The need for a System Dynamics based Open Source, Online Interactive Learning Environment Creation Tool.

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Abstract: *System Dynamics needs a tool, which allows modelers to create Interactive Learning Environments that help modelers share the knowledge that they have learned by model building, with users who only use their models. To do this they need tools that allow them to better represent the relationships between model structure and model behavior. I have been creating a software tool called Open Dialect, which allows modelers to create ILEs for the web that incorporate new model structure visualization techniques. The purpose of this paper is to introduce you to Open Dialect, and to show you that Open Dialect will allow modelers to create effective, intuitive, modern, aesthetically pleasing, online single user ILEs that will most importantly help the close the gap in knowledge gained through model building (the modelers) versus just model using (the users).*

Keywords: Interactive Learning Environment, Open Source Software, Model Interfaces, Interface Design

Introduction:

This paper outlines the construction of an ILE creation tool, which will allow for the creation of visually appealing, simple to use, single-user and potentially multi-user web based ILEs that incorporate new model structure visualization techniques.   In this paper I will focus two main areas. First, on the ability of this software to create ILEs that can reach the 1.3 billion people that are online today (Miniwatts Marketing Group, 2008). Second, I will focus on how this software will help to shrink the knowledge gap between modelers and model users by improving model and data visualization techniques.

Current ILEs are generally lacking in many areas including: visual appearance and aesthetics, web accessibility, operating system (OS) independence, and data visualization. The current method of creating and using ILEs has served its purpose for the past 20 years, but it is time for ILE creation tools to evolve and take full advantage of the power of the Internet and advances in computing in order to better reveal model structure to model users. I believe that current ILEs are now reinforcing the knowledge gap between modelers and model users, because generally current ILEs do not allow users to easily access and learn about model structure, but are generally offered as the solution for model based learning when group modeling is not feasible or possible.

As of the writing of this paper (May 2008) I have already created an Open Source tool called Open Dialect, which allows models to be published on the web. Open Dialect can create ILEs that are quite intuitive and aesthetically pleasing.   All ILEs that are produced by Open Dialect are OS

independent and web accessible.

Sterman considers education and learning as two of the most important goals of system dynamics (1994). In order to reach those goals the results of system dynamics research must be spread to the general population. One of the best ways to involve the general population into modeling oriented fields is through simulation or gaming (Alessi and Trollip, 1991). An example offered by Alessi and Trollip are the Sim games (Sim City, Sim Earth etc). These games encourage learning through experimenting with the model that exists underneath them through simulation. This allows the user to learn about the system while gaming and simulating the model, rather then the traditional approach of model construction.

It has been the hope of the System Dynamics field that ILEs would serve as the necessary push to stimulate the large-scale use of models and system dynamics in society (Sawicka and Kopinasky, 2008). According to Sawicka and Rydzak the evidence to support the effectiveness of ILEs has not been fully established yet (2007). Kopinasky and Sawicka identify group model building as the most effective way to disseminate model based information, but they acknowledge the limits of this approach when it comes to teaching en masse (2008). They suggest that ILEs ought to expand past running simulations and experimentation to allow the user to explore model structure and function, in order to learn what is causing behavior to happen rather then just what behavior is happening.

Davidesen suggests that ILEs should strive to include not only behavior, but structure because it is the relationship between structure and behavior that is key to learning (2000). His main concern seems to be model transparency, which is the idea that the ILE should not hide or abstract the underlying model at all levels. He believes that models ought to be fully visible to users who desire to learn about how the system is functioning. He thinks that the key to successful ILEs is it the ability to accurately represent model structure and behavior relationships. It is his belief (and mine) that the true power of system dynamics comes from its ability to relate system structure to system behavior.

Alessi takes a slightly different stance then Davidsen suggesting that always having the model structure available does not always lead to optimal learning (2000). He suggests that in certain cases having the model readily available in full detail is not necessary and can lead to slower learning. He says that content should be matched to the target audience in order to ensure that confusion is avoided. His major findings can be repeated most easily as "… conceptual simulations should have opaque models, whereas procedural simulations should have both (opaque and transparent models)." Where procedural simulations refer to for example flight simulators, where the model is not as important as the results (Alessi, 2000).

A good example of model structure visualization helping to close the knowledge gap between modelers and model users is Wheat's MacroLab model (Wheat, 2007). He used Stella's story-telling feature, to teach basic macroeconomics using the feedback method and compared that to current methods for teaching macroeconomics. He found that the students who were taught through the feedback method knew more about the system then those who weren't. This research is encouraging, because it gives a concrete example of how model structure visualization can improve learning, and close the knowledge gap between modelers and model users.

Much work has already been done on how to design ILEs in order to be effective under many different situations. I will not go over this portion of the literature since I am not as much interested in specific design techniques at this point, but rather I am interested in the utility of ILEs in general, the tools used to create them and closing the knowledge gap between modelers and model users. As an example of a future feature I would like to include in Open Dialect, I mention Stella's story telling, which allows modelers to let their audiences interact directly with models in a positive, controlled manner (iSee Systems, 2008).

Alessi and Trollip have put forth that the web is the next logical step for the evolution of computer based learning (2001). They state that there is much potential for the spread of ideas and for learning via the web. In regards to data visualization, even Sterman in his text Business Dynamics

clearly states that data visualization is one of the next key steps in the development of system dynamics (1994). Therefore, I consider my work to be important to the future of system dynamics as a field.

As of this date (May 2008) there are two other software suites, which have been released to the general public that allows modelers to dynamically display the results of their models on the web. The first is by a company called Forio Business Simulations, which in my opinion it offers a limited range of possible ILEs with a significant cost (Forio Business Simulations). The second is Stella's NetSim, which as of this time I have no experience with, but I plan on gaining some right away (iSee Systems, 2008).

Generally the most important issue I have with current solutions is they do not go far enough. They do not allow modelers to reach the largest audiences possible, they put unnecessary limits on how modelers can show model results, and they prevent modelers from working outside the bounds envisioned by the software designers. This I believe is one of the major reasons why ILEs that help close the knowledge gap between modelers and model users have not yet been perfected. While there are most certainly some exceptions to the above statement, I argue that in general it is true.

Problem Statement:

The major shortcoming in ILE development seems to be coming from the inability of current software packages to allow modelers to teach the information they have learned by going through the modeling process. I believe that one of the key causes of this shortcoming is the issue of data and model structure visualization. Since learning and education are two of the most important goals of system dynamics it is very important for those not involved in the modeling process to be able to absorb and learn the knowledge created by going through the modeling process.

Most learning occurs during the model building process, not just by using the model. Arguably, this is because model building requires an intimate knowledge of the connection between the system structure and the system behavior. Model users typically are shown only half of this relationship, the system behavior, and rarely are their attentions focused on the structure of the system. Current software has addressed this problem but not sufficiently. Enabling users to better visualize structure and its resulting behavior would go a long ways towards addressing the knowledge gap between modelers and model users. By putting ILEs on the Internet, it allows this knowledge to be made available to hundreds or if it's user-friendly, maybe thousands or more interested users.

Long Term Hypothesis:

I intend to show that Open Dialect allows modelers to easily construct single user web based ILEs that incorporate novel visualization techniques, which help the ILE users better understand the concepts the modeler was hoping to teach closing the knowledge gap between modelers and model users. The key concept in this hypothesis is that users ought to have a better understanding of the system that the ILE represents. To do this modelers will need to use novel visualization techniques including: audio/visual interaction (movies and sounds), animation, or other more game like techniques used in traditional computer based learning software. In order for this to happen modelers must be easily able to use the tools offered by Open Dialect, and the user interface of Open Dialect should be very familiar to modelers. It should draw on the user interface improvements and appearances in the software packages they already use.

Results:

Many of the above stated goals of Open Dialect are well on their way to being achieved at this time there exists a basic Open Dialect interactive development environment (IDE), which allows for

the creation of simple to moderately complex single or multi-user ILEs. A simple single user prototype ILE can be viewed at www.T21NorthAmerica.com/PolicyResistance.html or seen in Figure 1.

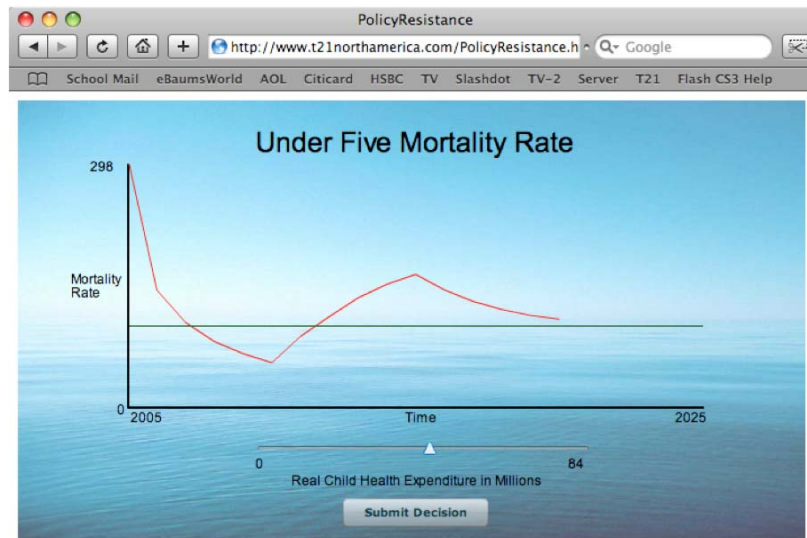**Figure 1:** *A simple prototype ILE in the Safari Web-Browser.*

Figure 2 shows the Open Dialect IDE; notice how ILEs are broken into pages. Each page also has its own timeline complete with layers and frames so that advanced users can make complex animations. By default this behavior is hidden in order to encourage novice users to use Open Dialect, without being overwhelmed by superfluous information.

Figure 2: *The Open Dialect IDE showing the prototype interface under design. You can see on the left all of the components which can be incorporated into an ILE. Behind that is the Pages view which shows a re-orderable list of all of the pages in an ILE. The bottom pane contains information on the selected object, in this case the line graph object. The toolbars up top allow modelers to easily access the most important parts of the program with ease.*
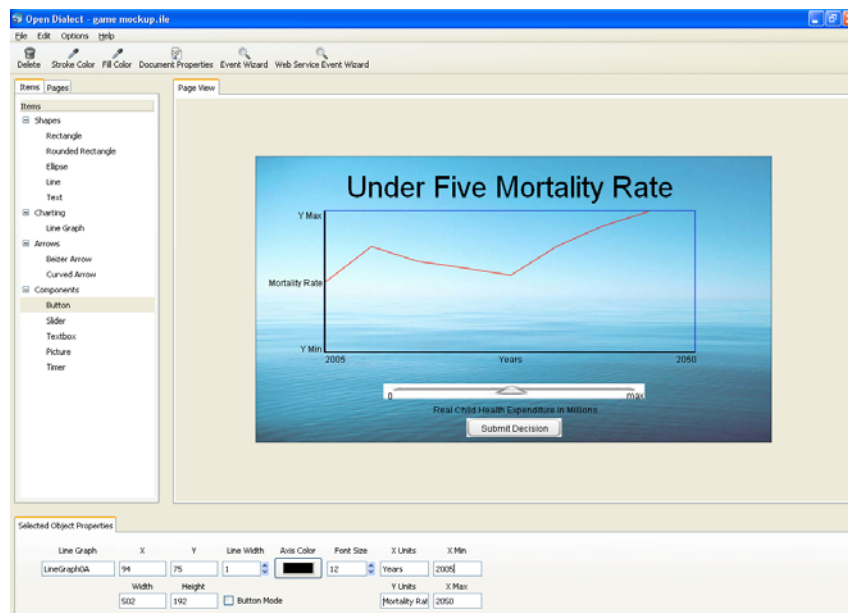
Figure 3 shows the Event Wizard, which is a dialog that helps users write the necessary Actionscript 3.0 code in order to handle events, and model interactions. In order for the ILE to know how to respond to a click of a certain button the user must handle that buttons click event. The event wizard allows users to code these events without knowing any syntax at all. All users need to know is the logical sequence of actions to take place. As you can see the event wizard prompts users to enter the necessary information so that the software can complete the action desired by the user. Also notice how in the event wizard all of the attributes of all objects are potentially modifiable, this means that for instance a certain model result could be used to move a rectangle across the screen, in other words it opens up the possibility for new innovative visualizations that move away from simple line graphs, sliders and buttons.

Figure 3: *The Event Wizard showing code generated to Login to the Model during a click event. As you can see this wizard offers the modeler many options on how to handle events, pay particular attention to the fact that the program asks for the necessary information and then it constructs the actual code seen on the right, which can be re-ordered by hand if necessary. Also notice the properties pane, which allows users to access all of the attributes of any object in the entire document.*
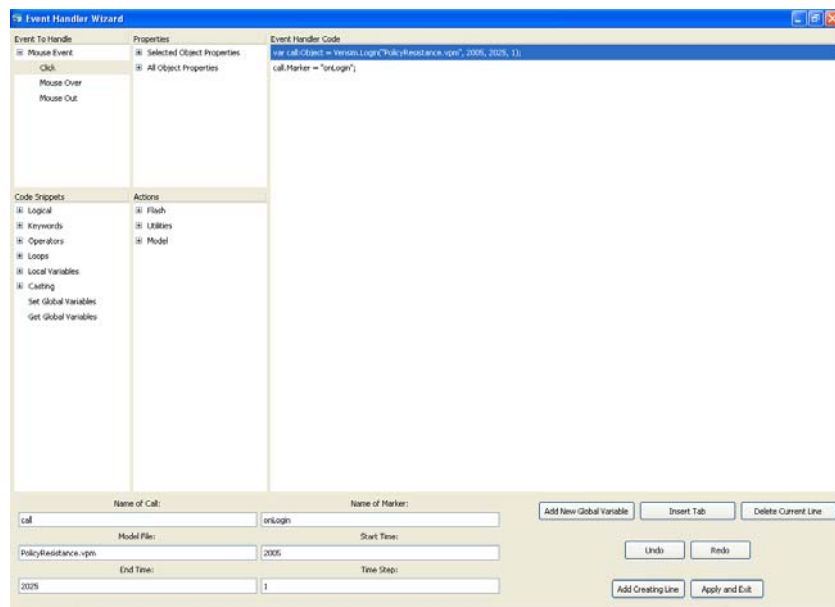
To compile and test an ILE all the user has to do is select the Publish SWF (or Test SWF) menu item in the File menu which will build the currently loaded ILE and open it for testing in the local web-browser. The final step after testing is done, is to upload the resulting ILE (.swf) file to the appropriate server running the ASP.NET Web Service, which runs the Vensim model.

Discussion:

I believe that current tools available to modelers do not allow, or severely hinder the development of ILEs, which truly represent model structure, not just behavior. In Open Dialect it's possible to represent the state of the system using much more then graphs, charts and numbers. Open Dialect allows the modeler to represent the state of the system through colors, shapes, charting, or any combination of the above-mentioned techniques. In this way Open Dialect tries very hard to provide to the modeler the necessary tools to reveal the structure of their model so that learning can be facilitated.

Right now the goals stated above have not been totally met, this software does not yet allow people to easily enough create structure visualizations. Without this key component there is much work to be done in order to automate the process and allow users to reveal the structure of their models with the click of a button, or the drag of a mouse. Though, even without this ability, in its current state Open Dialect does help modelers to create simple single user online ILEs, and by doing that I think it is still encouraging learning.

Open Dialect can be and will become a very important tool for the modeler who wants to spread the results of their work over the Internet. With Open Dialect ILEs that help to close the knowledge gap between users and modelers are: relatively easy to create (and will become easier), OS independent, visually appealing, up to date aesthetically, and dynamic.   The goals of the Open Dialect project are well within reach, especially within the next year.

Open Dialect is most certainly not done yet.   Future features to Open Dialect may be the addition of the ability to produce DHTML in addition to flash files allowing ILEs to be run on more environments including smart phones that do not support Adobe Flash, particularly the iPhone and iPod Touch. In addition, to adding more platforms Open Dialect may be customized to allow for the production of desktop applications as well, using the open source Adobe AIR software development kit. In addition, licensing issues permitting, Open Dialect will be able to interact with more modeling software packages besides Vensim and OpenSim.

Conclusion:

Work on projects like Open Dialect is necessary in order to bring the ideas of systems thinking to the general public. Since the Internet is such a major part of our society today, tools to publish content to it are becoming more and more important if the audience for a particular project is the general public. Open Dialect also has a lot to offer the System Dynamics community because it allows user to create ILEs that are web accessible, modern, and reveal both the structure and behavior of a model system with little effort.

Open Dialect will allow modelers to easily construct single user web based ILEs that incorporate novel visualization techniques, which help the ILE users better understand the concepts the modeler was hoping to teach. Hopefully this software can close the knowledge gap between model users and modelers. Users will be the main beneficiaries of this work, because they will be able to learn more about systems and systems thinking, capturing a larger part of the knowledge created by modelers going through the modeling process. Modelers will also benefit from this work because they will be better able to perform their roles as educators. Modelers will be able to easily use novel structure visualization techniques in order to make the knowledge they have gained by going through the modeling process more accessible to users in the form of an ILE.

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