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Building Sustainable Interest in Modelling in the Classroom: The Implications of the S-curve for Hooking New Practitioners in Schools

"Your job is not to make drink, your job is to make them thirsty"

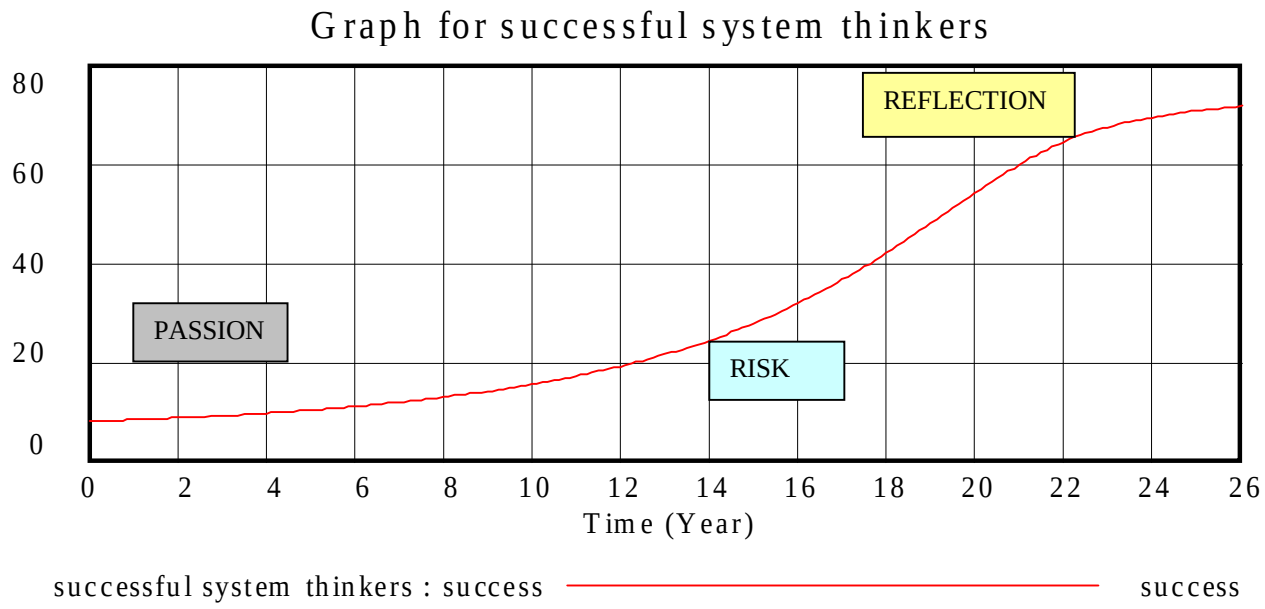
Abstract

System Dynamics has had a tough time breaking into High Schools. Like all good ideas the most difficult part is convincing those who would most benefit that this new approach is in their self interest. When system dynamics is only presented as a computer based tool, most teachers will not try it. When we introduce systems methodologies in a way that focuses on the richer, softer and more human side, teachers start to simulate more quickly. Learning the "System Dynamics Way" is in fact introducing a changed relationship of learner, teacher and subject material. Five strategies that have been practiced in three countries will be presented in detail. Systems Thinking can help to build a sustainable learning process. The three distinct parts of the classic learning S-curve that can be represented as "curriculums" are: build ***Passion*** slowly, accelerate learning through ***Risk*** taking and consolidate understanding by ***Reflection***. Using computer models is the goal because computers are the best tool for student controlled exploration and reflection. To bring practitioners on board stealth should be used to *implicitly* train students and teachers about systems thinking.

"People don't resist change, they resist being changed"

Introduction

The implied message of a System Dynamics classroom is a change in the POWER that the learner has. The student now holds more power than the subject or the teacher. The sustainable S-curve will be used to study teaching methodologies that will work in the LONG TERM. This paper will present experiences of the past two years experimenting in classrooms using the principles of system thinking. There will be examples of experiences in Canada, Australia and Singapore. The author believes that System Dynamics needs to focus on more than computer modeling. As a community we need to push for a changes in the overall teaching process and in the learning strategies that it, by its very nature, implies. A better understanding of this human dynamic would mean more practitioners would take up simulations as a regular teaching tool. A simplified version of the 6 step modeling process of Goodman and Karash (1995) is used as the template for this process. The proposed model for a 3 stage sustainable learning curve is:



"My company was an overnight success after 10 years of blood, sweat and tears"

Learning Strategies to build Sustainable Learning

In this paper five strategies to create a sustainable learning curve that have been used in three countries are presented. These techniques are NOT presented as THE answers but rather as tools that have been found effective in the situations encountered. What becomes more important than mere information is the changed attitude towards the knowledge acquired: "What can I do to develop deep, sustainable learning?" For of what use are schools if the students just learn to pass the exam and then forget what they have learned? Rather, following in the path of Peter Senge (The Fifth Discipline), educators need to be asking themselves ***"What can we do to turn our schools and classrooms into learning organizations"?*** (O'Neil, J.)

The strategies that will be presented are:

1. **Quality Learning**; using TQM principles in the classroom (Langford)
2. **Strategic Learning**; parallel to subject content learning skills to "learn how to learn" are taught (Simpson & Nist); a good example are the "lateral thinking" tools of E.deBono (deBono)
3. **Brain based learning** (Dryden & Vos) & "Layering" (Nunley); use the latest in brain research and experiences gained with learning disabled kids to improve learning for all kids; focus on differentiated tasks, student choice, and setting up tasks ahead of time with learning styles and multiple intelligences in mind. (Gardener)
4. **Simulation as Serious Play**; using simulations in the sense of computers supporting open ended, exploration that values process, relationship and personal meaning over the "right answer" (Schrage)
5. **Web based learning**; use the internet to allow self-paced, interactive courses so students can learn at their own pace (EDEN project)

When these strategies are used together in the systems structured sense of Passion – Risk – Reflection, any classroom can be turned into a mini "learning organization". In effect, there are at least three curriculums which can be matched to the 3 steps of the sustainable learning model outlined above.

Curriculum #1 is about creating **Passion; how to motivate**, build self-confidence and answer the career oriented question "What's in it for me?"

Curriculum #2 is about creating an **atmosphere of Trust so learners Risk**, explore and increase the speed of learning new material, have more retention by active participation, and are taught strategies of "learning how to learn"

Curriculum #3 is about **Reflection and Metacognition** of the subject material; "Do I know what I know?", "Can I explain what I think I understand to somebody else?"

New teachers and student practitioners are "hooked" when they see the enthusiasm, success, and apparent ease at which teaching and learning seems to flow in a Systems based classroom. It is thus by example, by word of mouth and slow diffusion (Surry & Farquhar) that a new technology and approach to learning gains adherents. It is slow and takes persistence. But if you persist, the System Dynamics way of active, student centred learning with the computer, will take hold in any class and in any school.

Work on the System - Not in the System

Case Study #1 – Grade 7 Science Class, Alexandra, Australia – Creating Passion

While on a teaching exchange in Australia last year, I was initially frustrated by my inability to connect with the students. Their anti-authority cultural stance made any "pushing" to higher standards

and quality of work counter-productive and only created bad feelings and tension in the class. However Australian students and adults are enthusiastic to try out new ideas. This exemplified by their expression "Give it a go mate!". As a results risk and innovation are supported. This allowed the author quickly introduce new teaching models in his classes. The challenge in this small country school was clear: how can a teacher meet the learning capabilities and needs of a large spectrum of ability without boring some and frustrating others. While doing research on this question from a Systems Thinking world view, the author came across three approaches that started this school onto a path of more inclusive teaching. These approaches; Layering (Nunley, K.), Quality Learning (Langford, D.) and Multiple Intelligences (Gardener,H.) supported "sustainable learning" in the classroom by supporting the three step Passion- Risk – Reflection process. The focus in this case study is part one of the sustainable learning curve: building passion for learning.

You can't direct the wind but you can adjust the sails.

Step 1: Build Passion

For a non-Australian the biggest shock was to experience the discrepancy between the students' ability, which was very high, and desire to achieve high standards, which for most part was very low. (Australia has the second highest High School drop out rate in the Industrialized world) The author told the students up front that as this was my "Sabbatical year" I would be trying out new teaching methods ***with*** them and needed their participation and comments to make them work. This certainly got their attention. We decided together to study an entire unit in groups and present what we had learned to the class with a handout. The questions and answers they wrote would become the unit test. Unfortunately this approach failed to include all learners. The weak students still did nothing and if anything did even less and behaved even more rudely than before. In spite of this, there were great presentations by the highly motivated students who really enjoyed taking charge of their learning. So I paused, taught myself and tried K. Nunley's concept of Layering. Her approach works as follows:

A. Give students a range of work options at the start of the unit which is listed in 3 "layers", work options include all learning styles (visual, oral, kinesthetic, concrete operational or abstract) and the 3 three levels correspond indirectly to the final mark (assuming good work quality) desired by the student
B. The students then worked at their pace; alone or in groups, on the work requirements with experiments on a regular basis to enliven the activities. My job was less to teach than to assist individuals when needed. It also gave students the chance to explain to others what they had learned and become peer mentors.
C. Finally, the evaluation type and time was decided together with a "pre-test" given with answers and more time to identify and repair misunderstandings. The final test itself was "layered" so that it the mark the students were striving for was clear. A variation I added was to reverse the mark weighting so the layer 1 (easier questions) were worth more marks than the layer 2 & 3 questions. Every step of the learning process was clear ahead of time and had been decided upon together.

The sense of control this gave to the students turned the class around and, more importantly, it changed our relationship from one of confrontation to one where we were together moving towards a common goal.

Learned Helplessness or Learned Optimism – The Choice is Ours ***- Martin Seligman***

Step 2: Create Trust so the Students will Risk & not be afraid of Mistakes

Thank goodness this was an easier process than creating motivation. Australian students loved to risk, never had problems with mistakes and were used to working in small groups. The only problem was that some of them would openly say "I'm too stupid to do this work or understand it" and then of course not even try! This too was a shock. It seemed that they were so insecure that to do hard work and then to "fail" was more dangerous than an open public admission of a low IQ! Since I had managed to motivate them the trick was to get them out of their comfort zone and extend themselves. So the students did an Australian version of Gardener's multiple intelligences (McGrath, 1995) test with an explanation and several stories about people like Einstein who had dyslexia but were still

geniuses in one "intelligence". Then I created a "modifed" Science program that allowed students to have an individualized work and assessment program. This was done in conjunction with the school "Student Welfare" teacher and with the parents. Involving the family was a big plus. All of this planning was initially much more work however it reduced misbehavior and increased learning because of students were less frustrated as they felt in control of their learning.

Step 3: Help the students "Know what they know" by Reflecting upon their Skill Level

The ultimate goal of this sustainable learning paradigm is the toughest: can the students explain to others in written or oral form what they know and are they able to track and predict their marks. I was lucky enough to attend a 4 day workshop entitled *Quality Learning* (Langford,D.) The Ministry of Education in the State of Victoria is working with the Australian Quality Council (www.agc.org.au) to instill, voluntarily, Demming's Quality Management Processes (Walton,M.1986) into School Administration and Classroom teaching. To quote David Langford:

"The results of using Continuous Improvement Processes were dramatic. Using basic statistical tools students were able to chart their own learning process, evaluate their work and start taking responsibility for their learning." (Langford,D.)

The values that go along with this very quantitative and rigorous approach to student learning can, with some thought, be instituted into any class, school or school system as it focuses on processes, not curriculum. Some fundamental beliefs are:

> Grading is not a motivator.
> Students can and should help plan their own learning processes.
> Failure is a learning experience.

After several months of working with the above methods, in a constant feedback cycle, I was able to see that I was getting close to my goal of students learning for its own sake. I was spending my time working on learning processes, rather than classroom management and discipline; in other words, to use a Quality Improvement aphorism: I was working on the System, not in the System. The payoff in terms of spreading these approaches with other teachers were:

A) many came to workshops I offered
B) several asked for resources so they could teach this way ***because the students asked*** them to
C) the Principal asked me to make a presentation on Layering to the governing School Council so that this method would be officially recommended to all teachers for the following year

Those who dare to teach must never cease to learn - Socrates

Case Study #2 – Teaching Staff of New Town Primary School, Singapore – Encouraging Risk

On the return flight from Australia I was invited to present a half day workshop on the use of the Quality Learning values and methods based on Systems Thinking processes. Although the two cultures and educational systems could not be more dissimilar, both had arrived at one key shared point: that learning more "stuff" did not make a better education. In Singapore, the government initiative to spur on more creative thinking is called "Thinking Schools". (Yin Mee) An example of the kind of shift in method and values that Singapore is attempting is given by this comparison below. (Deitz, M. 1996)

Current Design		***21'st Century School***	
Design Element	→ Consequence	Design Element	→ Consequence
1 teacher & 1 class	isolation	teams teaching	adaptability
external control	fragmentation	internal control	commitment
staff are replaceable parts	alienation	variety of staff roles	flexibility
isolated tasks	simplification	integrated task grouping	learning
1 best way	conformity	many "right" ways	innovation

The cultural norm of "saving face" and not admitting to mistakes makes innovation and risk taking very difficult in Singapore. What I call step 2 of the sustainable learning curve; RISK, was the challenge presented to me as I presented a 5 hour workshop entitled "Systems Thinking & Quality Learning: How Can the Best Get Better?" (Kubanek,G. Singapore 1999) In the workshop the focus was on using experiences and provocative systems games (Booth) to get the teachers out of their comfort zones. The key learning tool was a simulation called Fishbanks (Meadows). Based on the feedback sheets new insights that would stick came about when the ***teachers experienced learning*** rather than being told or shown this new way of teaching.

Upon reflection and after reading the feedback from the participants my guess that experience, rather than information and explanations of theory, made an impact on "hooking them" into teaching like Systems thinkers was validated. However, the degree to which experiential "playful" learning (in the sense of using simulations as Schrage) worked and the degree to which my explanations had virtually no impact, shocked me. It seems that adults, even more than students, need to be in charge of their learning, work in teams, be motivated by curiousity and know that their leadership is there to support them, not "boss" them. I was grateful for the teachers' feedback as it made clear that it is more difficult to get adults than students on board the "Systems thinking bandwagon". Only by personal exploration in a non-threatening experience did the adults open up to a new way of teaching and learning.

If you think you can you can and if you think you can't you're right. – Henry Ford

Case Study #3 – Grade 13 Chemistry class in Ottawa, Canada – Building a mood for Reflection

In this grade 13 Chemistry class I noticed that deep learning was being blocked by an obsession with marks. Fear was blocking many students from reaching their potential. They would not work together even when asked. The challenge was to change the "mood" of the class by a subtle shift in values. By using stories, activities and different assessment tools that could make students first enjoy the class, work in teams and use a system dynamics simulation project, I was able to have the students see learning as process rather than a final goal. The challenge here was step 3 of the sustainable learning curve: reflection. But to get to this goal of metacognition, I had to work building in assessment processes that were intrinsic (learning for its own sake) rather than extrinsic (marks' driven results).

As with all sustainable learning, it was a slow start and the initial "tilling of the soil" was in the "Affective Domain" (emotions). I read stories, for example; some chapters from Goleman's book *Emotion Intelligence;* or the article about the London cabbies whose posterior hippocampus [part of the brain used in navigation] was larger for cab drivers who spent more time on the job. (Freeman) We even played poker one day! Why? Because many students in this class felt that they could only achieve a certain level because they were not "smart", or did not have good support at home, or some other "reason" that allowed them not to take full responsibility for their learning. By using the Poker game as a metaphor (lectures are useless!) they could begin to see that it was more important how you played your cards (personal effort and social skills) than the cards dealt to you (family background, gender, etc.). Now clearly this is a gross oversimplification but by using similar techniques almost every day, the mood of the class was subtly shifted and there was even laughter most days.

Once the values that I was striving towards were clear an Independent Study was assigned. Three options were given but most students chose to do a system dynamics simulation. The project had several parts: download the instructions to do an oscillating clock reaction from the web, do the experiment and collect the data, learn Vensim enough to build a simple oscillatory model whose frequency would match that of the experimental data and, most importantly, log the feelings on the

learning process. It was made clear to the students that coming back to me for questions, after doing lots of work, was a necessary part of this project. Students who did come for help at key points and thus used me as a "coach" loved the project. Those who were still "afraid" and unable to grasp the fact that there was no "right" answer did not come for help. They were frustrated and did not do well as they were unable to document what they did and why. The role of metacognition, of being able to communicate the stages of learning they went through were critical to the success of this project. Here are quotes from two of the students:

"As she walked deeper and deeper into the Australian jungle Dihanna didn't know what she would come across. She had been sent into this wilderness by her professor Dr. Kubanek to investigate…" (Kitcher)
"After observing the real experiment, I understood that I was expected to make a model of what I just saw and hopefully be able to match my observations to the graph the program would produce. I went home, downloaded the program, looked at it and thought "***Huh?***" After discussing the software with Mr. Kubanek, I was shown a preliminary model and I went home to ***play*** around. But I knew that I gave the desired look that I wanted, a nice oscillation back and forth. "However, you want the reaction to die off," he said to me. "Look up damped oscillations in the .pdf manual that you can download from the website. You will need an Adobe reader as well." Pdf manual? Adobe reader? That's when the real fun started." (Orchard)

While the students were working on this project outside of class time I kept hammering away every day, 5 minutes only, to get them to value process over result and seeing the question as more important than the answer. Examples of methods used to do this were deBono's alternate route game (de Bono, E. 1995) and his presentation on using provocation (de Bono, E. 1998) to enable movement out of your comfort zone. I also read them chapters from Schrage's book *Serious Play*, (Schrage,M. 1999) and showed them some "microworlds" downloaded from the internet that showed that "big people" also valued exploratory learning where there was no one "right answer". Altogether, after several months, the learning in the class style and mood changed dramatically. The students were now comfortable working in teams, going to the board to explain their solutions, making mistakes was OK. They enjoyed the class much more and, finally, there was a marked improvement in the quality of learning. All these Strategic Learning (Simpson & Nist) methods meant that learning was as much about ***"learning how to learn"*** as the content of the chemistry course. With the sustainable learning curve in mind, with the 3 steps of Passion – Risk – Reflection, learning tools were selected and employed that turned memorization for the test into metacognition of how Science is learned and how Scientists interpret the world.

The result are encouraging. Spreading the value of active, student centred learning within the school has been excellent. Other teachers and student teachers have tried several of the ideas. I now DO what I believe is best for students: teaching using this three step Systems Thinking template to build sustainable learning. The use of computer simulations as a theme for a grade 10 Ecology project has been enthusiastically welcomed, and the Principal has been a great supporter of more computer, student centred learning styles. Furthermore, the local Board has sent me to conferences, workshops and invited me to speak at several workshops on the use of the above described teaching strategies.

Learning is not a Spectator Sport

Conclusion

The educators at the more senior levels understand very well that all these efforts are instilling a different mood into the class were learning is personalized, and where Senge's ideas of creating learning organizations is beginning to take fruit. As stated in the Abstract building sustainable learning is about changing the power equation; but with this power comes responsibility. As Senge himself said once in an interview (O'Neill):

"One characteristic of an organization that has a very low ability to learn is that people at all levels see themselves as disempowered; ***they don't think that they have leverage*** *to make any difference."*

Since these experiences, other tools have appeared on my desk that provide routes to enable students to take charge of their learning. These tools all revolve around web based training; using the internet as a learning tool in high schools. I am currently involved in a Pilot project use of one such web based learning package from the EDEN Project. (EDEN, 1999) However take note; ***there is no one solution*** in building a sustainable learning environment that engages and challenges all learners: (Sagor, 1995)

> *"In schools where teachers are active learners, excitement and curiousity contribute to a rich learning environment."*

Even before the Information Age, the following quote (Chamberlain et al. 1942) highlights the value in the search for tools that support improved student performance and which upholds the learning organization paradigm:

> *"The most successful school are characterized not by the particular innovation they had adopted but by* ***their willingness to search and struggle*** *in pursuit of valid objectives, new strategies, and new forms of assessment."*

In the Information Age schools are in danger of making themselves irrelevant if they do not shift their focus from teaching to learning, from control to choice by using ideas like these presented in a whole systems framework. By using Systems Thinking structures any school in the world, at any age level, with students of any academic ability can benefit from a shift to active, student-centred, learning the "System Dynamics" way. To change the way students learn we must first change our mental model of what teaching is about, and be mindful of what Albert Einstein said:

Our theories determine what we measure.

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