CUSTOMIZING HANDHELD SIMULATION SCENARIOS WITH A HANDHELD AUTHORING-TOOL

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ABSTRACT

Recently we have been assisting to an increase in the use of handheld software in education. Yet, in what concerns modeling and simulation, what we find most are closed packages, representing a specific situation, that once used become exhausted. We need tools that allow representing more situations easily and quickly. This motivated the development of Sim-H, an authoring system for handheld modeling and simulation that uses essentially direct manipulation techniques, various representation and interaction forms to create and test models and simulations. At the moment it is made by three editors, one for model building, or a modeling tool, another to create scenarios for models that are easier to interact with than the models themselves, and a third one to include support to learning in a model or a scenario, namely extra information and guidance, that is to build simulations. Due to Sim-H architecture it is very easy to aggregate to a single model several scenarios or learning layers. In the scope of this paper we will focus mainly on the scenario editor, its characteristics and the kind of products it allows to build.

KEYWORDS

Handheld devices, modeling, simulation, authoring-tools.

1. INTRODUCTION

Handheld devices are becoming quite popular nowadays, including in education. They have many advantages like small size, weight and price, flexible enough, usable anytime anywhere,

etc. They will surely become common personal work and educational tools in a very near future.

Although we find already much handheld educational software for many subject matters, for math's, science, languages, etc., and of many types, like spreadsheets, text editors, graphical editors, games, there is still a lack in some areas, as it is the case of modeling and simulation (Lockitt, 2005, Naismith, 2005, Roschelle, 2003, Savill-Smith and Kent, 2003, Sharples, 2006, Soloway, 2001).

Modeling can be defined as the use of a model in an educational context. A model is nothing more than a representation of a system, usually simpler than the system itself. In learning it can be used by the teacher or by the learner. In the first case it is generally used as a demonstration aid. In the second case it can be used in an exploratory way (the learner interacts with a model, usually provided/built by the teacher) or in an expressive way (it involves the construction of the model itself by the learner). A broad class of models used in education is continuous models or models described by differential equations, although other types can be used too, like discrete, hybrid and qualitative models.

Simulation involves the use of a simulation, a computer program that represents a dynamic situation, described by a model, with which the learner can interact. In this mode, the learner does not know the model details, although he still can play with it in a manner similar to the one designated above as exploratory. In this case he can similarly develop a mental model of the simulated or represented situation.

In the area of modeling and simulation for handheld devices we find mainly three approaches:

- The use of closed simulations,
- Modeling tools whit which the user can build and test his own models and
- Simulation authoring-tools where the first category of simulations mentioned can be built to be used after.

In the first category we find already a lot of examples. Some are described and can be found in (Geney, 2003, GoKnow, 2006, PDA Participatory Simulations@MIT, 2005).

Tools for handheld modeling and simulation authoring are scarcer. We have Model-It from Hi-CE (Centre for Highly Interactive Computing, University of Michigan, Luchini at al. 2002) in the second category and C5 from Agentsheets, Inc. in the third, although it does not involve only handheld devices, but other more sophisticated hardware, like a server (Agentsheets, 2006).

Model-It is a visual modeling tool for qualitative models that was developed primarily for desktop computers. To build a model it is necessary to identify objects, variables and relations among them. Model results are presented graphically. The version developed for handhelds was adapted from the desktop version and was called Pocket Model-It.

C5 (Distributed Simulations for Handhelds) uses handhelds, desktop computers, and Internet to support students' work. Using a simulation server, it is possible to simulate a part of a model with a handheld and after compare, reflect and analyze results in group.

Another tool that we can mention in this category is AgentSheets of AgentSheets, Inc. (Agentsheets, 2006). Although not being for handhelds, we can build with it small simulations and games and transfer them after to a handheld device (PDA, phone, etc.). It is quite easy to use, but to represent some aspects in some models it requires a certain level of knowledge of the built-in programming language, which is usually not easy for an ordinary teacher.

This paper is structured in the following way: in the next section we present Sim-H main characteristics, an authoring-tool for handheld modeling and simulation. After, in section 3,

we focus on one of Sim-H components, the Handheld Scenario Editor. In section 4 several examples developed using this tool are described. Finally, in section 5, we present the paper conclusions.

2. SIM-H

After analyzing the tools referred above, we realized that some desirable characteristics for a handheld modeling and simulation authoring-tool were still missing in these currently available tools. Among them we refer:

- Being both for modeling and simulation and
- for several types of models,
- Requiring a simple infrastructure,
- No need of any kind of programming knowledge to be used,
- Having a handheld-based environment
- Allowing for several animation techniques in simulations,
- Allowing for integration of data from experimentation in a model or a simulation,
- Allowing to register learner performance when using a model or simulation in order to individualize learning,
- Usable "anyway anywhere" (in the classroom, at home, in the lab, etc. (Marcelino and Brigas, 2007)).

As a consequence, we identified a set of requisites for a handheld modeling and simulation authoring-tool. Based on them we are developing a prototype of a tool to support educational handheld modeling and simulation. We called it Sim-H which means SIMulation for Handhelds.

We envisage a model and a simulation for handhelds, and also for stand-alone or Web-based contexts (Brigas and Marcelino, 2004, Marcelino, 1999), as being two extremes of the same continuum and, in this respect, as a group of layers that are:

- The model,
- The scenario, or a simpler interface for a model
- The learning layer, a layer to support and optimize learning.

Related to this conception we can also think of different types of activities and products that a teacher can create and use with handhelds for students. We distinguish between modeling, quasi-simulation and simulation activities and models, quasi-simulations and simulations. What characterizes each one of these is:

- Modeling activity: the construction or the exploration of a model by a learner in an educational context. The student can build a model or use a pre-built one. In this last case he usually interacts with it by modifying the value of its parameters and watching to what happens as a consequence to model behavior.
- Quasi-simulation activity: the student explores a pre-built, but hidden, model by interacting with a simpler interface or quasi-simulation. He cannot change the model, although he can change some parameter/variable values. The interaction is simpler than using a typical simulation or model.
- Simulation activity: the utilization of a simulation by a student. The simulation is usually built by the teacher or other expert (Marcelino and Brigas, 2007).

This model, where we grounded our approach, determined also the structure of our tool to build handheld models and simulations. It is made by several editors, one of which is a modeling tool, the HME, or Handheld Model Editor (Marcelino, 2006). Another is the HSE, the Handheld Scenario Editor, a tool to build scenarios for these models. For some learners the direct interaction with a model can be rather hard. What they need is a simpler way to do it. This is exactly what the HSE scenarios allow. It will be explained further in the next section. Yet another tool is the HLE, or Handheld Learning Editor, a tool for developing learning layers to aggregate to models or scenarios that is to build simulations.

HME allows implementing continuous models of generic systems. Like the other two editors it has a graphical easy to use interface whose interaction is done mainly by direct manipulation techniques. A model is described by an iconic diagram that specifies its entities and their relationships - state variables, constants, rates of change and auxiliary quantities. The relationships among the several model elements are made by connecting them with links. Model results can be seen in tabular or in graphical form. The calculation of a continuous model is done using typical numeric integration methods (1st order Euler method by default and several Runge-Kutta methods, when more precision is needed). Model independent variable is the time, by default, but it can be altered very easily, as well as the integration step. HME can be used alone, to develop or run models, or it can be used with the others Sim-H editors to provide models for scenarios and simulations (Marcelino, 2006).

HLE is a tool to develop learning layers for Sim-H simulations. A learning layer is a layer to put around a model or a scenario and can include elements like:
- Extra information about the topic addressed in the simulation,
- Guidance instructions while using the simulation,
- Materials to register simulation data,
- Questions and answers,
- Help,
- Etc. (Marcelino and Brigas, 2007).

3. THE HANDHELD SCENARIO EDITOR

The Handheld Scenario Editor, or HSE, allows developing scenarios for simulation models. In Figure 1 we can see the main screen of HSE.

A scenario can be made by a group of elements of the following types:
- Input elements,
- Output elements and
- Background elements (optional).

In Figure 2 we have a resume of all the element types that can be used in a scenario. Let us describe each one of them in more detail, starting by input elements.

Input elements are elements to interact with model parameters and/or variables. For the time being they can be:
- Editors and
- Potentiometers.

Editors are small boxes where we can type and change the initial value of a model quantity (typically a parameter or a state variable). They show also the value of the associated quantity

during model run, which means that they function as output elements simultaneously. Their value can be changed too by clicking in the adjacent spin buttons.
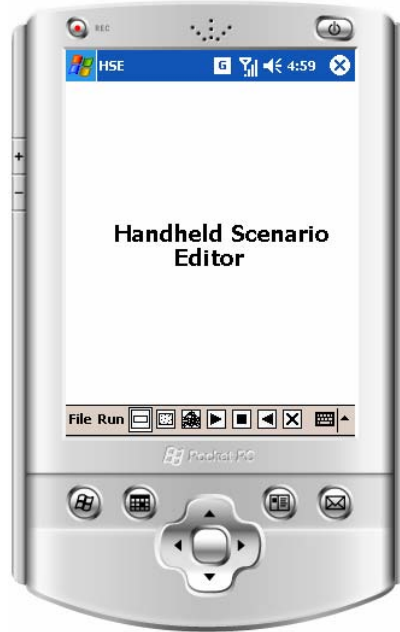

Figure 1. Handheld Scenario Editor main screen.

Potentiometers are similar to editors, but have a different design and interaction, as can be seen in Figure 2. Both editors and potentiometers show by default the name of the associated quantity, although we can change it to a more expressive one easily.

Output elements are elements for model behavior visualization. They can be:

- Progress bars,
- Animation views,
- Tables and
- Graphs.

Progress bars show the value of the selected model entity in terms of the corresponding percentage of a small bar. The quantity current value and name is shown by default. As with editors and potentiometers we can change the text that appears above the bar.
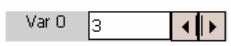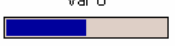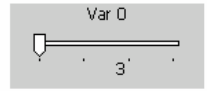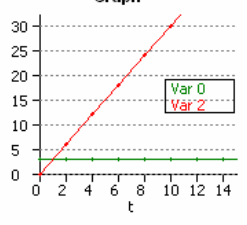
Input elements	Output elements	Background elements
Editor Var 0 `3` ◀▶	**Progress bar** Var 0 � progress 1	**Image** 🔔
Potentiometer Var 0 3	**Movement** Var 0 ↵ 3	
	Color Var 0 🟩 3	
	Shape Var 0 🐢 3	
	Number Var 0	
	Table	

t	Var 0	Var 1
0	3	0
1	3	3
2	3	3
3	3	3
4	3	3
5	3	3

Graph

Figure 2. Handheld Scenario Editor input, output and background elements.

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Animation views are particularly interesting, because they can provide a better notion of the simulated reality. They can render change in:

- Position (that is movement),
- Number (that is density),
- Color and
- Shape.

Other types, like blinking effects, will be added soon.

In the movement type an icon moves in a 1D space (along a line), horizontally or vertically, accordingly to the value of the represented model entity. Again the text above the icon is by default the variable name, but it can be changed.

In the change in number type it is the number of elements that vary with time in a 2D space to represent the same information. Element values are represented by small squares of several colors, one for each associated quantity. We can represent one, two or three model elements in the same space. This type of representation is particularly suited to show two or three model entities and evidence the variation of one in relation to the other(s).

Change in color and change in shape are similar. In the first one it is the color, in the second one it is the shape, that varies and reflects the changes in the associated model entity. We can define one, two or three threshold values for the selected element and thus define corresponding changes in color/shape.

Tables show the value of the model entities over time in tabular form. They allow seeing each value taken by all model entities and provide a precision in terms of model results that other representation forms do not, although they are harder to infer behavior from.

Graphs show the evolution of model elements over time in graphical form. They are only linear graphs at present. They can have a legend or not and we can change the quantities to be plotted too.

Background elements are static elements that do not represent any model entity and the main reason to include them in a scenario or simulation is to give fidelity to the scenario. They can be:

- Images and
- Icons.

Others, like small texts, will be included too soon.

Generally to create a scenario the user will have to do the following tasks:

- Link the scenario to the model to which it refers to (basically open a model file),
- Insert input elements that allow changing the data of the desirable quantities (model constants/parameters and/or initial values of sate variables),
- Include output elements for visualization purposes and
- Include background elements to give more credibility to the scenario/simulation (optional).

In HSE all elements are created by selecting their type in the tool main toolbar and pointing and clicking in the canvas. For changing elements type/details the user has to double-click the element. A dialog box like the one in Figure 3 appears.

In this case the element is an output element of the type animated view, subtype change in number or density. We can change the legend (name) to appear in the scenario, the model elements to be shown and their associated colors. It is also possible in this dialog box to alter the subtype of the element to progress bar, movement, change in color or change in shape. Of course, in this case similar subtype options will have to be configured appropriately.
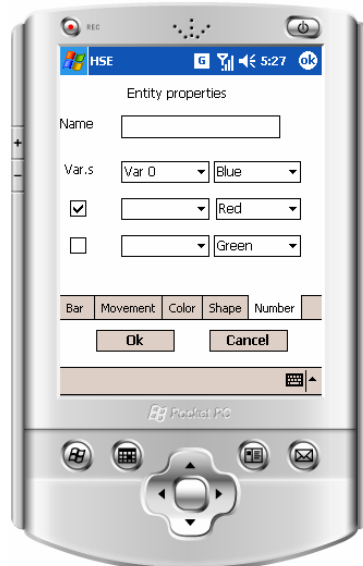
Figure 3. Specification of a variation in number or density output element options in HSE.

HSE allows us to specify a scenario in a few minutes, providing the underlying model is already built (using the HME Sim-H tool). These models are not time-consuming to build too. As HME follows a similar approach to specify the models, a model takes as well a few minutes to be created (if the model equations or relations are known or after they have been devised).

After a scenario is build it is possible to interact with it and run the underlying model without knowing the mathematical formalism behind (differential equations). This is an advanced mathematical topic usually not master until college. This allow to use these tools in earlier educational levels, like secondary level, for instances, or in other areas, like social sciences, where the knowledge of mathematical skills is much more limited than in traditional science areas, like physics or biology. Indeed these scenarios can be used in several subject areas, from physics, to chemistry or math, passing by social sciences, etc. Sim-H is an open product in this sense and the use of these products becomes particularly attractive when the alternatives are more expensive, time-consuming, dangerous or even inexistent.

Sim-H scenarios+models are what we called quasi-simulations. In reality a scenario is a kind of a model interface that is easy to operate than the model itself. We can say that a quasi-simulation represents a model in an easier and friendly way, allowing the learner to concentrate more on model behavior rather than on its elements and associated relations or model structure.

Another important aspect of HSE is that it is very easy to aggregate to a single model several scenarios. With these tools we can gain in flexibility and diversification very easily. This also saves author time and effort. So we can gain in efficiency too.

Yet another benefit of these tools is that we can use them separately or integrated having the possibility of using diverse kind of products and giving rise to different learning modes and strategies:

- A model, that the learner can build and change,
- A quasi-simulation (a model + a scenario), with which the learner can interact, but without any learning strategy behind, or
- A simulation (a model + a scenario + a learning layer), within which the learner can be more or less guided in order to make learning more effective.

In the next section we present a few typical examples where we can use the Handheld Scenario Editor to construct simple scenarios to support the study of a concrete topic in the scope of the discipline of Chemistry of the Portuguese high school national curriculum. With them we also demonstrate better some of the main aspects of this tool as well as its applicability in a real context. The examples presented are quite simple. Others more complex could easily and likewise be thought, but our intention here is mainly illustrative.

4. CUSTOMIZING HANDHELD EDUCATIONAL SIMULATIONS

The study of chemical equilibrium in chemical reactions is part of the Portuguese chemistry curricula of both the 10th and the 11th years of the high school national curriculum (Martins, 2001 and Simões, 2001). In such a reaction, chemical equilibrium is a state in which reactant and product concentrations have no net change over time. Chemical equilibrium applies to reactions that can occur in both directions i.e. forward and reverse. Usually, it is achieved when the forward and reverse reactions proceed at the same rate. These rates are generally not zero but, when they are equal, there are no net changes in any of the reactant or product concentrations. This equilibrium is dynamic, which means that the amount of products and reactants are constant (not equal) and both reactions are still occurring.

We can use Sim-H to build some scenarios to support the study of this topic. But before creating the scenarios we must have the models built with HME. We can start by the model:

$$\frac{dA}{dt} = r2B - r1A$$
$$\frac{dB}{dt} = r1A - r2B$$

where A and B means the quantity of substance A and B in the reaction, r_1 and r_2 are the forward and the reverse rate constants and t the time (Laidler, 1987). In HME it can be represented as in Figure 4.

As we can see, inspecting the graph, substances A and B, after a while, achieve an equilibrium state – their concentration values do not change, although they are not the same. Actually the final values reached depend on the initial value of each substance and the relation between the rate constants.

In HME, a model is represented by an iconic diagram where differentiated or state variables (in this case A and B) are symbolized by black squares, its rates of change or derivatives (dA/dt and dB/dt) by green triangles and model parameters (r_1 and r_2) by gray squares. Intermediate relations are represented by circles with an arithmetic operation, like * or – in the figure that represent a multiplication or a subtraction between their incoming inputs. Arrows express the connections between the several model quantities.
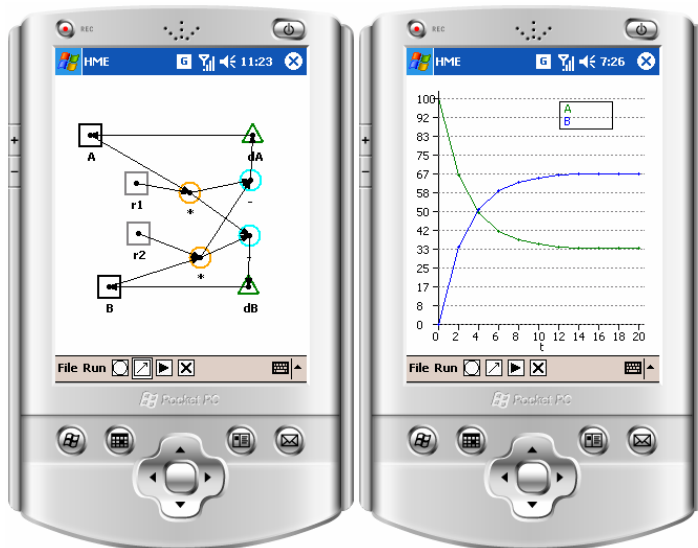
Figure 4. The chemical equilibrium model in HME.

It can be too complex, however, for secondary school students to interact with such a model, because of the aforementioned reasons. We can overcome the problem very easily using HSE. With it we can build a scenario that hides the model and still lets us study the phenomenon in a similar way. In Figures 5 and 6 we show two alternative scenarios for this model, one more concrete, for younger pupils, and another more abstract, for older ones, that can be the basis of several learning activities.
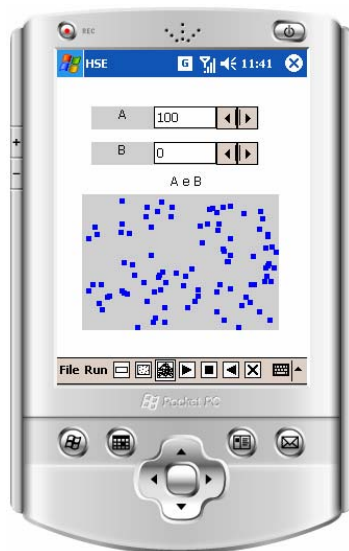

Figure 5. A HSE scenario for the chemical equilibrium reaction model.

Figure 6. Two views of a more abstract HSE scenario for the chemical equilibrium model.

In the first scenario we chose two editors to show the value of the model state variables A and B and eventually change their initial values. The evolution of the reaction with the time can be seen in an animated view where each square represents the same number of molecules. The view shown is at the beginning of the simulation and, at that moment, only the A substance is present in the reaction in this case. During the simulation run the number of A molecules diminishes and the number of B molecules increases, which is shown by the diminishing of A blue squares and the appearance of red squares (these were the selected colors to represent the substances). Of course, the two editors' numbers vary accordingly.

In the second scenario we chose a more abstract interface. This time we included a table and also both reactions rates, forward and reverse, for students to play with and observe the consequences of their actions. The table representation does not convey the information in a live format, like the animated view, but we can argue that it gives a more precise vision of the visualized results as one can see the exact values of the represented quantities.

The big issue here is that students can interact with these two scenarios without knowing the underlying structure of the model and in this way easing substantially the interaction and the study of the phenomenon.

Both scenarios and model were built in about 10 minutes. But, of course, the topic of chemical equilibrium is quite complex and requires at least the experience with a few examples to be fully understood. As the system allows building these models and scenarios so quickly it will not be too much time-consuming for a teacher to do it. Also, if he wants he can develop with Sim-H more complex simulations with the same easiness, although taking a bit more time, using the HLE tool. Alternatively, simulation guiding instructions, quizzes or materials to register experimental data can be develop in a more traditional way, like using pen and paper or an ordinary computer text editor.

5. CONCLUSION

Although handheld devices are becoming quite popular and we can find a lot of software specifically developed for them, in what concerns modeling and simulation authoring-tools that is not the case.

In this paper we described the main characteristics of HSE, a Handheld Scenario Editor for handheld devices. HSE is part of the SIM-H system, a set of tools to support the development and use of modeling and simulation activities in learning. We already have tested the usability of HME and HSE with a small group of potential users (learners and teachers) with positive results. Next steps of Sim-H development include the development of another tool, to support learning evaluation while using a model, a quasi-simulation or a simulation, as well as its utilization in real settings, as the classroom or the lab, to support students work.

REFERENCES

AgentSheets, 2006. http://www.agentsheets.com/, last accessed 30th October 2007.

Brigas, C. and Marcelino, M., 2004. SimulWeb: Web-based Modeling and Simulation Authoring-tools. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004*. Lugano, Switzerland, pp. 801-807.

Geney, 2003. http://guir.berkeley.edu/geney, last accessed 30th October 2007.

GoKnow, 2006. http://www.goknow.com/Products, last accessed 30th October 2007.

Laidler, K. J., 1987. *Chemical Kinetics (3rd Ed.)*, Benjamin Cummings, San Francisco, USA.

Lockitt, B., 2005. *Mobile Learning*, 3T Productions Limited, 3.

Luchini, K., et al, 2002. Designing Learner-Centered Scaffolded Tools for Handheld Computers. *Proceedings of International Conference of the Learning Sciences*. Seattle, USA, pp. 268-275.

Marcelino, M. J., 1999. *Contribuições para o desenvolvimento de aplicações educacionais que envolvam técnicas de simulação*. PhD Thesis. University of Coimbra. Portugal.

Marcelino, M. J., 2006. HME: a Handheld Model Editor for Educational Purposes. *Proceedings of 8th International Symposium on Computers in Education*. Leon, Spain, Vol. 1, pp. 309-316.

Marcelino, M. and Brigas, C., 2007. SIM-H: a Set of Educational Modeling and Simulation Authoring-tools for Handheld Devices. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007*. Vancouver, Canada, pp. 3150-3157.

Martins, I. P. et al., 2001. *Programa de Física e Química A – 10º ano*. Ministério da Educação, Portugal.

Naismith, L. et al., 2005. *Learning with Mobile Technologies*, *Report 11*. NESTA Futurelab, UK.

PDA Participatory Simulations @ MIT, 2005. http://education.mit.edu/pda/index.htm, last accessed 30th October 2007.

Roschelle, J., 2003. Unlocking the learning value of wireless mobile devices. *In Journal of Computer Assisted Learning*, Vol. 19, No. 3, pp. 260-272.

Savill-Smith, C. and Kent, F., 2003. *The Use of Palmtops computers for Learning*, Learning and Skills Development Agency, UK.

Sharples, M. (Ed.), 2006. *Big Issues in Mobile Learning: Report of a workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative,* University of Nottimgham, UK.

Simões, T. S. et al., 2001. *Programa de Química Aplicada – 11º ano*. Ministério da Educação, Portugal.

Soloway, E., et al., 2001. Log on education: handheld devices are ready-at-hand. *In Communications of the ACM*, Vol. 44, No. 6, pp. 15-20.