Drawing Insights from a Small Model of the Growth of a Management Science Field[1]

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Abstract

A formal model of the dynamics of growth, stagnation, or decline of an emerging field is presented, followed by eleven scenarios and strategies that might affect those dynamics. The purpose of the model is to stimulate thought and conversation within the field of system dynamics about the growth of the field and to provide a bit of simulation-based grounding for those conversations.

Introduction

Over the years there have been a number of reflections by system dynamics practitioners focused on or related to the growth of the field, including (Fey 1981), (Wolstenholme 1983), (Andersen, Radzicki et al. 1997), (Sterman 2007), (Warren 2007), (Forrester 2007), (Homer 2007, 2014), (Graham 2009), (Milling, Harbig et al. 2012), (White and Sholtes 2013), Homer (2013), (Warren 2013, 2014), and undoubtedly others.

Some of the talk has been pessimistic: we should have grown more, or faster. We should be more widely recognized among the management sciences, or in the popular press. Some has been cautiously optimistic: It's been asserted that we've grown at roughly 8% per year since 1960. Homer (2014) tracks the actual data of the membership in the Society and shows that the growth of the Society has slowed to about 3% per year and may even have stopped. Other model-based investigations include Andersen, Radzicki, Spencer, and Trees (1997) and Warren (2007). The latter reports on structured strategic conversations with members of the Society. Using his strategy dynamics approach and tools, he identifies important resources related to the broader growth of the field.

This model-based study is intended to build on those varied efforts and to move us toward implementable policy initiatives. Though small, it is larger than the model appearing in Andersen et al., broader in scope and less data-based than Homer's, and less detailed but richer in feedback structure than Warren's. The purpose is to help the system dynamics community think about opportunities and threats affecting the growth, stagnation, or decline of the field. To be clear about assumptions, the note necessarily begins with a focus on the model, its structure and behavior under a variety of scenarios. But the discussion is aimed toward thoughts about the real dynamics of our field and initiatives we might take to influence its growth.

A Model of the Dynamics of Growth of an Emerging Management Science Field and its Domains of Practice

People who identify with an emerging field can be aggregated and disaggregated in various ways. Here we choose two populations: less experienced, less skilled, less knowledgeable practitioners – here called Novices – and those who would be regarded as very experienced, very skilled, and very knowledgeable in the field – here called Experts. (See Figure 1.) The more of such practitioners, doing quality work that becomes known, then the more people are attracted to join them in the field. The model defines "expert" as the level of expertise one acquires in about fifteen years of guided and reflective experience.

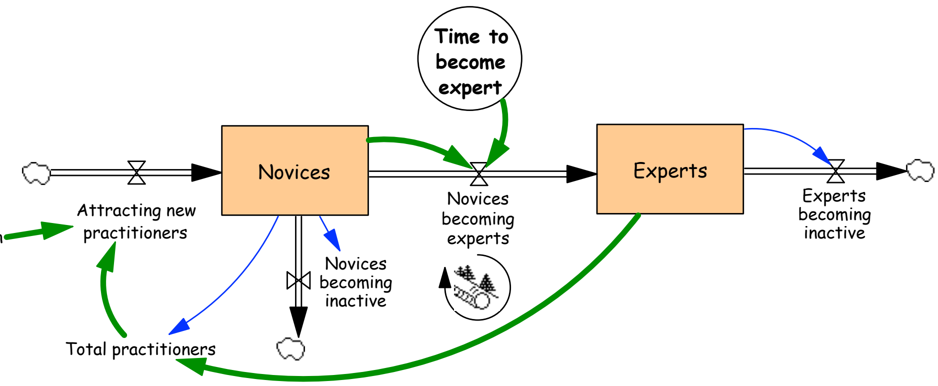

Figure 1: Reinforcing loops in the growth of practitioners

Novices and Experts produce products (see Figure 2), an aggregate concept encompassing conference papers, articles, consulting projects and reports, newspaper articles and columns, web postings, and so on. Some fraction of these (the model assumes 70% in the base run) are somehow visible in the broad marketplace of applications and ideas. The quality of these products is scaled from 1 to 10, with the baseline quality of novice work set at 1 and expert work at 10. The particular scale, of course, is immaterial; what matters in the dynamics of the model is the quantification of the *effects* of quality.

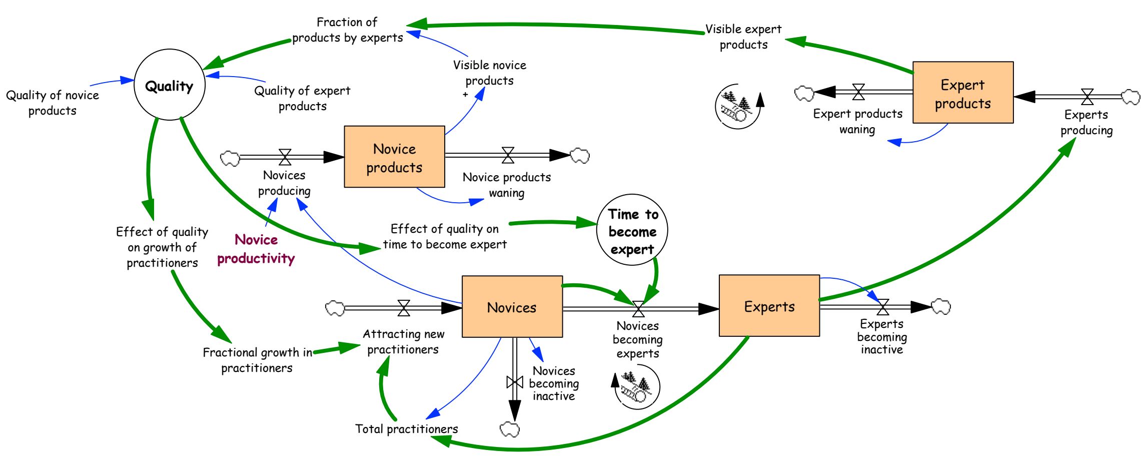

Figure 2: Feedback loops associated with promulgation of work in the field and the resulting perception of Quality.

The visibility of work in the field (Figure 3) and its quality attracts potential consumers of system dynamics work, here optimistically called Supporters. Over time, some fraction of these (the model assumes 0.1% per year) become potential project champions, likely advocates and sponsors of system dynamics work. Those Potential Project Champions help to generate Demand for system dynamics research and applications. The ratio of that Demand to the number of Experts in the field feeds back to influence the productivity of experts and the length of time experts and novices are active in the field.

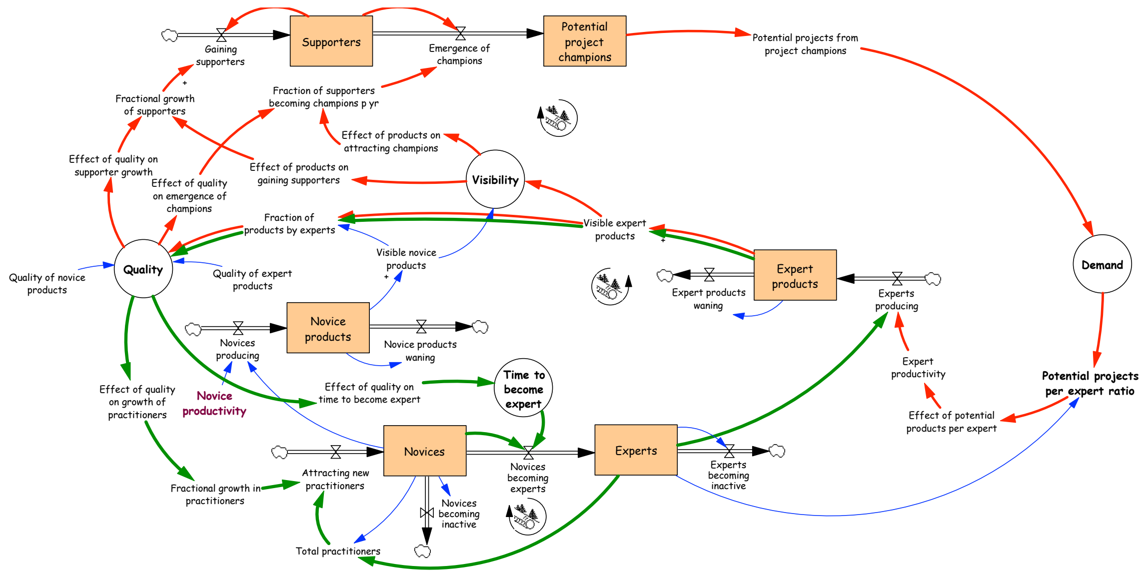

Figure 3: Adding stocks of supporters and potential project champions, together with feedback loops (in red) associated with growing demand for work in the field.

Figure 4 adds the notion of Domains of application and research. The model assumes that the more such Domains are developed, the greater will be the number of potential projects and thus Demand for system dynamics work. Figure 4 also completes more feedback loops involving the time Novices and Experts are active in the field, and the attractiveness of the field to new practitioners.

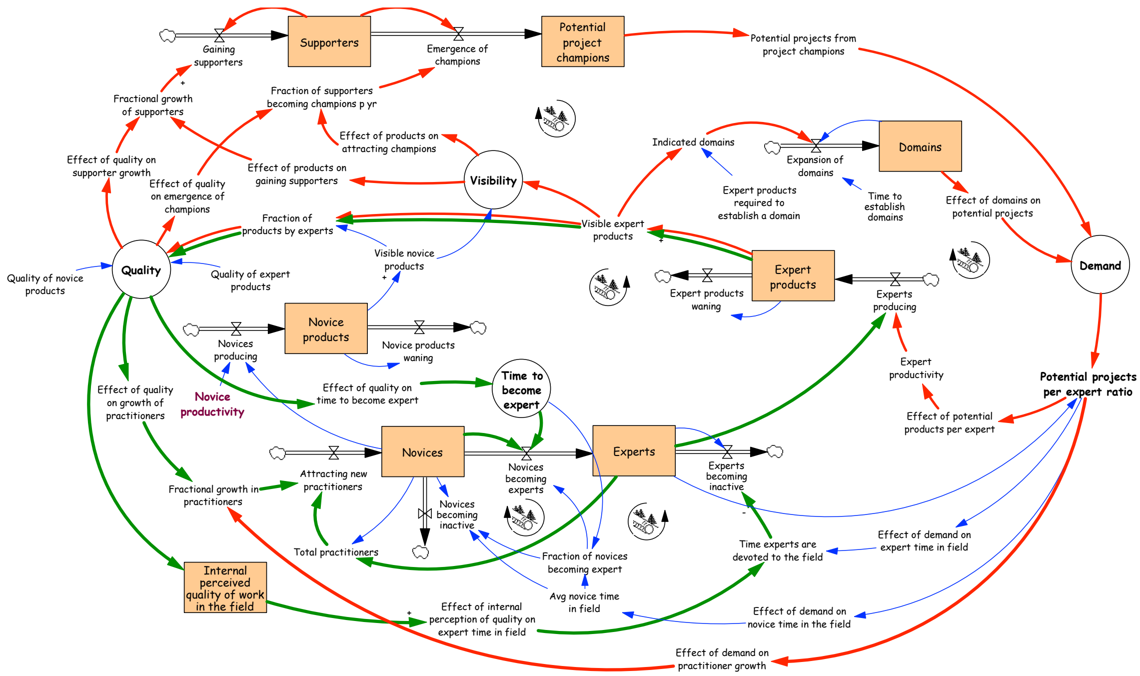

Figure 4: Adding the stock of Domains (areas of application) and closing loops back to the dynamics of practitioners completes the stock-and-flow / feedback structure of the model.

Figure 4 is the entire structure, minus a few scenario and policy levers left out of this view for clarity of the picture. The result is a small dynamic model that nonetheless captures some of the complexity of the growth of a field like system dynamics, as the next section will illustrate. Visibility of work in the field appears in 66 feedback loops in the model. The stocks of Experts and Novices are involved in 105 and 117 feedback loops, respectively. Quality figures in 101 loops, and Demand 105. One could say the model is small and conceptual, but rich.

Thoughtful Experiments with the Model[2]

In its present form, the model is at best merely suggestive about scenarios simulating the growth of a field like system dynamics. The time frame begins in 1960, and the numbers of early Novices and Experts roughly matches our field, but the model has not been carefully fit to data matching our field. Parameters in the model have been selected for plausibility and for their potential to help us see implications, but they have not been tested rigorously.

Nonetheless, the model can stimulate thought and conversation, and that's its purpose.

Base Run

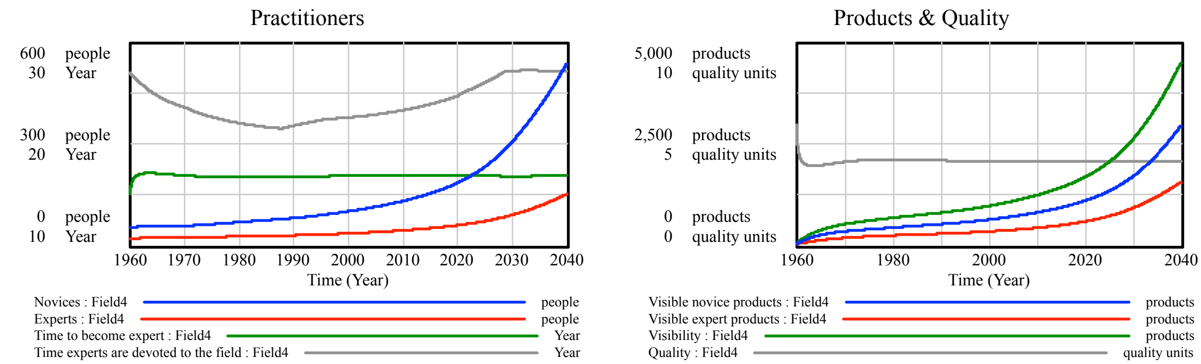

Figure 5: Base run of the model, showing on the left practitioners, and on the right products, visibility and quality.

The base run of the model in Figure 5 shows modest growth of the field, probably more modest than the field of system dynamics has experienced. Certainly the number of "products" (articles, consulting reports, conference papers, newspaper items, blogs, and so on) is smaller than it appears to be in our field. One might suggest the normal fractional growth parameter is too small. It's set at 15% per year in this run. So let's try raising it. If it is set at 20% per year, we see the following unexpected behavior: *less* growth in practitioners, supporters, and domains of application.

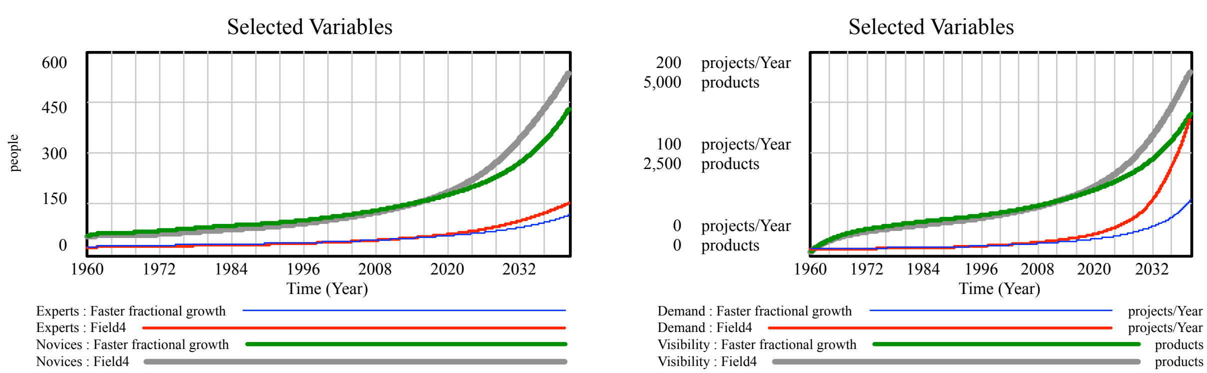

Figure 6: Setting the parameter for the normal fractional growth of practitioners to 20% per year, up from 15% in the base run, results in *less* growth of the field: Fewer novice and expert practitioners and supporters (left), and less demand and visibility (right), all compared to the base run (called Field 4 in all these graphs).

Why should that happen? The model makes the very plausible assumption that the quality of novice work in the field is much less than the quality of expert work, and that the quality affects the reputation and attractiveness of the field. Raising the parameter for the normal fractional growth of practitioners does indeed generate a greater inflow of practitioners and a greater number of novices up to about 2012. The number of practitioners is a bit greater up to about year 2008, but the lowered perception of quality of work in the field slows the growth of supporters and potential project champions. The important implication of this simulation is probably its opposite: a field can try to grow too fast; counterintuitively, slower attraction of new practitioners may actually be the faster growth path.

But we are ahead of ourselves. Let's try more experiments to generate more thinking.

What if Potential Project Champions (Figures 3 and 4) never take off?

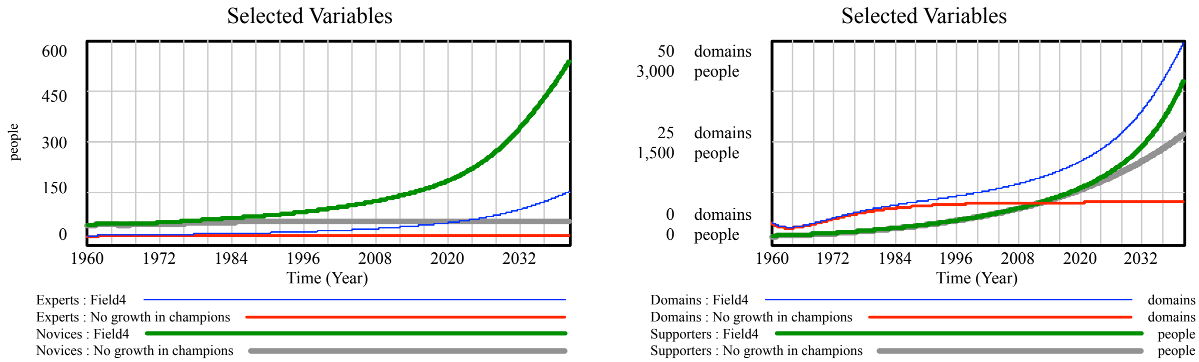

Figure 7: No growth in Potential Project Champions. Practitioners are on the left, Domains and Supporters are on the right, again compared to the base run. The field fails to grow beyond 1988.

Setting the normal fractional growth in champions to zero from the beginning of the simulation means they never grow beyond their initial assumed value of 5. Growth of the field never takes off. The field in the model doesn't die out, as probably it would have in such a dismal real scenario, but the implication is clear: Without the reinforcing tendencies of supporters and project champions, the ability of the field to grow is nonexistent.

What if it is more difficult to expand into new domains for system dynamics work?

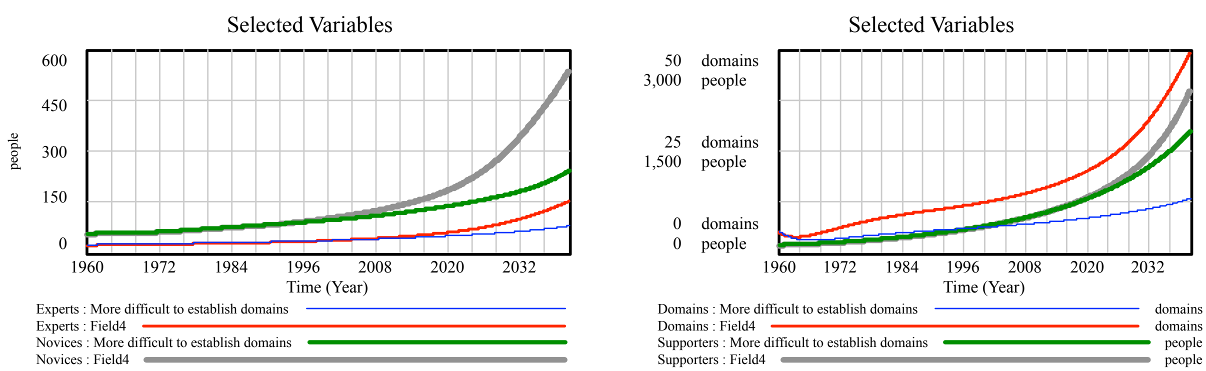

Figure 8: More difficult to enter new domains for system dynamics research and applications. (The number of products required to establish a domain is raised from 25 to 50 in this run.) As expected, less growth in practitioners, supporters and potential project champions (not shown), and less growth in visibility (not shown).

The stock of Domains in the model is intended to capture the idea of areas of research and application open and interesting to practitioners and potential project champions. The model assumes that expert products (research and applications) come first, opening the way for domains to become established. It takes a number of such expert products to start a new domain (the model assumes 25 in the base run), and they take time to develop (5 years in the base run). Figure 8 shows what happens if it takes more applications to carve out a new established domain. Figure 9 shows what happens if it simply takes longer.

What if it takes longer to establish new domains?

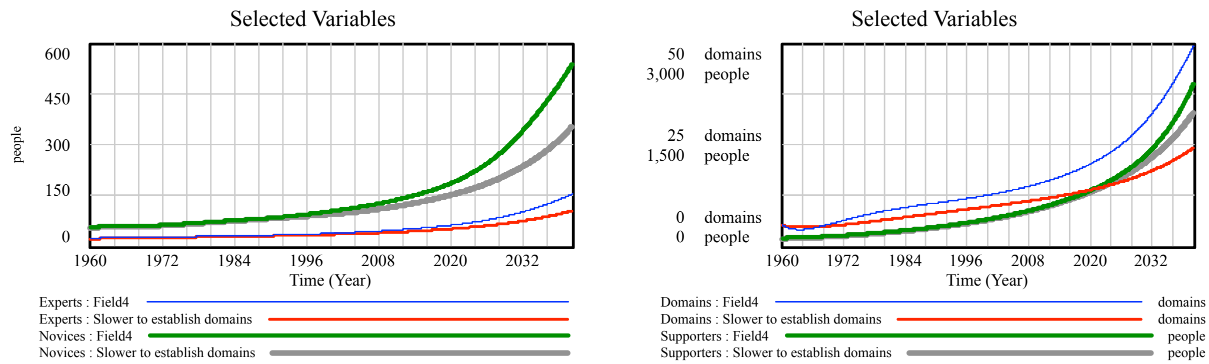

Figure 9: The time it takes to establish a new domain of work is increased from 5 years to 20 years. The result is similar to the run in Figure 8 – slower growth overall.

For a management science field like system dynamics, it is plausible to think that there are limits to its domains of applicability, or at least "easy" applicability. As more domains are opened up, the emerging dynamic puzzles are likely to be harder to solve, and the field may plateau (Sterman 1985), (Wittenberg and Sterman 1992). The model contains no such constraints.

What if the novice products are more visible – a greater presence of novice work in research and applications?

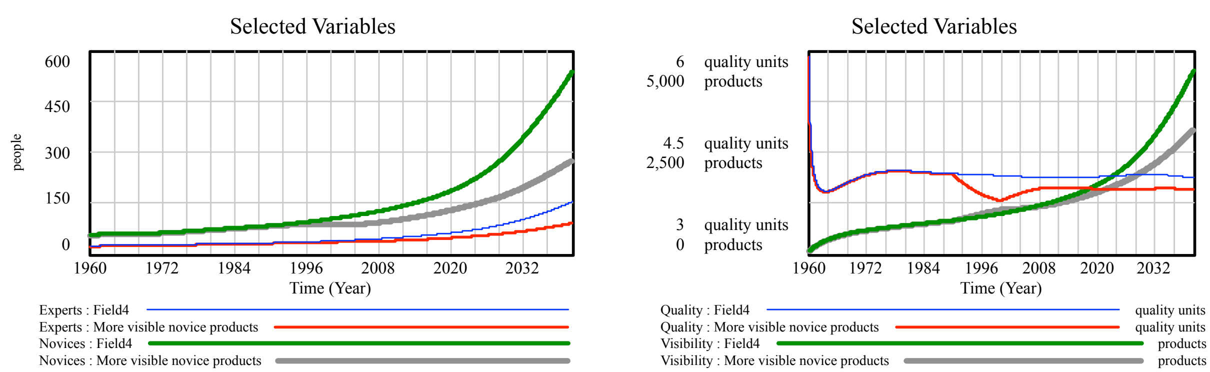

Figure 10: More visible products from novice practitioners.

In the simulation run in Figure 10, beginning in year 2000 the fraction of novice products visible (published, available on the web, or otherwise readable) rises from 70% to 90%. The result is less growth of the field -- fewer practitioners shown at the left, fewer supporters and potential project champions (not shown), lower overall quality, and fewer visible products (shown at the right) in spite of the greater visibility of novice products.

What if novice products remain visible (available) as long as expert products?

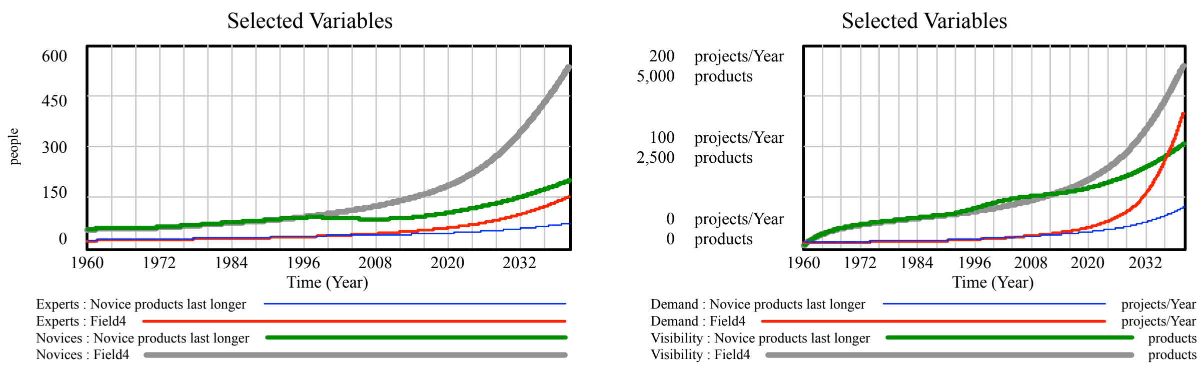

Figure 11: The visible life (availability) of novice products is raised beginning in 2000 from five years to the life of expert products, here assumed to be eight years.

Longer availability of the lower quality work of novices actually produces a decline in the number of novice practitioners. Growth resumes very slowly around 2012 in this scenario.

These scenarios are both disturbing and instructive. A field that fails to manage the visibility of the work of practitioners on their way to becoming expert, but not yet there, will slow its growth. That management has traditionally been accomplished in the peer review process in journals. But in the modern day it is complicated by the plethora of journals, the emergence of electronic journals specializing in speedy publication, and the resulting inability of some journals to involve experienced system dynamics practitioners in reviewing and accepting work for publication.

The simulation in Figure 12 suggests an opposite scenario.

What if the visibility of novice products is deliberately reduced?

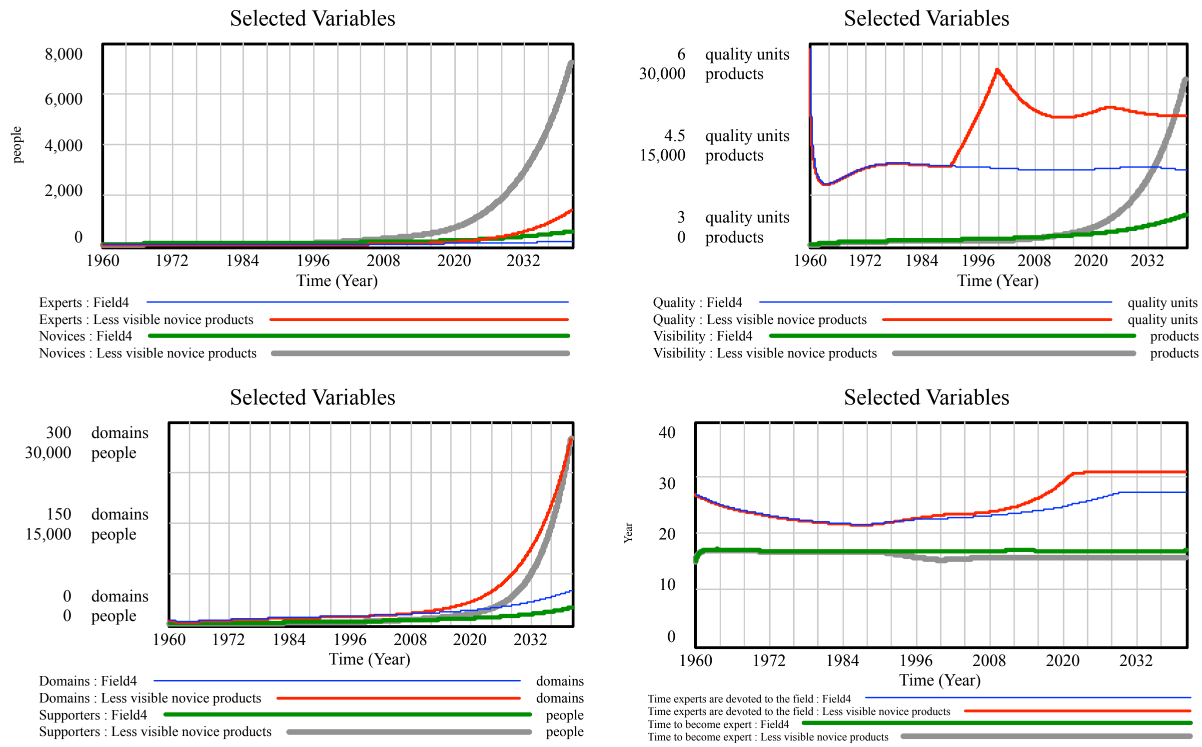

Figure 12: *Less* visibility of novice products. Beginning in 2000, the fraction of novice products visible is reduced from 70% to 30%.

In the scenario simulated in Figure 12, the field grows dramatically in all areas: practitioners (look at the scales in Figures 10, 11 and 12), products, quality, supporters, potential project champions, and domains of potential research and application. There is even more visibility of work in the field, even though the scenario constrains the visibility of some 80% of its practitioners. Expert practitioners remain active in the field longer, novice practitioners take a slightly shorter time to become expert, and there are dramatically more of both.

The scenario is Figure 12 is an unmitigated success for the field, achieved at the expense of holding back developing practitioners from making their work known. In the system dynamics world, it would mean not putting all the papers in a conference in the printed or web proceedings. It would mean the difficult work of being sure that non-system dynamics journals use experienced system dynamics practitioners in their review processes, to assure that only high quality work gets through even if the editors are unfamiliar with our field. It would mean taking seriously the suggestions in Homer (2013) for tough standards for visibility and for policies to assure our various audiences know what to expect from good system dynamics work, whether “exploratory” or “full” (Homer 2013, p. 127).

What else might a field do to achieve such growth?

What if the field deliberately markets its work? Advertising, shared conferences, joint issues of journals, advertised workshops, and so on?

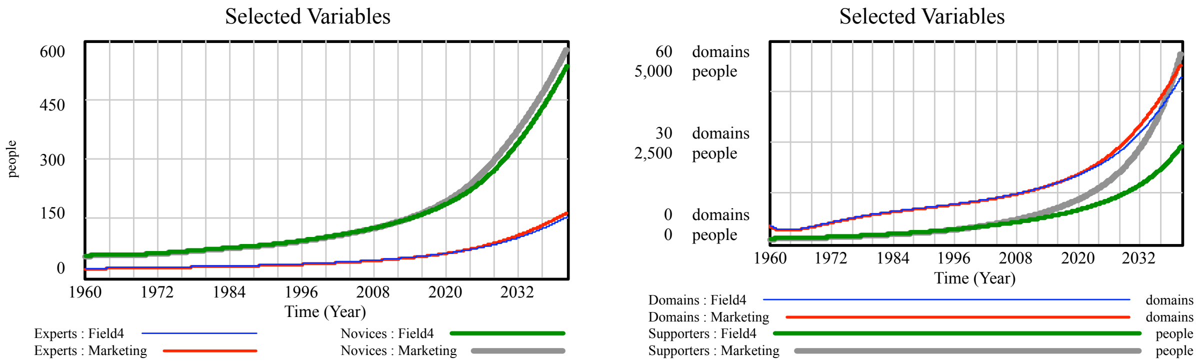

Figure 13: Market the field (by unspecified mechanisms). Great growth in supporters (grey and green curves on the right), but not a significantly greater growth in domains or practitioners.

Marketing, as captured in the simulation shown in Figure 13, does not appear to be a high leverage policy, and it could be expensive to implement. The reason for the lack of real improvement is that the reinforcing loops passing through quality and visibility do not get triggered. Only slight growth in visible products results, and there is no change whatsoever in the quality of work done. More powerful is marketing targeted at Potential Project Champions (note shown). Marketing targeted at supporters gets more of them, but that's about all it gets, at least in this modeled scenario.

What if we could leverage mentoring to speed the growth of expertise?

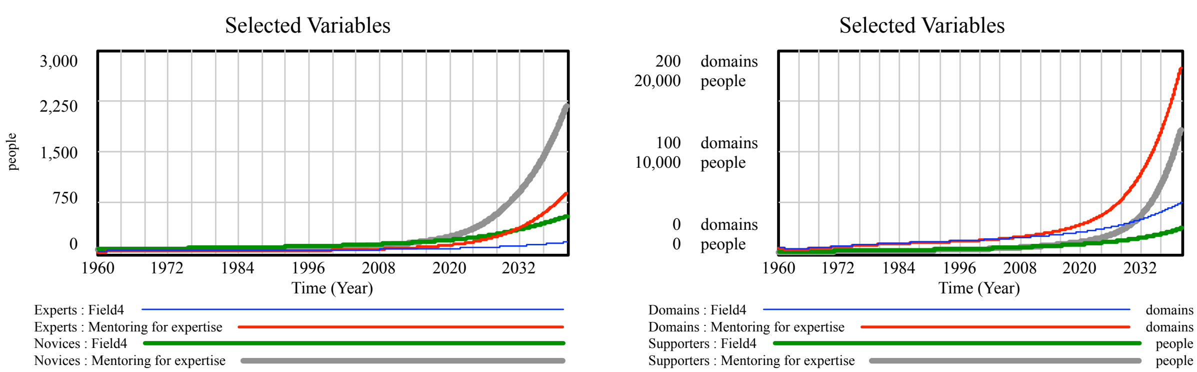

Figure 14: Mentoring, to reduce the time it takes to become expert by 40%.

The scenario simulated in Figure 14 is quite heroic, but if it could be achieved, mentoring to speed novices on their way to become experts in the field is dramatically successful. There is growth in practitioners, dramatic growth in supporters, and higher visibility and higher quality of work in the field. The one downside is that from 1994 to 2020 the time experts are devoted to the field drops a bit, but it rebounds by the year 2020 and rises above the base run after that.

What if we could improve the quality of novice work by mentoring?

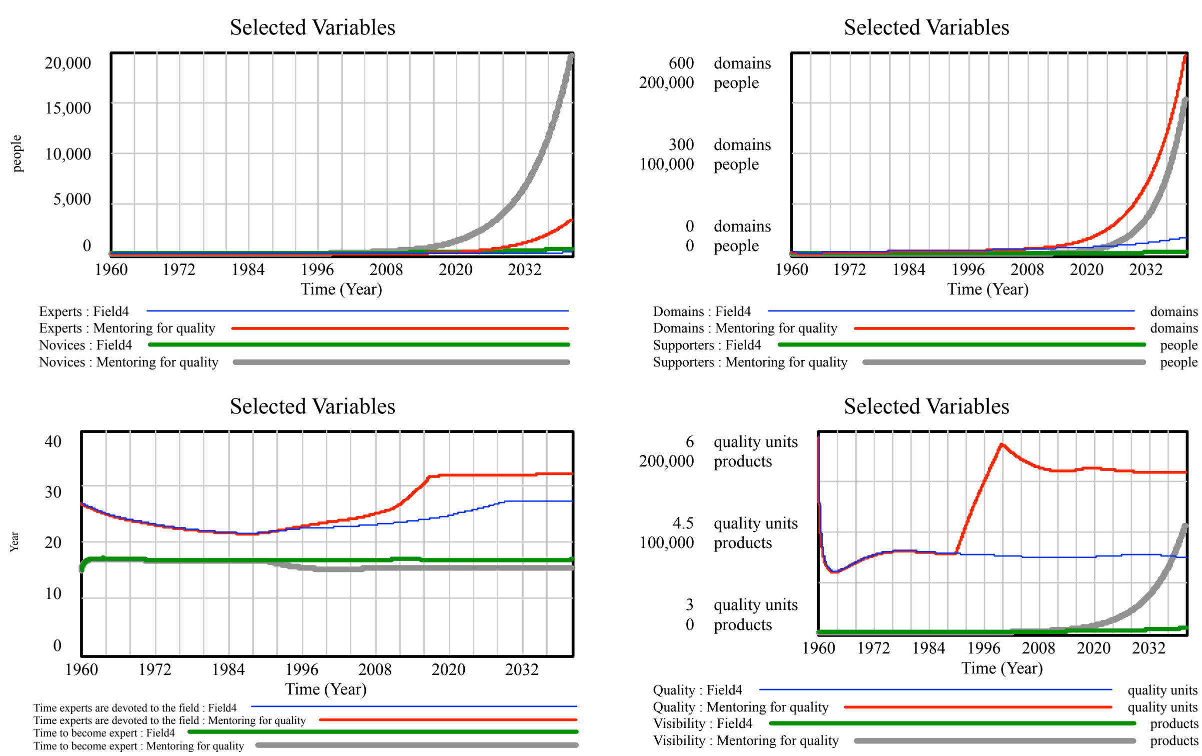

Figure 15: Mentoring for quality. (The quality of novice products is assumed to rise from 1 to 4 beginning in the year 2000.)

As one might expect, improving the quality of work in the field is a great stimulus for growth. Everything grows.

Costs

The scenarios in Figures 14 and 15 look terrific and undoubtedly carry implications that practitioners in any field concerned about growth should think about. But it is worth noting that mentoring might be costly.

Mentoring requires a workable ratio of experts to novices and a means of bringing them together for close collaboration. Too few experts and too many novices mean mentoring is difficult or impossible, or limited to a subset of new people coming along. The model contains no structure assuring that the resources required for effective mentoring are in place.

Mentoring is costly in time as well as currency. Helping others takes expert time away from working on projects, doing research, writing reports and articles, pursuing collegial work with others, and so on. That takes time away from billable work, so it involves opportunity costs. And it should be noted, it also takes novice time away from such activities, although the mentoring is probably helping novices to get better at all of them, so for novices it would be a net profit.

Discussion

It is seductive to think that this small but rich model of the dynamics of growth of an emerging field can teach us important insights about growth scenarios and policies for the field of system dynamics. But at this stage it is more proper to realize that the model can serve as a stimulus or contributor to our *thinking*. The learning we manage to create comes from thoughtful reflections, probably not from the simulations themselves. With that in mind, the following emerging insights – potential insights – are worthy of our attention.

- Trying to grow too fast can actually slow the spread of a field, just as it can a company or a political movement.
- Failure to attract supporters and champions forces the field to try to grow without them: consultants would find it difficult to find clients, and the growth of the field would probably be left to academics and retirees, people who are freer to pursue their interests even if the marketplace isn't particularly interested. Growth is severely constrained, if not eliminated completely.
- Expanding into new domains of research and application is key to the growth of a field like system dynamics. The more effort and time it takes, the slower or more constrained is the growth potential of the field.
- A field can grow if it produces visible work of high quality. Low- to mid-level quality is not enough. The most effective (and cost effective) strategy for growth emerging from this model-based study is to hide low quality work.

- Managing the visibility of work in a field is undoubtedly difficult. A field can monitor its own conferences and journals and perhaps prevent all but high quality work from being promulgated, but it would have trouble managing all the possible outlets for publication or dissemination. However, the power of limiting the visibility of the work of novices in the field is so great for the health and growth of a field that much thought should go into how best to accomplish it.
- It is fair to say, the field of system dynamics has erred (if it is erring) on the side of inclusiveness, welcoming early practitioners to its conferences and publishing their work along with the work of our most expert practitioners. Limiting the exposure of their work in our conference proceedings would be distressing for them, and for those of us who care about them, until we all realize that such limits grow the field dramatically and actually shorten the time to become expert. Expert work in the field becomes what everyone sees, and all can learn more quickly what makes for good work and how one creates it.
- Visibility means making our good work known widely. As disturbing as it sounds, doing that means that academics should be publishing much of their best system dynamics-based work in peer-reviewed journals other than the *System Dynamics Review.*
- Visibility also means finding ways to make widely known the work of consultants and practitioners in the public and private sectors. They may lack the time and incentives necessary to publish, but perhaps we can link advanced PhD students with practitioners and get out publications that benefit both. Practitioners would get their work out with appropriate control and minimal effort; PhD students would learn about state-of-the art applications and processes; and PhD students would get publications as second-authors reporting on great work.
- Expanding conference opportunities with such initiatives as the recent Asia-Pacific Conference in Tokyo creates growth potential for the field, but carries with it the dilemma about promulgating only high quality work. That is not to say practitioners in the Asia-Pacific area are less expert than anywhere else, but rather to say that all conferences inevitably have to address the contradictions inherent in welcoming beginning or less expert practitioners while wanting to make only expert work visible.
- Mentoring is another enormously high-leverage policy. Consulting firms naturally take a mentoring approach, much like the internship process for growing the expertise of doctors. Mentoring goes beyond coursework. In its most powerful forms in a field like system dynamics, it involves skilled experts (academics, consultants, practitioners in business and the public sector) working every week with people who have graduated from university coursework and want to become truly expert.[3] As a field we are probably missing much of the growth potential of mentoring.

Let us proceed to further thinking about the policies and scenarios for the growth of system dynamics, grounded, I hope, with formal models to guide us.

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Notes

[1] This work is a joint effort of David Andersen, Roberta Spencer and the author. However, the responsibility for details of the model and the paper rests with me. We have benefited from reflections and contributions of others, including in particular John Sterman, Jack Homer, Kim Warren, John Morecroft, Peter Hovmand, and Jay Forrester.

[2] The word “thoughtful” is not here to brag about the experiments that follow, but rather to emphasize what we want to use those experiments for. We would like these simulations to help us think wise thoughts about how best to grow our field, for the benefit of ourselves undoubtedly, but also for the benefit of the worlds we are trying to help.

[3] An example is the self-organizing Thursday Group out of the University at Albany, involving our former students and others, literally around the world, every week, pushing research, applications, and publications forward under the expert guidance and collaboration of David Andersen.