from?

Figure 17. Here is the hidden answer to the question at Fig.16.

"Here is the force of self-organising matter. Look! The bubble always mounts while the ball sinks and the spiral turns round. The "mushroom" will tinkle while wheels will rotate. The grains will divide according to their size and behind the moving hole there always rise whirls. Regular waves develop on bubbles of certain size while a small impulse from outside is enough to create a storm inside! Here is the space to start to understand the complexity of world in a new way."

Applying complexity approach, each Exhibit of the EE Surprises in Liquids can be understood also as a challenge, and model, to understand any other complex process

Figure 18.
Two successive records of the Exhibit with many small glass beads in tubes with water. In each tube is also a small amout of air, and in the two left tubes also light balls.



The balls are recorded just before and after getting over the bulk of beads, but the bulks don't seem as there were any big intruder short time before.

<u>Task example</u>: Try to assort the Exhibit (Fig. 18) with other exhibits from the EE (that were applied in the examples of the BB and CC above), concerning to the following key concepts: Time of Interaction, Process Rate, and Continuum System. you can add own exhibits, and or other concepts you need. the goal is to get a meaningful set of exhibits that support complex understanding of the case recorded at the Figure 18.

6 WHO CAN CREATE THE e-LEARNING ENTITIES

The learning trail of any upper described e-learning format is expected far away from linear thinking. The format is prepared so that enables to use any scientific and playing methods. To prepare the e-learning Entity ´only the genius cases are needed´, and skilful editors – specialists to keep the SCHOLA LUDUS learning spirit. The application of complex dynamic approach and serious creativity are requested [4].

The BB authors´ first task is to create attractive displays and consider how to turn them into provocative learning case. Potential prototypes for BB are anywhere. The virtue of BB is in creativity of both, authors and players.

To propose good CC is imprimis a challenge for scientists. The format enables to induce for users an adventure of complex discovery related the bases of science and or the recent open questions of science and technology.

To design a good EE requires overview of experts in the respective science and technology field and awareness of strong message to the addresses.

CONCLUSION

The SLVSC offers a platform for pro-science learning, tools to create e-learning Entities of respective formats, and the respective educational expertise. Besides BB, CC and EE there are prepared also other formats.

To run the SLVSC a powerful provider is wanted and new and new ideas to build up concrete e-learning Entities. The more e-learning Entities at the SLVSC, the bigger probability that every user will find learning cases for himself / herself.

ACKNOWLEDGEMENT

This contribution is dedicated for ´SCHOLA LUDUS in the IT Age´ at the ICL 2011 conference, in the 20th year anniversary of the project SCHOLA LUDUS. We want to thank the Organizing Committee of the ICL for opening the highly actual topic.

This work is supported by the Slovak Research and Development Agency under the contract No. LPP-0395-09.

REFERENCES

[1] Prensky, M.,Changing Paradigms from "being taught" to "learning on your own with guidance", Educational Technology, July-Aug. 2007

[2] Wieman, C.: "Why Not Try A Scientific Approach To Science Education?", Change magazine, September 2007

[3] Gunther, M., Can serious games help change the world? News@Cisco Jan.26, 2011

[4] Teplanova, K.,"The SCHOLA LUDUS virtual science centre - Building e-frame for new paradigm of teaching and learning", Benchmarking Forum, SCHOLA LUDUS in the IT Age 2011 International Conference ICL 2011, Piestany Sept. 2011.

[5] Teplanova, K., "SCHOLA LUDUS theory of teaching and learning", In: 17th Conference of Slovak physicists, Bratislava. Slovak Physical Society 2009.

[6] Teplanova, K."Ako transformovať vzdelávanie : Stratégie a nástroje SCHOLA LUDUS na komplexné a tvorivé poznávanie a učenie." 1. vyd. Bratislava, Metodicko-pedagogické centrum, 2007.

[7] Zelenak, M., Teplanova, K., Matejka, M.: Significance of solid digital record in learning process by SCHOLA LUDUS. In: 17th Conference of Slovak physicists, Bratislava : Slovak Physical Society, 2009.

[8] Minski,M., "Steps toward artificial intelligence", IRE 1960.