

Reaction to System Dynamics Modeling From a Woman's Perspective

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"We can't seem to interest many girls in signing up for the System Dynamics modeling classes," lamented Tim Joy, a teacher at La Salle High School in Portland, Oregon, a few years ago. "They think it's a class for computer nerds." Similar comments have been voiced by others teaching SD modeling courses in other high schools. Since SD modeling is such a powerful tool for analysis, the dearth of female modelers in the pipeline does not bode well for the future. With the loss of Donella Meadows there seems also to be a void in women role models who are active at the upper level of the system dynamics community of modelers. Why is there an imbalance in student interest? More to the point, what can be done to attract more females to the study and use of SD modeling?

In hopes of shedding light on this issue, a set of seven questions were posed to some women who have been formally trained in SD modeling or use SD modeling in their work (perhaps having studied the method independently), or both. An email was sent to a group of twenty-four women who were found within the author's network. Five women felt they were not able to answer or did not want to answer the questions, feeling they lacked sufficient experience building models. Four other women did not respond at all. Fifteen women responded to the questions. Of the fifteen, six are in K-12, three of whom are high school students in an SD modeling class. The others are either working at the university level or in the corporate world.

Each question will be presented with a summary of the responses. Within a quotation there may be parenthetical information used by the author to connect, clarify, or at the request of some contributors, rephrase their submitted information.

Question 1: Why do you think learning to create and analyze dynamic systems models is important?

The world is dynamic, both in the physical and social sense. System dynamics modeling is an extremely useful tool to use to understand more completely the causes/interactions of parts of a system, thereby bringing clarity to the forces influencing the behavior of a system. "...before solving any problem, a person should understand the reasons behind the problem and how particular solutions can mitigate or eliminate the problem... It is impossible to come up with good solutions with only partially analyzing the system." "It is more difficult to skip 'hidden' parts of an issue..." "The world is full of feedback, all relationships in the world -- geological, biological, social -- are dynamic, and SD is therefore an extremely useful tool to describe and understand things in the world." "...great tool for helping us make our assumptions explicit and explore the ways in which we might create and can intervene in the problem we face."

Secondly, "It clarifies my thinking and raises questions for further study." "Simulations can help us question our perceptions ..." " Gives a person insights into problems that cannot be addressed with other approaches." "It teaches how to think more deeply."

Finally, it is a "...language for communication, while also requiring a level of rigor..." "Learning to understand systems modeling and create simple ones is essential to understanding social systems, which we desperately need to do."

Question 2: What attracted you to this study?

Again the responses tended to fall into three categories: In the first scenario there was a difficult problem to solve. Either guidance or coercion led to SD modeling as a possible means to solve the problem. "... it was a useful tool for the problem I was working on ..." "...my PhD advisor wanted each of his students to model something to graduate." "I was charged with remedying an intractably poor relationship between two divisions (in my company) who badly needed to work together. ...I gradually gravitated to system dynamics and Argyris' action research as two powerful levers for my work."

Secondly, the cross-disciplinary nature, along with the multi-dimensional design of the models was attractive to others. "I was always fascinated by having holistic approaches to problem solving." "I find it to be a good tool to express ideas using both social science and mathematics skill sets." "... I could quantify real life problems ..." "... you can include many variables in the model that reflect both statistical reality and fuzzy variables which are not statistical."

Finally, the ability to communicate complicated ideas to a broader audience was attractive to those whose job it is to influence/teach. "... (what attracted me was) the fact there was a common language which enables better communication of ideas to all others..." "... at first we were encouraged to think of these concepts and tools as strategies for the classroom. ...I saw great potential for the concepts and tools to be applied in our own thinking and analysis, in the way we viewed our school, our district, our community and in the way we approached decision making."

Question 3: What makes this field especially attractive to women?

Some women responded stating the attraction of the field to people in general: "Both female and male students feel really empowered by learning how to model. They have a sense that they are learning a really useful skill... none of my students, female or male, can resist the STELLA software." "It's holistic, dynamic approach to problems." "You can show a richer reality in your model than traditional statistical tools will allow."

Another group suggested attraction came from SDs ability to address issues that might be more gender related in importance to women, specifically: "I often use the concepts of causal thinking and feedback in my personal relationships with loved ones and other social circles." "...understanding ourselves in relation to others (people, places, events) and about studying ways to improve communication of complex ideas." "Women enjoy analytical thinking, in general... the counterintuitive insights...knowing where the leverage in a system is." "It gives us a common language... it takes the 'gender ability to think' assumptions out of the picture." "...females tend to be analytical...I think most women find that ST/DM serves many purposes, including a validation of the need to analyze and think through and discuss situations." "Using systems models requires concentration, persistence, and organized thinking, ... (characteristics) that I would definitely attribute to myself and many females. Systems modeling is hands on and exciting, but at the same time clean and organized." "... women want to do something challenging and unusual..."

Surprisingly, the final category of responses seemed to come from some of those women who have been formally trained in SD programs. The responses give us pause: "There is not much that makes this field especially attractive to women." "I'm not sure this field is especially attractive to women." "I do not know that it is (attractive to women)." "I do not feel that system dynamics is all that attractive to women. ... either the field is not attractive to women or the field does not encourage women."

Question 4: Why do you think more women are not pursuing this field of study?

Responses to this question were more diverse. The first relates to what might be expected with respect to the fewer number of women in more technical fields. "Many women are not pursuing mathematics, engineering, and other fields that require rigorous thinking. ... I think it is related to social values." "Despite efforts in recent years to attract females to the study of math and technology-there is still a tendency for that field to be perceived as 'not for girls.' ...Some of the improvement should be in how we teach math and technology. There are many societal influences that play a part..." "As with all analytical fields, women appear to lag behind men in participation. One hypothesis is that women have negative experiences with STEM (science, technology, engineering, and math),...second hypothesis, women do not have as much exposure to STEM...third hypothesis, women are more socially oriented...fourth hypothesis, women as early as middle school go through declines in their overall self-esteem and confidence, making them less likely to pursue STEM...last hypothesis: young women do not see a community of practitioners in the SD field that can serve as role models or even like-minded friends." "They may be intimidated. The tradition of male 'computer geeks' still applies, and being a female in such a male field is hard. ...girls...don't want to be classified as one of those 'computer geeks.'" "Just as in the field of mathematics, there is not expectation of a women's ability to successfully 'do' SD modeling."

Some women thought that the method used to teach system dynamics played a role in its lack of attraction for women: "SD as a study today is offered as a method, which is something rather conceptual. Women ... I believe are more attracted, on average, to practical pursuits. Thus, if SD was offered as a component of understanding say, how an education system is set up in a developing country, or how a marine ecosystem is disturbed by global warming, then probably you would find women catching on to it just as well, or better, than the men taking the course ..." "... absence of women is (due) in part (to) long lead time in obtaining advanced degrees. Extensive graduate education in SD, offered at only a couple of universities in the US, is one of the most solid means to becoming capable of wielding the tool...precious few (women are graduating) in a program with a 40-year history."

More pointedly, some women state the unfriendly atmosphere in the SD society, as a deterrent: "I think the social dynamics within the society result in a certain hierarchical exclusivity that can be alienating." "... (there exists a) lack of highly visible female role models, an SD society culture of arrogance coupled with ignorance about other fields..."

Some women experience an unfriendly atmosphere in their training: "The leading SD folks are male. There are SD programs, which are NOT welcoming to or even discourage students outside the 'inner-circle.' I think that women react more negatively to this harsh treatment."

A number of women stated that few women have heard of the field: "I think most women, like most men, have not heard about the field of system dynamics." "I think it just might be lagging because it is a newish and unknown field. Women often get into those later." "...women do not know about this field of study..." "They're not familiar with it or they're afraid they won't understand it..."

Finally, a breath of hope: "I can't speak to this because I haven't found this to be true at (my university)."

Question 5: What were some of the most difficult problems you encountered in your study (either topics or pressures)?

The most frequently occurring response had to do with inequity women felt in their educational environment: "...it is not always easy to be in the minority. ...I had the sense that the females had to work harder than the male students in order to get the attention and respect of the male professors who taught in this discipline." "The most difficult challenges I faced had less to do with system dynamics theory or practice than with the environment in which I studied. ... I found it hard to do

creative research in such an environment. If I hadn't cared so deeply about my dissertation topic, I probably wouldn't have stuck it out." "...there was little expectation of my succeeding. While the men in my training group were given all the trainers attention and positive feedback, I was at first put to the side. It took longer for an acceptance of my skills in SD. ... while the men in the group could be aggressive ... I was assumed to be pushy and dominating when I put forth my ideas on models. I had to adjust my style to be more accepted by the men and other women I worked with than I feel a man in my position would have been." "Students were treated subjectively, with rules for performance assessment shifting during classes, making the learning environment an extreme hardship." "One problem I had with writing models is that I did not conform to the standard way of writing models...So, one model of mine has been used as an example of a badly formulated SD model...There is not a critique of the actual dynamics in the model, which apparently people find to be somewhat credible. ...the incident has been something of a turn-off. I do SD now in my own work all the time, but I don't bother publishing it in the SD review or going to the conferences." "Whenever I tell people that I enjoy systems dynamics modeling and that it's one of my favorite classes at school, I invariably get answers like 'Wow, you're such a nerd.' I try to shrug it off, but I don't really remember ever hearing one guy say to another guy that he's a nerd for liking computer classes."

Some women felt uncomfortable in the initial application of SD in the workplace: "The most difficult problem for me was learning how to confidently approach the different players in the industries I was studying. I was never sure that they would be honest with their information, give me the time I needed to understand a particular dynamic...It was difficult to identify who would have the information I needed." "I am not sure I have the experience or confidence to approach practitioners in the field to gather the appropriate data for the models I develop."

The rest of the responses did not seem to cluster around any one theme. They are presented here in a miscellaneous category: "...the biggest problem I had with modeling was not having had any introduction to it (before being required to use it)..." "We are required to take lots of subjects in unrelated fields, therefore leaving less time for major and minor subjects..." "The fact it (SD modeling) takes so much time and it is easy to get notions which are inaccurate and in fact wrong. It does not follow the same logic paths which are conditioned in us in school." "The only difficulty that I have encountered is that some people seem to think that you are either a systems thinker or a dynamic modeler. If you talk about one, they think you know nothing about the other."

Question 6: Have you or do you think you will use what you learned in SD modeling in your career? Why or why not?

Many of the respondents plan to and do use SD modeling in their field of expertise: "The modeling I have done has focused on studying the impact of climate change on lake basins in the Southwestern U.S. I've developed my own models and have also used existing (models) ...I'm sure I'll continue to use these models..." "I will always use it to formalize and test the consistency of my thinking...I may also use it to test the behavior of systems that I am working with and to find leverage points." "It became a style of teaching and thinking for me. In addition to my mentor and training of teachers and students, I have used it in presentations to adults in the school systems for population studies." "I currently have funding from NSF to use SD-based tools in my research. I am interested in dilemmas faced by the general modeling communities associated with policy implementation. I use system dynamics models as the backbone for a population of individuals that learn from one another using evolutionary algorithms. The individuals make decisions that influence the structure of the SD models." "I currently use system dynamics both in theory development during research and in practice as I help a few companies address dynamically complex problems." "I use modeling in many ways (in K-12)...developing and demonstrating content understanding, thinking skills, technology skills, generic structures, developing instructional skills in teachers, dynamics system awareness and to facilitate 'what-if' scenario thinking/planning..." "In physics, when learning about springs, I found myself constructing rough

mental STELLA models to model how a spring's oscillations approach zero because of air resistance." "...I have to at least have some conversance with modeling in order to work in SD in K-12." "I am planning on publishing papers in the system dynamics field as well as introduce this field and methodology to the finance field."

Others, use SD modeling as a way to think about how to approach their work: "I think I use it all the time. My experiences with this discipline have fundamentally changed the way I see the world. ...I have a lens of inter-relationships through which I view the world." "I use it all the time, but I have no connection to the SD world...perhaps that is true for more women." "The aspects of system dynamics I use the most are the 'mental model' aspect involving both the broad view and the long view. Also the SD principle of closed feedback loops..." "I will use some of the techniques - stocks and flows, causal loops. Due to my bad experience, I now feel my modeling skills are inadequate...My bad memories have led me to refrain from building SD models."

Question 7: Has it been your experience that fewer women (than men) study dynamics systems modeling? Why or why not?

One serious issue appears to be the inaccessibility of formal training sites, leading to lack of diversity in training styles: "Training is not offered in very many places. ... the barriers to entry in math may be barriers to entry in SD..." "Yes...Now, I am the only woman in the PhD program at (my university)." "Yes...it (SD) is presented as a method, to study separately, rather than as a tool to use within a practical pursuit of an important issue ... there is something of an orthodoxy in the way SD is taught in SD departments...which has to do with form rather than content, and...may be less attractive to women..." "My observation here at (my university) is that more men than women have the opportunity and desire to take on graduate studies, so I see the difference as more of a gender thing than anything else." "Yes, I think it is because it is such a small field. ...there are a greater proportion of male teachers involved in SD than there are in the general teaching pool."

On the other hand: "No ...I've had about 50-50 representation." "In my work with teachers there were more women involved at the introductory stages. Although with students more boys became interested in the actual modeling process."

Conclusion

If it is deemed desirable to try to increase the number of women who study and use SD modeling some suggestions can be made about how to proceed.

It appears that a significant number of women find the use of this tool more attractive if applied to a diverse set of real world applications, rather than as the study of a methodology in the abstract. Multiple responses indicated that the tool helped bring insight to social relationships. Many women felt the "richness" of the models that could be built, compared to traditional statistical methods, was very important. The ability to use the tool to communicate to a diverse audience was attractive. So curricula that addresses some of these issues may be helpful in attracting women.

Having been exposed to the field via trying to solve a seemingly intractable problem, or because it provides a means to study problems holistically (using visual software that reaches a broad audience) almost all the respondents felt the SD modeling approach was valuable.

Why was SD modeling attractive? Because it was empowering! Because women felt it allowed them to address important problems, without the oversimplification of traditional modeling. SD modeling provided more potential "choices" for influencing the behavior of a system, that would have been hidden by other methods of analysis.

For those comments that were more specific in SDs attractiveness to women, it appears the approach fits the natural desire for analytical, social, and communication study that might be considered gender based.

All the women indicated that they use/plan to use facets of SD modeling in their work. Some will create computer models, others will use the stock-flow diagrams to analyze problems. The long view and the feedback view will be part of their professional and personal lives.

When the request was made, for responses, the previously mentioned conclusions were the type of information anticipated. Yet, more issues surfaced which were of a nature that makes one stop and reflect on potential roadblocks to expansion of the SD approach. Unfortunately, some learning experiences have left some women with mixed feelings about aspiring to join the group of leaders in the SD community of modelers. This is a serious problem. Women need role models in the SD community. Those role models need to be women whom the SD community can embrace as worthy practitioners. If there are not such women, why not? Are not enough being trained? Is the training not diverse enough to attract a broad audience of women? Are those who are trained not welcomed/encouraged to participate in the community? This is an issue that merits attention.

Author's note:

I have been teaching SD modeling at the high school level since 1992. In that time I have not seen any difference between the males' and females' ability to model in my classes. I have almost always had a near 50-50 ratio of females to males in the modeling classes. Some of that may be due to the fact that, in teaching mathematics, I have tended to encourage females and males in my math classes to consider taking the modeling class. I do think that women who are somewhat facile with mathematics are more likely to respond positively to the technological part of creating models. Where should I recommend these girls go, if they want to continue to study SD modeling? We all, in the SD community, feel that SD modeling is a superior approach for analyzing real-world problems. We need to encourage women as well as men to continue along this path. (Of course, if we want to change the way the world thinks, first teach mothers.)

Appendix I: Summary of Responses

(The number in parentheses after each summary statement represents the number of women making a response that seemed to fit into the given category.)

Question 1: Why do you think learning to create and analyze dynamic systems models is important?

- SD modeling helps a person understand a problem more completely, especially the feedback dynamics, so potential solutions are more apt to work. (4)
- SD modeling requires the modeler to be more critical of her scope and depth of analysis, eventually enhancing her critical thinking skills. (4)
- SD modeling is a powerful communication tool, allowing analysis of complex social issues. (2)

Question 2: What attracted you to this study?

- SD modeling was seen as a means to solve a seemingly intractable problem. (3)
- SD modeling allows a holistic approach to problems in a cross disciplinary manner. (4)
- SD modeling is a powerful communication tool, allowing the user to reach a broad audience. (2)

Question 3: What makes this field especially attractive to women?

- The holistic approach made SD modeling attractive and the actual modeling process was empowering (3)

- SD analysis provided the ability to enhance interpersonal skill (2).
- Many women tend to be analytical so there is a comfortable fit with SD for women. (5)
- SD modeling was not especially attractive to women, since there are so few in university SD programs or prominent in the SD community. (4)

Question 4: Why do you think more women are not pursuing this field of study?

- Women are not traditionally attracted to technical fields, for many reasons. (5)
- The lack of a diverse curricular approach to the study of SD modeling, especially due to the few programs available for advanced degrees. (2)
- An unfriendly and/or non-inclusive atmosphere in some programs or in the SD community inhibits further interest in the field. (3)
- The SD field is not well known. (4)
- There are as many women as men pursuing SD modeling at one respondent's university. (1)

Question 5: What were some of the most difficult problems you encountered in your study (either topics or pressures)?

- The social environment in which the study was pursued was most difficult. (6)
- The initial application of SD in the real world, gaining the trust and assistance of clients, was difficult. (2)
- The steep learning curve was difficult. There is a need for more introductory lessons. (1)
- The time needed to learn SD well enough to be able to apply it was difficult. There is a need for more varied time frames to assimilate learning core SD concepts. (2)

Question 6: Have you or do you think you will use what you learned in SD modeling in your career? Why or why not?

- Many women use SD modeling in their work. (9)
- Others use SD analysis as a method of approach to their work. (4)

Question 7: Has it been your experience that fewer women (than men) study dynamics systems modeling? Why or why not?

- Yes, fewer women than men study SD modeling due to the inaccessibility of training sites and styles of instruction. (5)
- No, there are about the same number of women as men pursuing SD modeling in their arena. (2)