The Dynamics of Best Practices: A Structural Approach

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Abstract

The Dynamics of Knowledge and Best Practices in a field is influenced by a series of factors, amongst the most relevant are: (i) the dynamics of the population of practitioners of the field, (ii) the theoretical and practical productivity of the practitioners, (iii) the policies related to information and knowledge management in the field, (iv) the social judgment processes that take place to consider a practice as a best practice, and to consider a practitioner as an advanced practitioner and (v) the politics and power related forces acting in the field. The question that drove the effort to build a formal simulation model of the Dynamics of knowledge and Best Practices is: What underlying structure conditions the behavior observed in the dynamics of knowledge in a field? Why the best practices in several fields are not necessarily related to the best ideas? To address these issues a formal system dynamics model was built using Vensim. The findings obtained with the model include the high impact of the mentoring and networking activities in the development of knowledge and the critical influence of knowledge management activities to consolidate knowledge in the field. A critical piece of understanding from the model is how the dynamics are perceived and how this perception can be mistaken with the actual knowledge.

Keywords: System Dynamics, Formal Simulation Models, Best Practices, Population Dynamics, Modeling Process, Knowledge Management.

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Introduction

In the System Dynamics field, the single most powerful way of understanding the behavior of a system is the creation of simulation models. The power lays in the capability of taking into account the interactions of all variables in the model at the same time. In order to do this, practitioners must determine the underlying structure of the system, capture it and construct a model that replicates the behavior of the real system. System Dynamics also involves understanding the world and helping other people (and groups of people) in that process. In order to do that, SD practitioners should be able to build *readable* models from and for everyone.

Because the field has been expanding in type of systems modeled and number of practitioners all over the world, the general practice of model development have been changing over time. From the standpoint of some of the best SD modelers, the practice has been growing, but the quality of the practice has been eroding through the time. Moreover, the lack of good practices has promoted, from some experts point of view, a very limited growth in System Dynamics core modeling knowledge (best practices). Despite the accomplishments of individual practitioners, this practice diversity makes it difficult to broadly evaluate System Dynamics as a modeling practice and can prevent the field from continued development (Scholl 1995). One way to generate further insight on this matter is to build a formal model where the dynamics of best practices are captured and understood in their relation with knowledge generation and practice enhancement.

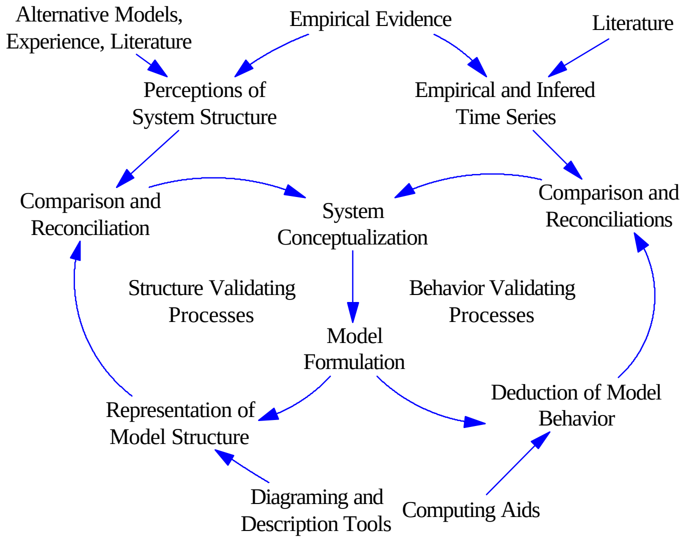
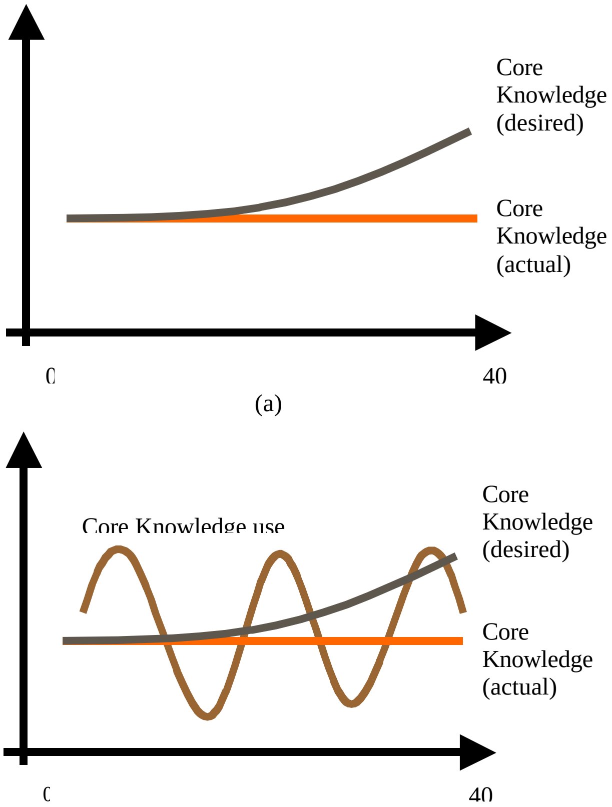


Figure 1. - The System Dynamics Modeling Process (Saeed, 1992, p.252)

Figure 1 shows the SD modeling process (Saeed 1992) as a couple of loops of structure and behavior validation. In the present paper this processes were followed in order to build a model to analyze population, project and knowledge dynamics inside the SD field.

In any field of knowledge there is a beginning, growth, consolidation and presumably in the long run (how long depends on the benefits of the field and the reinvention process of itself) a decay leading to death. We can say that the SD Field is growing in number of practitioners, type of practitioners, type of models addressed, software tools, purposes for modeling, etc. This is generating fragmentation and the growth of different lines of thought around how System Dynamicists should model and confront issues in the natural and social sciences. On this way, the basic behavior of best practices generation and use is shown in figures 2a and 2b. As we state above, some experts' perception is that core knowledge has remained relatively constant during the last years, but they believe that is desirable to this set of best practices to growth (figure 2a). This reference mode could be enriched with the point of view of some knowledge management experts (Pfeffer and Sutton 2000) who perceive that the use of core knowledge in any field has and oscillatory nature. That is to say, people in the field use and forget to use the field core knowledge.

The best practices model (*knowledge1*) has the purpose of (1) understand better the implications of the dynamics of best practices in a given field, (2) raise consciousness on the relevance of the issues amongst the individuals in the field, and (3) serve as policy making aid for the community with respect to knowledge management and population dynamics issues. The model should be able to capture the dynamics of the best practice in the field not only as a flow of them in time but the stock of them in any given time and how do these influence the promotion, learning, unity, creativity and growth in a field of knowledge.



(a)

(b)

Figure 2. Basic dynamics of knowledge use and generation

In the following sections, the structure and behavior of the Best Practices Model (*Knowledge1*) being developed are presented. The model has been evolving and changing over time following the iterative nature of the process. Best Practices are being considered in a sense as a part of the current paradigm (Richardson 1991) in the field that they appear and are related to a number of factors including population dynamics and the networking that occurs among individuals in the field. The effect of the way knowledge is managed is being taken into account too. The paper concludes with some insights for policy development within the field and with future directions of *knowledge1* further development.

The Best Practices Model (*Knowledge1*)

Model Overview

Knowledge1 is conformed by four main sectors (figure 3). The actual sectors of the model are Human Resources, Project Development, Knowledge Generation and Knowledge Management.

The Human resources sector contains the structure of population dynamics and mentoring and training processes. Although the initial conceptual analysis includes the culture and values of the people networks within the field, *Knowledge1* does not include these dynamics. From the authors' point of view, the nature of network dynamics and knowledge transfer pose a challenge similar to the one presented by Hines (Hines and House 2001) related with project managers' learning. Thus, network dynamics; culture, values and knowledge transfer processes within them can be modeled using different simulation tools like Agent-Based modeling.

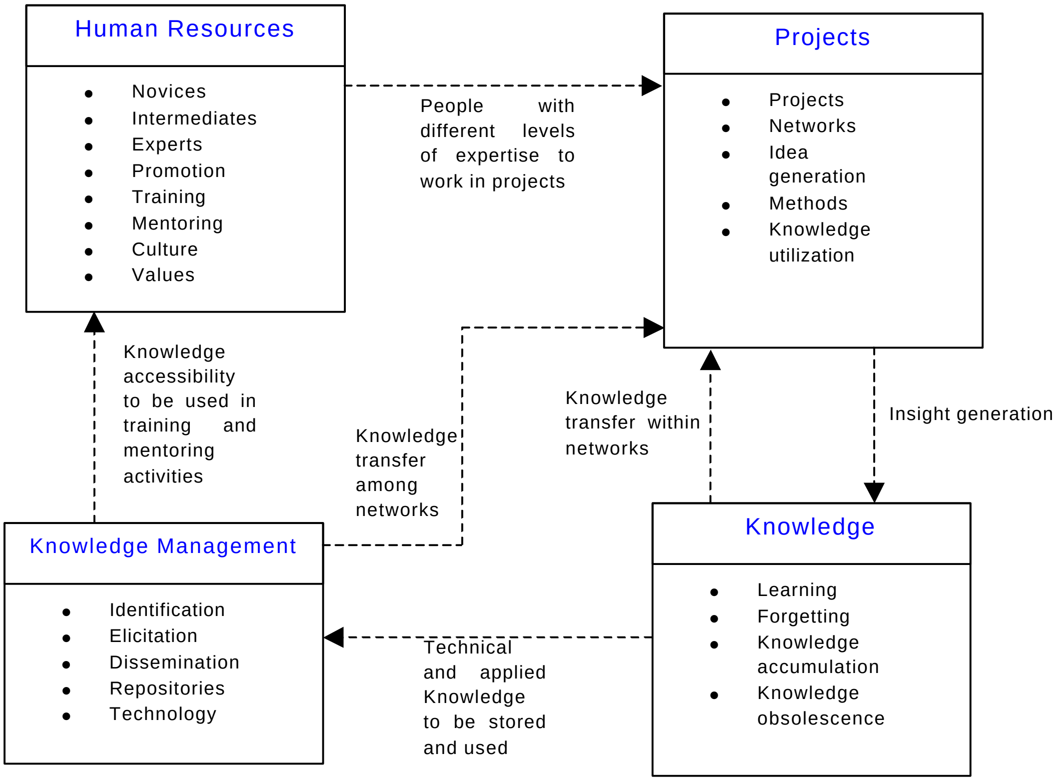


Figure 3. – Knowledge1 Sector Overview Diagram

The Project Sector of *Knowledge1* includes the processes of idea generation and group collaboration to project development. People work together to develop projects, and the total human resources available are the main constrain to project development. That is to say, although people could develop a lot of ideas, they have a limited time to translate ideas into actual projects.

The knowledge sector receives as a main input the quantity of projects successfully finished. The main result of those projects is a set of insights conditioned by the proportion of experienced people in the field. The model assumes that a fraction of this knowledge contributes to the SD field, but other fraction contributes to other fields' development. Another important assumption is that knowledge becomes obsolete as a function of two different processes, the rate of change of learning and human resources replacement. Learning rate of change is linked with new knowledge generation, and it is assumed that the more learning, the more feasible this new learning replaces old one. On the other hand, the knowledge modeled in this sector refers to the knowledge inside people's heads. Thus, people who leave the field take with them their cumulative knowledge.

The knowledge management sector represents the process of moving the people's knowledge from their heads to publications. The basic assumption is that just a fraction of the ideas is actually published. Finally, knowledge development perception is developed in terms of the concrete publications in the field.

The Human Resources Sector

Population dynamics are modeled as an aging chain composed by three stocks of people according to their level of expertise in system dynamics, junior, intermediate and advanced (figure 4). The different stocks through the aging chain represent the level of understanding about System Dynamics of the people in the field. Through this aging chain, people can move into a deeper level of understanding or quit, moving to other activities. Our assumption is that people at the junior and intermediate level quit because they get disappointed, and people at the advanced level moves to other activities or fields because internal conflicts among them. *Knowledge1* model assumption is that conflict is a function of the fraction of advanced practitioners in the field, the bigger this fraction, the bigger the probability of conflict.

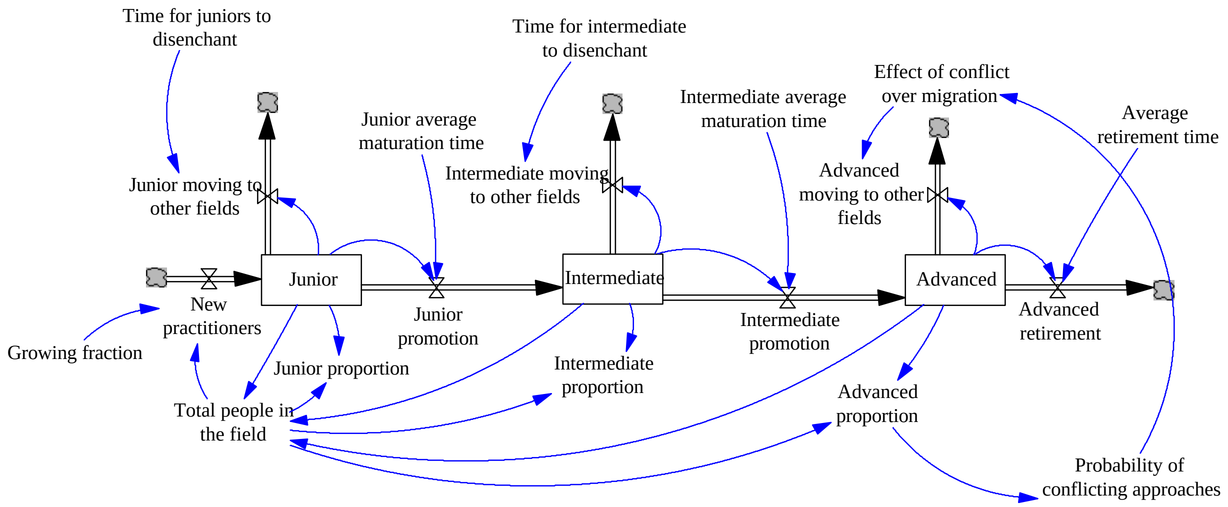


Figure 4. The aging chain in Knowledge1

On the other hand, the average maturation times in the model are affected by the adequacy of mentoring. That is to say, the proportion of juniors and intermediates joining mentoring and training programs make these average maturation times shorter (the internal dynamics of mentoring and training are described below). Moreover, maturation times are related in opposite direction with the disenchanting times in the model, making the disappointing times shorter for longer average maturation times (figure 5).

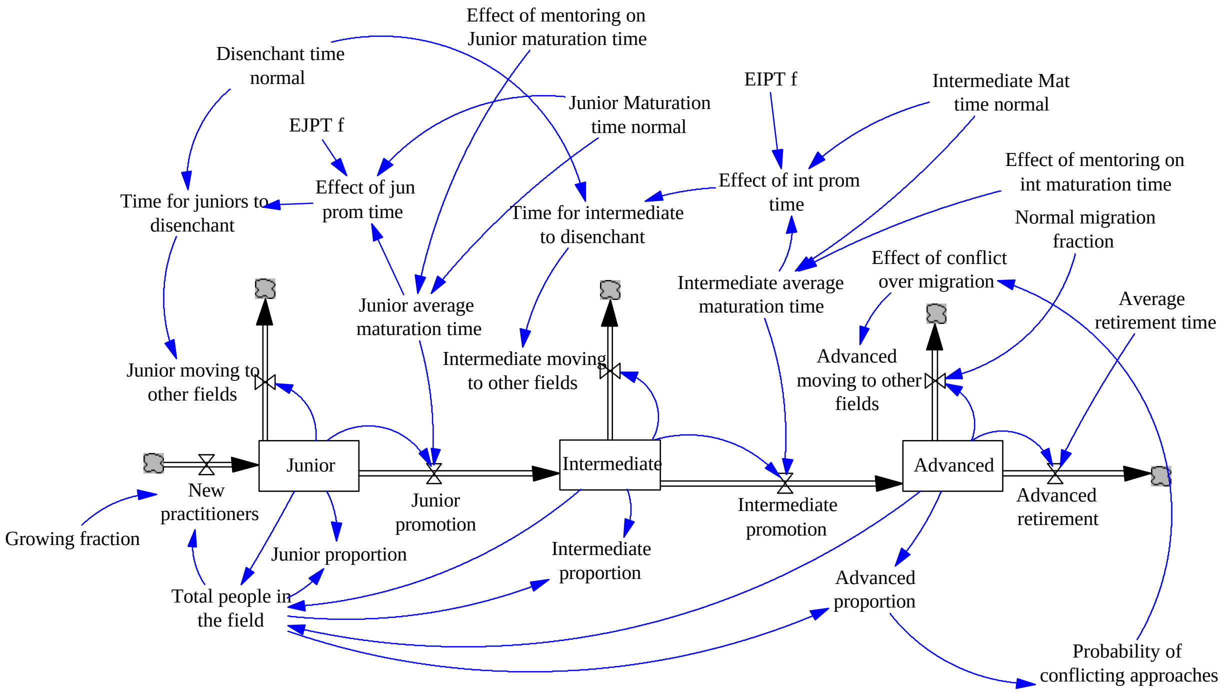


Figure 5. The aging chain with the average time to maturate and disenchant relationship.

The growing fraction of the field depends on field visibility. This field visibility is defined as the ratio of the perceived change in the field and the perceived change in other fields, and constitutes the connection point from the knowledge management sector to the human resources sector (figure 6).

As it was claimed before, a very important activity inside the human resources sector is mentoring and training (figure 7). In *Knowledge1* model, mentoring and training are modeled as a set of programs with a limited capacity to people incorporation. The capacity of the programs is determined by a fraction of advanced and intermediate practitioners willing to participate in the training effort and a maximum capacity of people that they can help during a period of time. On the program demand side, the assumption is that just a fraction of the people in the junior and intermediate stocks is interested on joining a training program. All the intermediate available effort on training is focused on the junior population, but the advanced mentoring capacity is distributed between juniors and intermediate that want to be mentored. The allocation of advanced resources is a policy decision represented in the model as a weight on junior, that is to say, the fraction of advanced effort devoted to junior education.

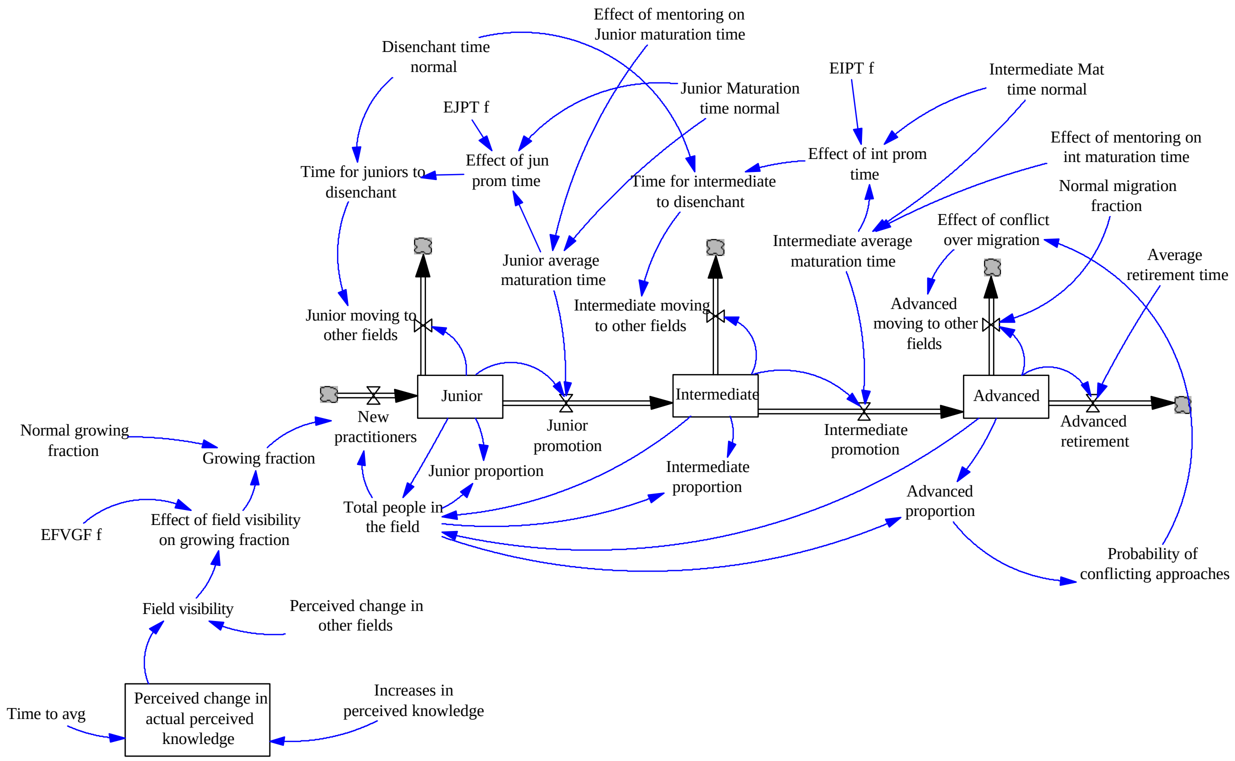


Figure 6. The aging chain with the effect of knowledge on the growing fraction

Thinking in an aggregate system that includes practitioners from several places around the world, it takes some time to people for joining a program. Besides, partial saturation of the training and mentoring programs increases the difficulty to join one, increasing the needed time to find a program to join to. When the programs are fully saturated, it takes a very long time to people for joining. Figure 8 shows the basic model structure of the junior practitioners joining to mentoring programs that implements these assumptions (next page). People in the programs are represented as two stocks; one for juniors joining to intermediate programs and a second one for juniors joining advanced programs. The inflows to both stocks are closed when supply or demand reaches the saturation point. Actually, figure 8 is a detailed view of the small feedback loops inside the rectangle of figure 7. The loop inside the rounded corner rectangle on figure 7, involves a similar process for the intermediate case.

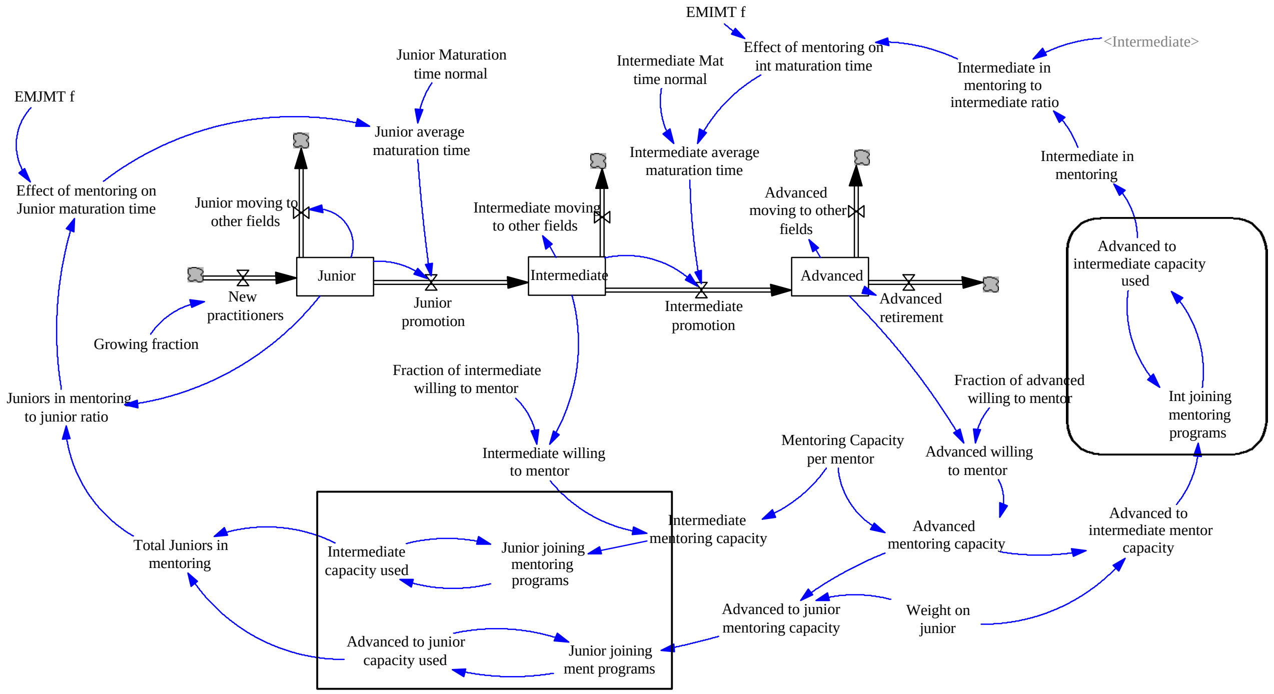


Figure 7. Adequacy of mentoring and its effects over average maturation times

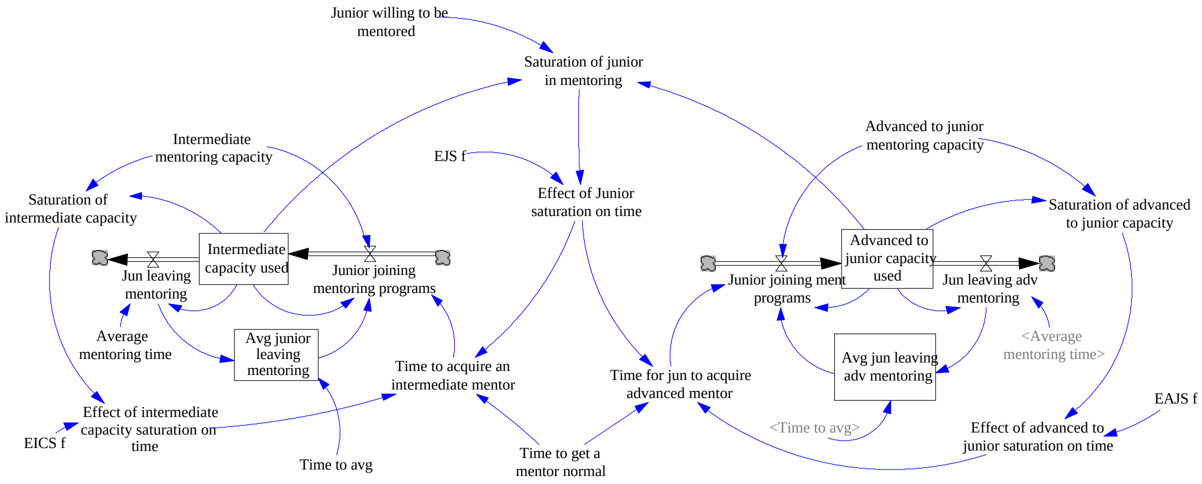


Figure 8. Junior population joining to mentoring and training programs.

Project Sector

Projects are a result of ideas generated by people. Thus, the model considers that the people in the System Dynamics field have a certain productivity in generating ideas that constitutes the potential future projects (figure 9). The network effect is a fraction that reflects people's limitation to see the complete pull of ideas. That is to say, people idea generation and people effort to transform simple ideas into feasible projects is bounded by the participation of each person in a network of practitioners. A practitioner in a specific network produces ideas related with previous work developed inside his/her network and devotes effort to maturate that limited set of ideas. On this way, the mature project ideas represent all the ideas ready to become actual projects.

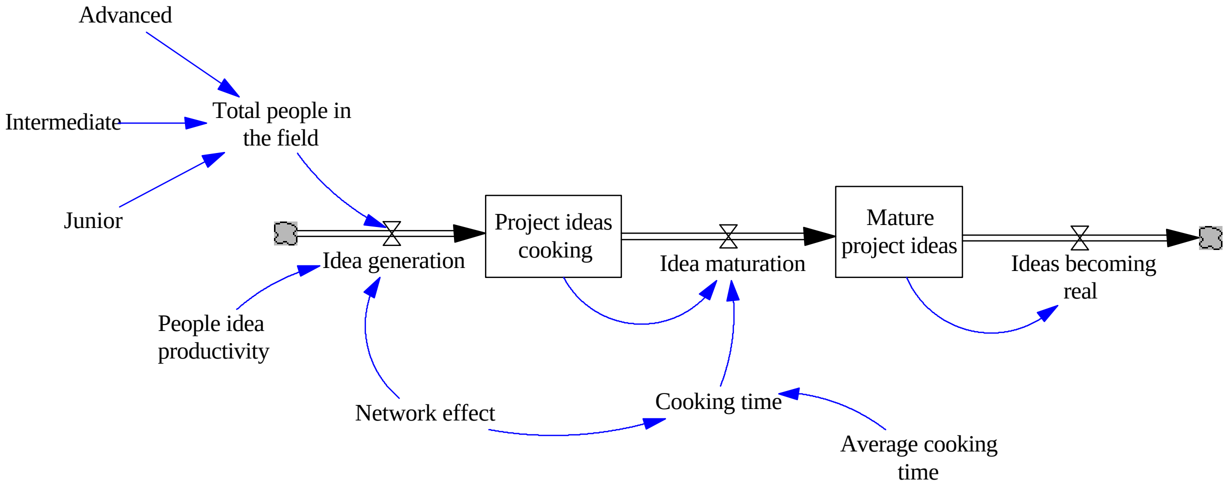


Figure 9. Project ideas generation.

Unfortunately, the outflow of ideas ready to go is constrained by a set of factors. The main constrain modeled in *Knowledge1* is people capability to work in projects (figure 10). People in the field are assumed to be organized in work groups with a fixed project capacity, a quantity of projects that each group can focus on per year. The ratio of projects in process and this capacity constitutes the average time for mature project ideas to become actual projects. As it is shown in the structure of figure 10, fraction of these projects will end with a success, but another fraction will never be finished. This fraction is assumed to be a constant in the model.

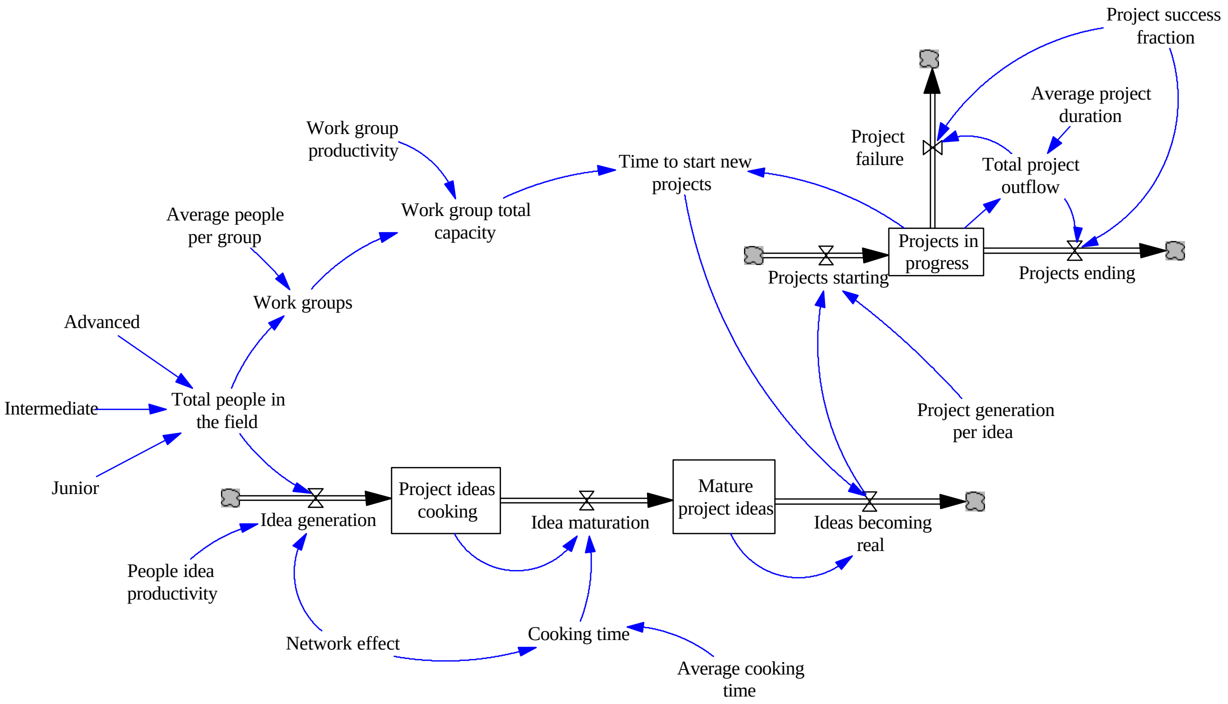


Figure 10. Work groups' capacity and projects in process.

<u>Knowledge sector</u>

An important model presumption is that learning takes place mainly by project development. Although it is possible to argue that people learn from failure, it is supposed that new insights to be added to the existing System Dynamics knowledge are owed to the successful projects (figure 11). On this way, finished projects are translated into new insights. Because of the interdisciplinary nature of the SD field, only a fraction of these insights enriches the SD field, and another fraction promotes a deeper understanding in other fields. As it is shown in the figure, knowledge has a lifetime reflected in the time to become obsolete.

On the other hand, insight productivity per project finished and the fraction of knowledge transferred to System Dynamics are considered to be a function of the experienced fraction of people in the field. In the case of insight productivity, experienced fraction is considered to be equal to the sum of both, intermediate and advanced fraction. In the case of the fraction of insights transferred to the SD field, experienced are considered to be only the advanced population.

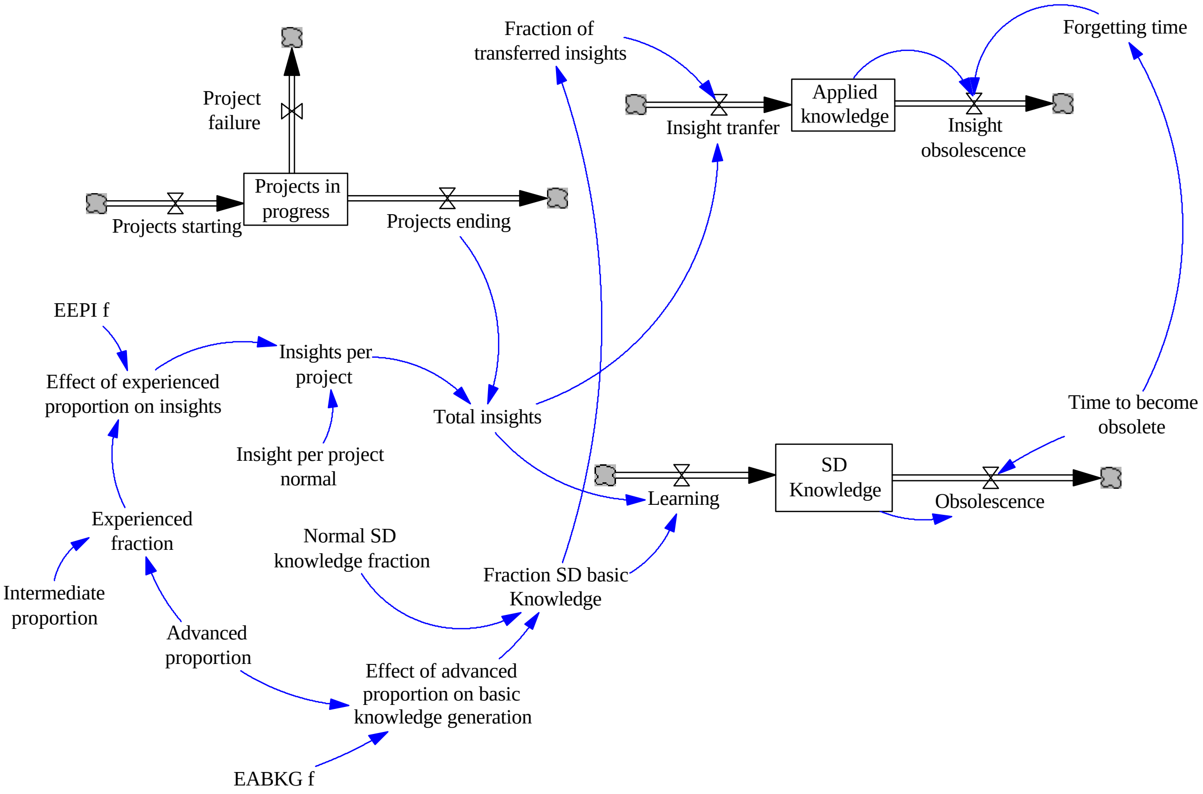


Figure 11. Projects and knowledge generation in Knowledge1 model.

Although at the beginning of the modeling process the time for knowledge to become obsolete was considered as a constant value. The actual version of the model considers this time to depend on two different structures. First, it is assumed that the rate of change of knowledge generation (learning) has an effect in the same direction that the obsolescence rate of change. In different words, it is more likely for knowledge to be replaced by new knowledge when learning of new knowledge is faster. As a result, the faster the learning, the faster the knowledge obsolescence. Second, knowledge modeled in this sector resides inside people’s heads. Then, practitioners’ turnover has an effect on knowledge obsolescence in the same direction, the higher the turnover, the higher the loss of knowledge or obsolescence (figure 12).

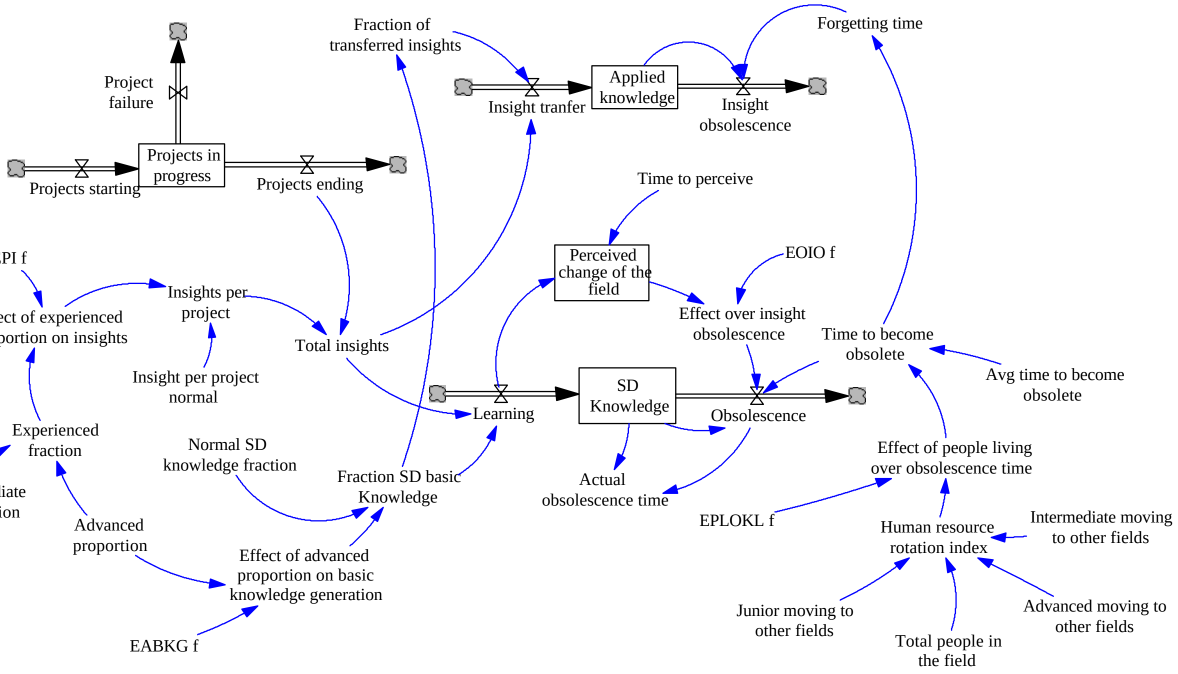


Figure 12. Knowledge sector, including knowledge generation and knowledge loses.

Knowledge Management Sector

Almost all the modern fields, professions and sciences assign an important amount of effort to record the knowledge generated by all practitioners. In general, the process starts with a good idea to be published and ends with a publication (i.e. a paper or a book). Learning produces new ideas. Some of them are published locally (dissertations, working papers, reports), and some of them are published widely (in books and journals). The knowledge1 model considers in this version only the widely published ideas. This process is modeled with the structure shown in figure 13 as a 4-stage process. Once an idea is considered good to be published, a person or a group of people decides to write something about it, and it takes some time to be done. After that, written works pass a revision process that takes time to be done too. During these first stages it is possible that some publications fail. Publications that survive the two initial stages wait a little time to become actual paper and ink. This finished works, unfortunately, are thought to have a lifetime similar to the normal knowledge lifetime.

Perceived knowledge in the field is considered to be a smooth of the finished publications. This perceived knowledge contributes to field visibility and field attractiveness explained in the human resources sector.

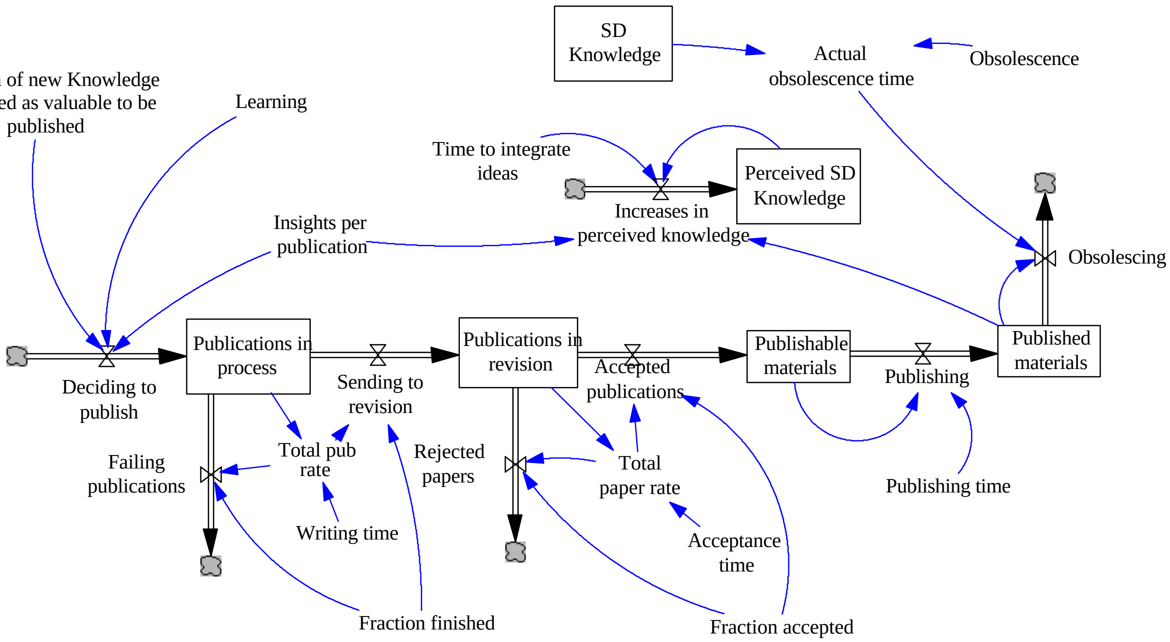
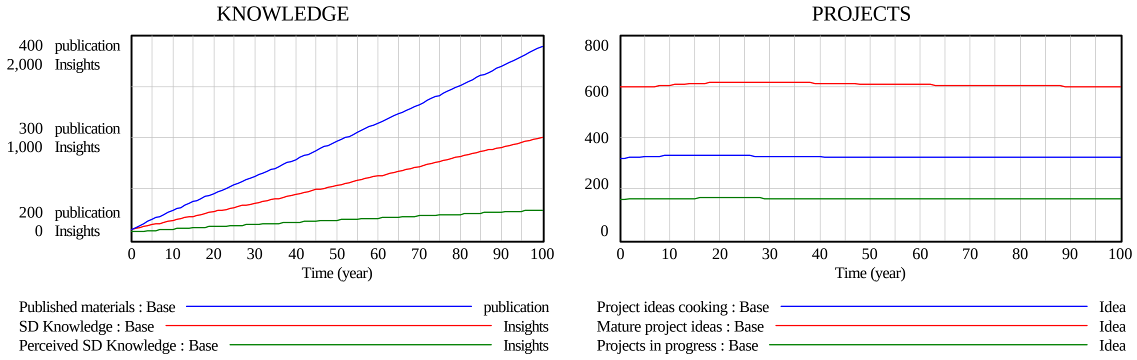


Figure 13. Knowledge management sector.

The Behavior of the Model (*Knowledge1*)

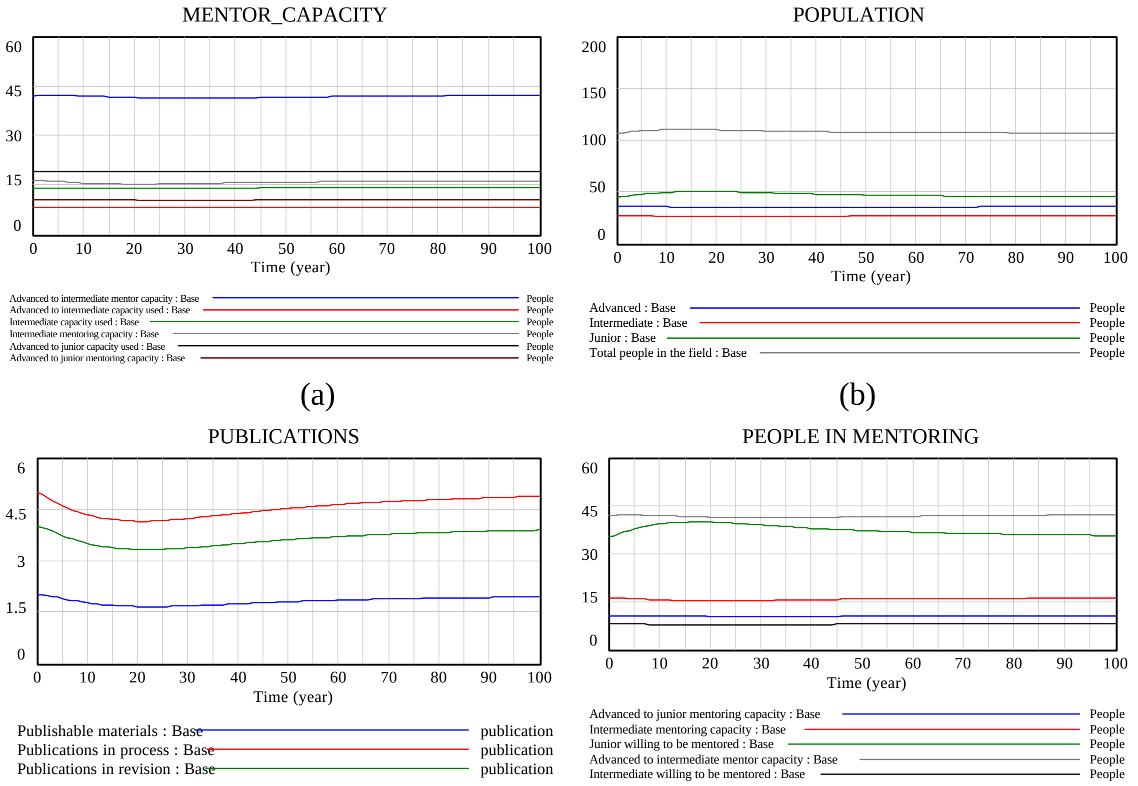
Base Run

The basic behavior of the model is shown in figure 14. The knowledge related variables are (1) SD Knowledge, (2) Perceived SD Knowledge and, (3) Published materials. *SD Knowledge* represents the knowledge generated in the System Dynamics field related to System Dynamics (core of the field); *Perceived SD Knowledge* represents the level of awareness of the people in the field with respect to the level of knowledge available to be used. *Published materials* represent the number of publications in the field.



(a) (b)

Figure 14. Knowledge and projects in Knowledge1



(a) (b)

(c) (d)

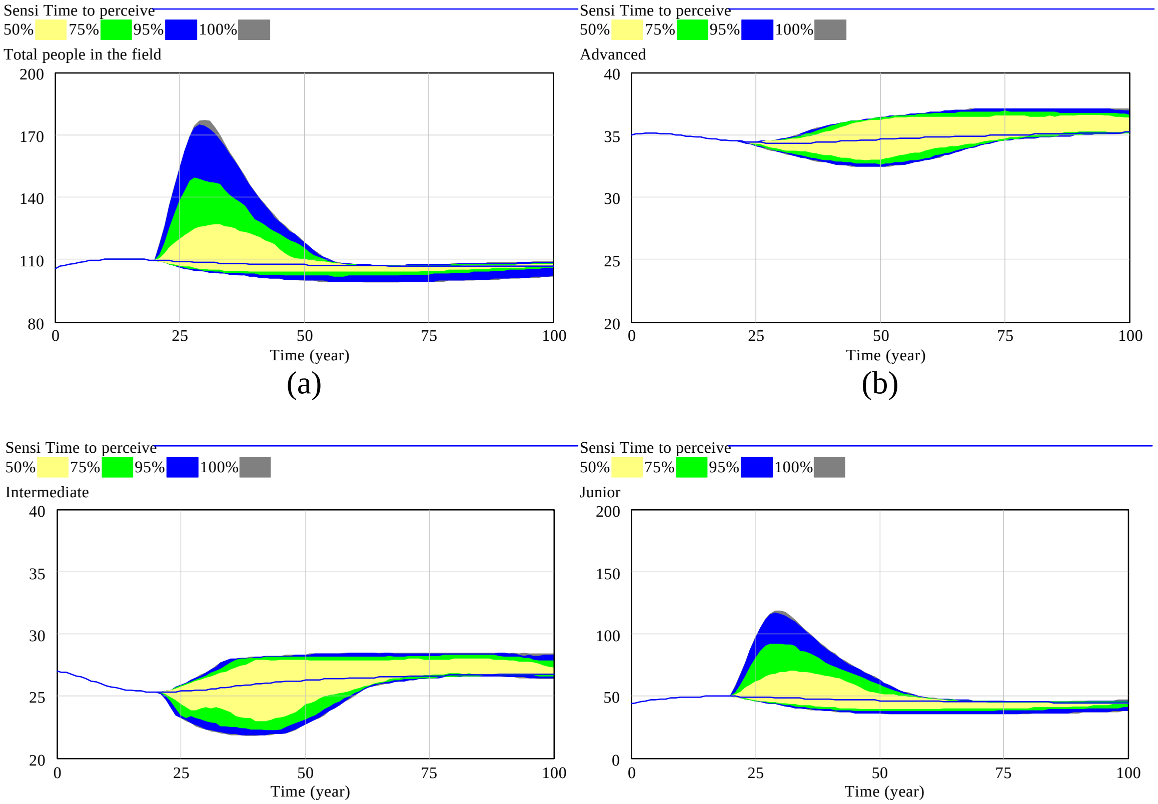
Figure 14 (cont). Population dynamics, mentoring and publications in Knowledge1.

Though the base run was intended to show equilibrium, the variations present are related to the fact that the initial equilibrium values were assigned by graphical methods by replacing the equilibrium state achieved by the model at the end of the run and not by the more adequate analytical mathematical method that would include the complete set of relationships to achieve equilibrium. On the other hand, for a relatively small and stable population, knowledge-related variables will grow in a linearly like way.

Run 1 Changes in Time to Integrate Ideas

The first sensitivity analysis performed is related to changes in the *time to integrate ideas*. The base time used is 50 years. This time represents the time that the average individual in the field takes to integrate the ideas generated in the field that helps his knowledge perception of the field. The change is introduced in time equals to 20 using a step function of size "*time for sensitivity*" which varies from –49 to +49 using a random uniform distribution (all changes introduced in sensitivity will use the same distribution). This means that the actual *time to integrate ideas* in the model will vary from **1**(50 + -49) year to **99** (50 + 49) years. This range was selected to represent the fastest time possible to a doubling the normal time used.

We can see that the effect of changes of the time to integrate ideas in the population sector of the model is almost entirely in the junior population (Figure 15). We observe an increment in juniors followed by a decrement that lead to the original number of them approximately. The behavior of the total people in the field follows the behavior of the juniors almost identically. The effect on the intermediates and advanced is less important.



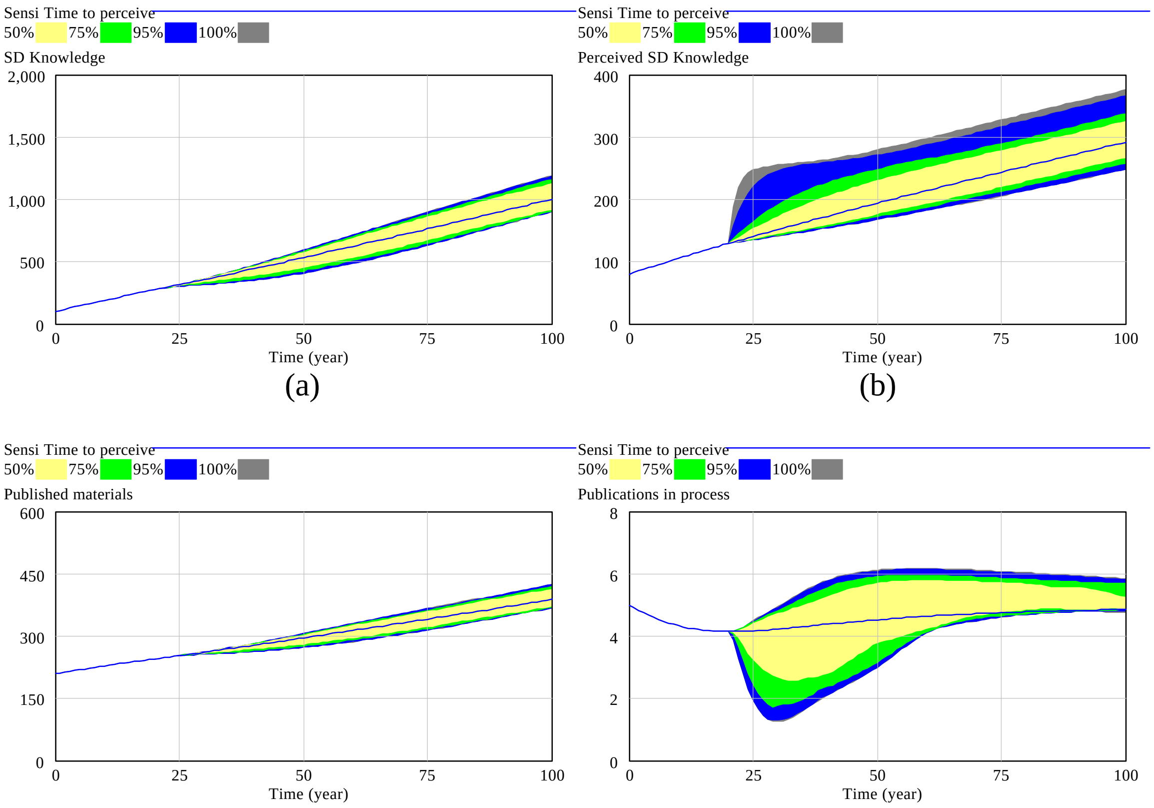
(a) (b)

(c) (d)

Figure 15. Population sensitivity runs for changes in time to perceive knowledge.

The high exposure of the field produced by the fast perceived change in the field attracts many people, but in the long run these would leave due to a lack of mentoring capacity and disenchantment of the field. The effect of doubling the time to integrate is not as nearly as relevant then making it little. The doubling can deteriorate the total number of people of the field for a while and then the population would become almost stable again.

We see a relatively low impact on the total knowledge generated (*SD Knowledge*) and the perception of it (*Perceived SD Knowledge*). The changes in the *time to integrate ideas* do not change significantly the behavior of these variables but change the final output of them (figure 16).



(a) (b)

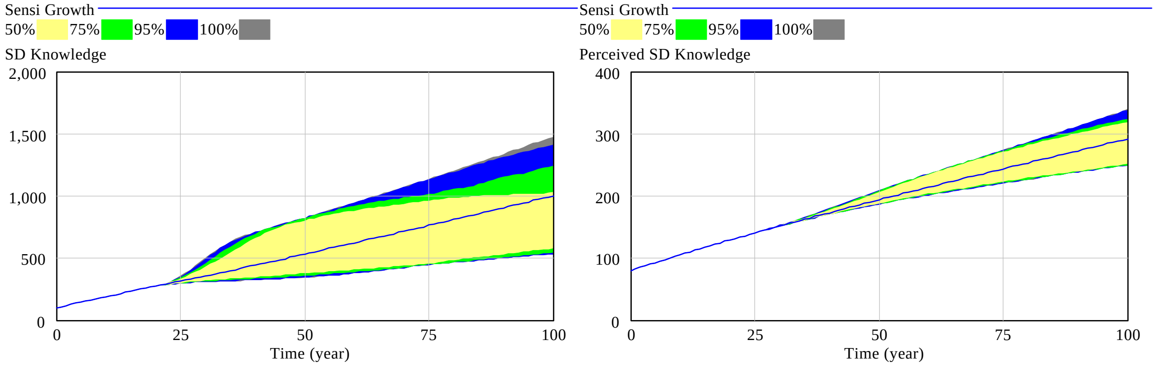
(c) (d)

Figure 16. Publications and knowledge sensitivity runs for changes in the time to perceive knowledge

Lastly, we see that the impact on published materials is low and that on publications in process is relatively high. The impact is smoothened though the aging chain of publications.

Run 2 Changes in Normal Growth Fraction

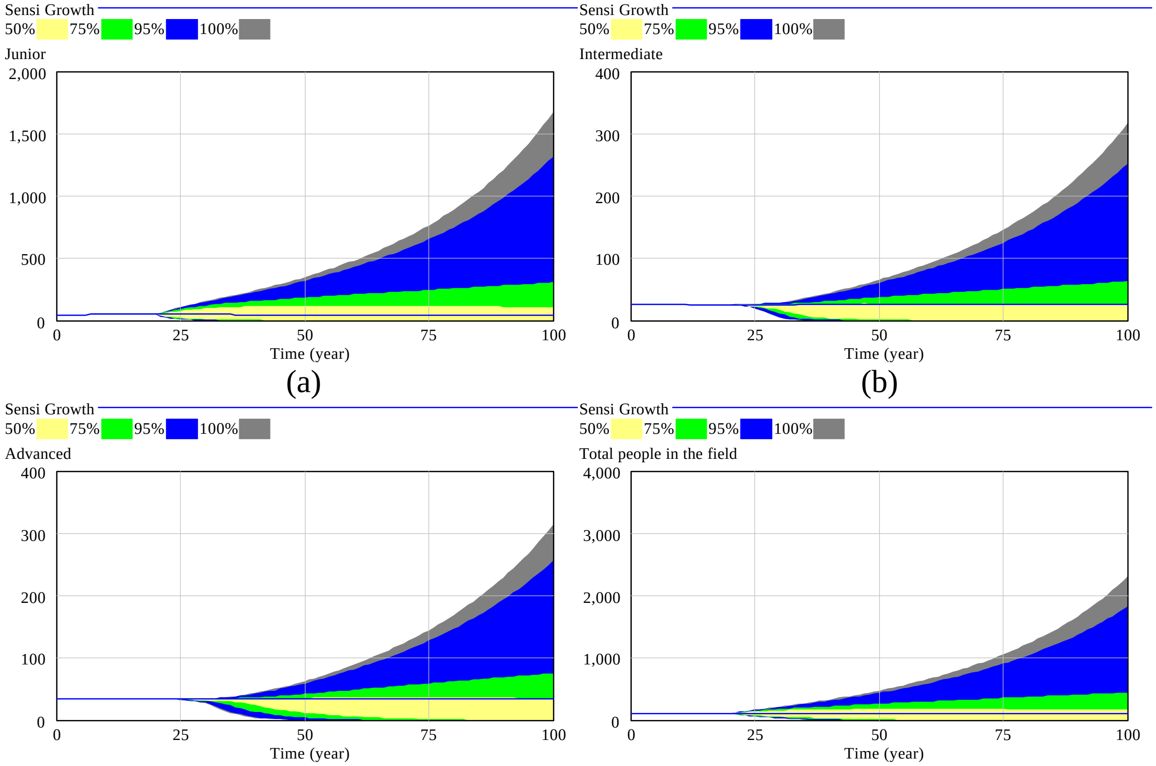
The second sensitivity analysis performed is related to changes in the *normal growth fraction*. The base fraction used is 10%. This fraction represents the normal growth, on the average, that the field experiments per year. The change is introduced in time=20 using a step function of size "*normal growth for sensitivity*" which varies from –0.09 to +0.09 using a random uniform distribution. This means that the actual *growth* in the model will vary from **0.01** (0.10 + -0.09) to **0.19** (0.10 + 0.09). This range was selected to represent the lowest positive growth feasible to a doubling the normal growth used.



(a) (b)

Figure 17. Knowledge sensitivity runs for changes in the growth fraction.

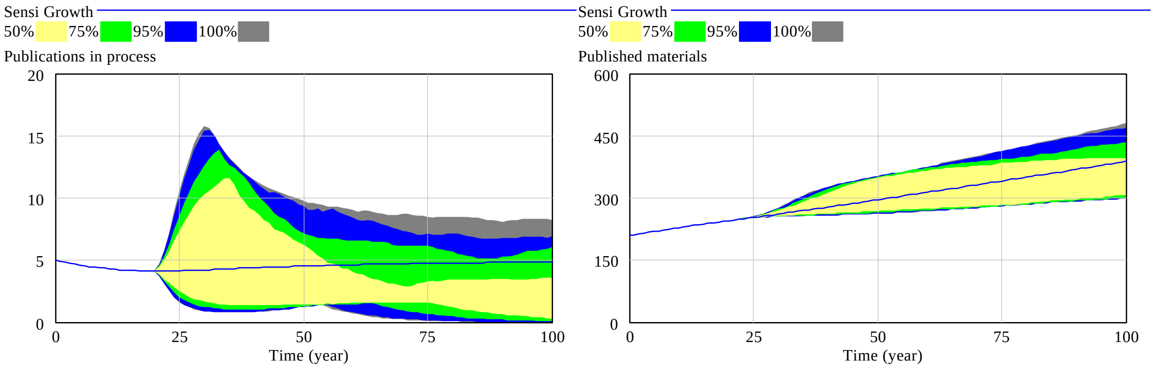
Changes in growth clearly influence SD Knowledge (figure 17) in a significant way this is derived of the activities performed by a larger number of individuals in the field. The growth generates large variability in the population variables as shown in figure 18.



(c) (d)

Figure 18. Population dynamics for changes in the growth fraction.

As we could expect the most affected population variable is the junior variable, it is interesting to see the way the growth affects similarly the advanced and the intermediate. As a consequence the publications in process and the published materials are affected (figure 19).

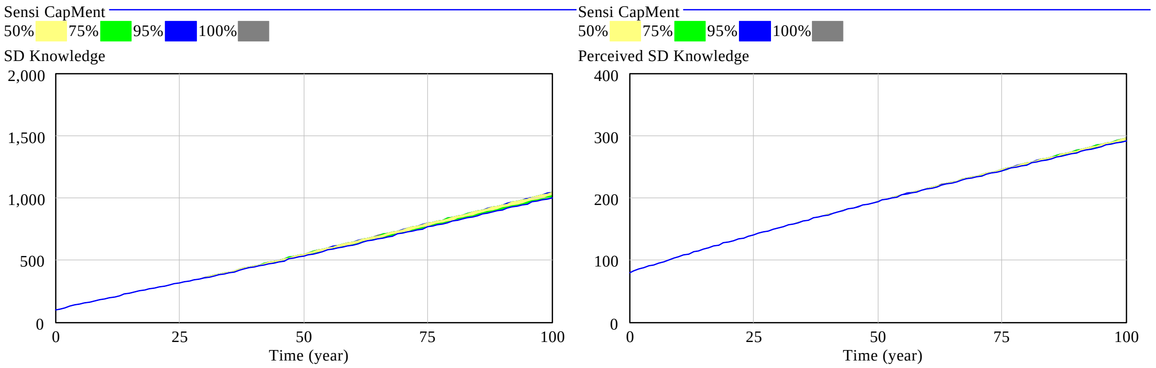


(a) (b)

Figure 19. Publication sensitivity runs for changes in the population growth fraction.

Run 3 Changes in Mentoring Capacity per Mentor

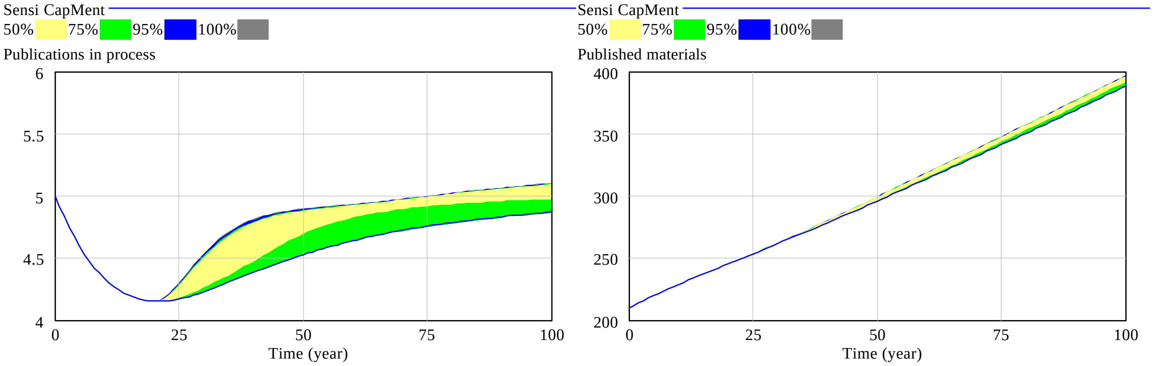
The third sensitivity analysis performed is related to changes in the *mentoring capacity per mentor*. The base capacity used is 3 people in mentoring for each mentor. This capacity represents the maximum number of people that the average advanced individual in the field can mentor at the same time. The change is introduced in time=20 using a step function of size "*mentoring capacity for sensitivity*" which varies from –2 to +18 using a random uniform distribution (all changes introduced in sensitivity will use the same distribution). This means that the actual *mentoring capacity per mentor* in the model will vary from **1**(3 + -2) person to **21** (3 + 18) persons. Increases in mentoring capacity could be owed to improvements in mentoring techniques or to the use of distant learning or other information technologies.



(a) (b)

Figure 20. Knowledge sensitivity runs for changes in the mentor capacity.

According to this model, the changes in mentoring capacity do not have a significant impact on SD Knowledge nor the Perceived SD Knowledge (figure 20). The effect of the changes in capacity is not sufficient by itself to influence the behavior of the knowledge variables, and it could be expected for a relatively stable population in the field. Changes in this variable could be more critical in growing periods.



(a) (b)

Figure 21. Publications sensitivity runs for changes in the mentor capacity.

Publications in process is influenced in a very slight way and by the time they get to be published materials the influence has vanished through the smoothing effect of the aging chain (figure 21).

The population variables of the model are influenced by these changes having a similar impact across stages of the aging chain. The most influenced can be considered the *advanced* variable where we can see that according to the model, the more people the advanced mentor the more advance there are in the field through time. This effect of growing through mentoring is due to the number of *intermediate* moving to *advanced* through mentoring (figure 22).

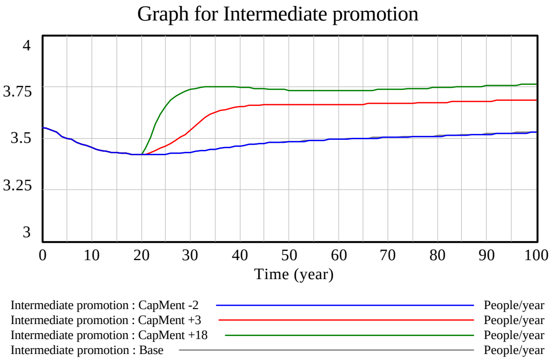


Figure 22. Intermediate promotion

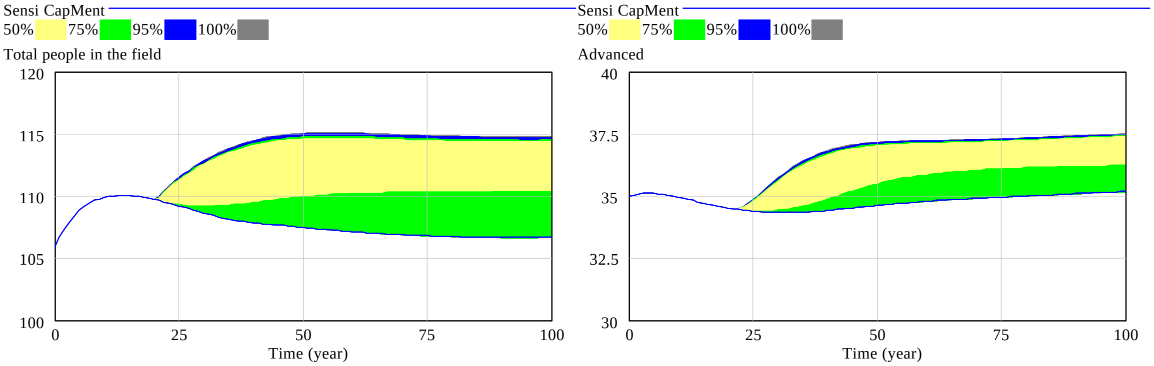


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Figure 23. Population sensitivity runs for changes in the mentor capacity.

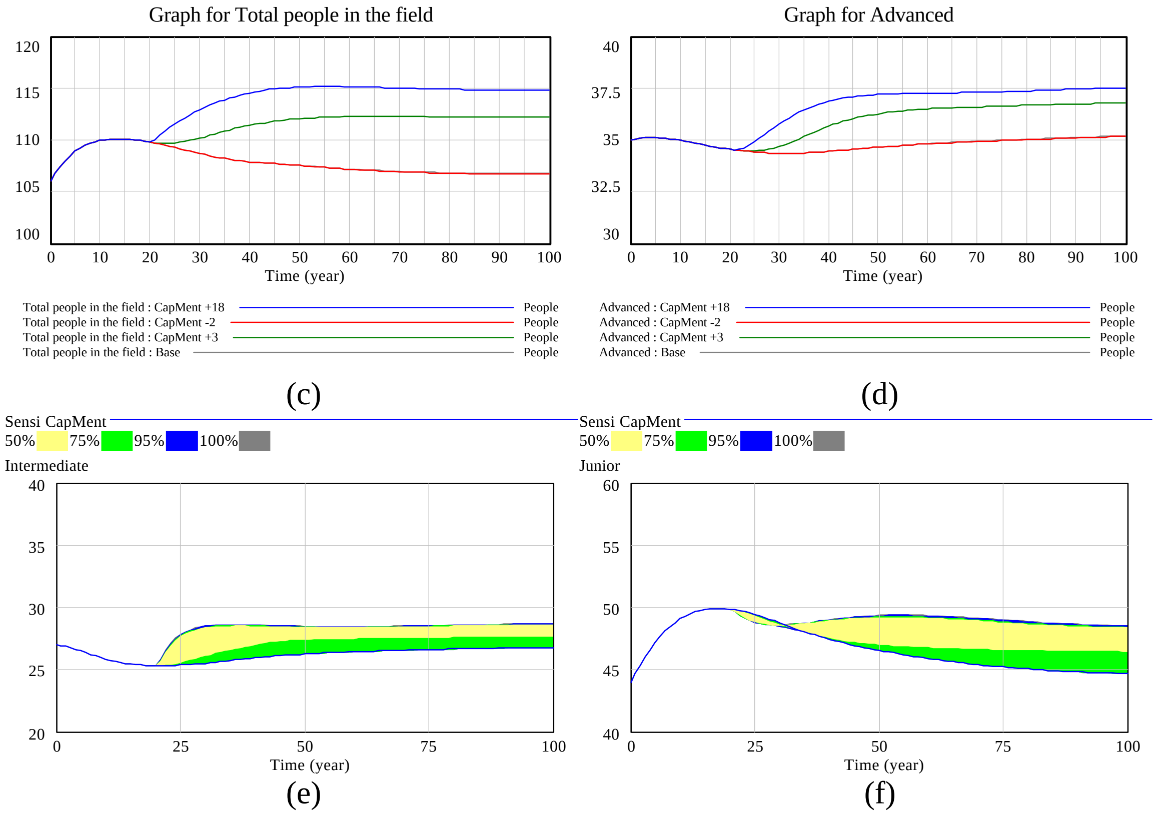
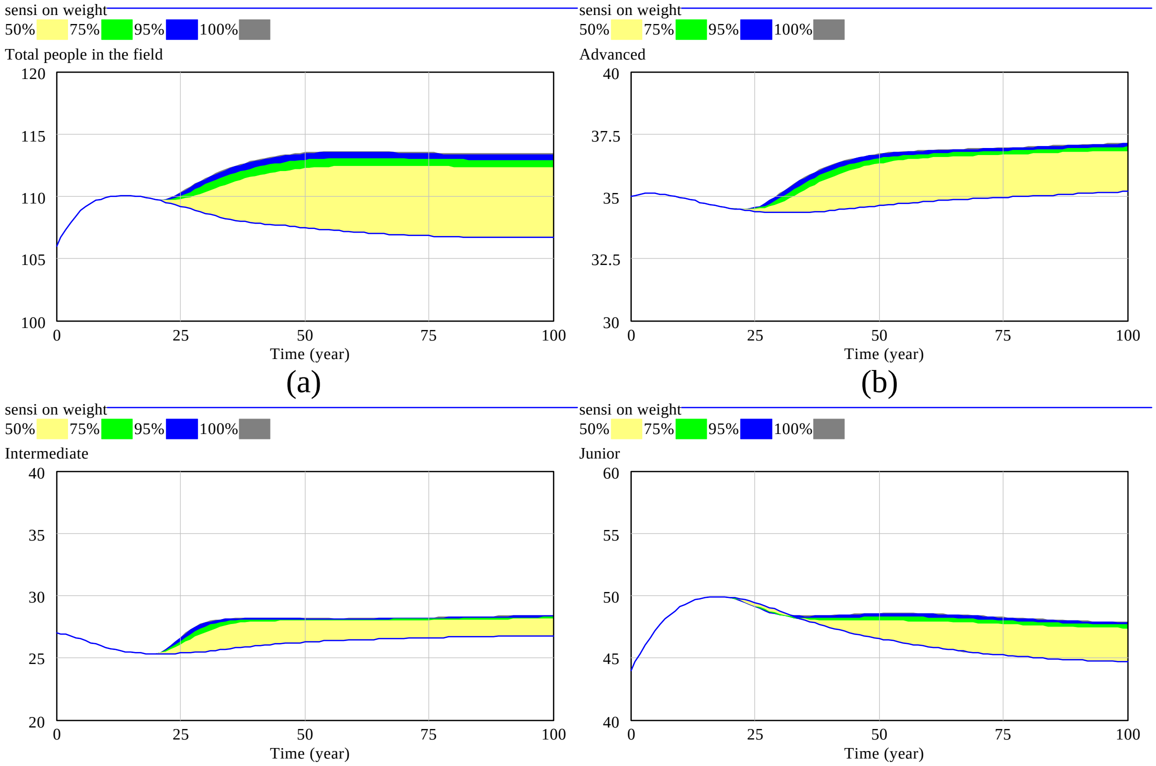


Figure 23 (cont). Population sensitivity runs for changes in the mentor capacity.

We present the sensitivity graphs and the normal graphs using four runs to identify specifically where, in the continuum, are the limits of the behavior. We can see that the run with Capacity in (+18) described by the top line tells us the story of growing through mentoring and the run with Capacity (-2) described by the bottom line tells us the case of low mentoring in the field (figure 23).

Run 4 Changes in Weight on Junior

The fourth sensitivity analysis performed is related to changes in the *weight on junior*. The base weight used is 0.2 or 20% of the advanced capacity to mentor goes to junior individuals, the rest goes to intermediate. This parameter represents the willingness of advanced people to interact directly with juniors and mentor them. The change is introduced in time 20 using a step function of size "*weight for sensitivity*" which varies from –0.19 to +0.79 using a random uniform distribution. This means that the actual *weight on junior* in the model will vary from **0.01** (0.2 + -0.19) to **0.99** (0.2 + 0.79). This range was selected to represent the lowest weight possible to the highest weight being a virtual 100%.

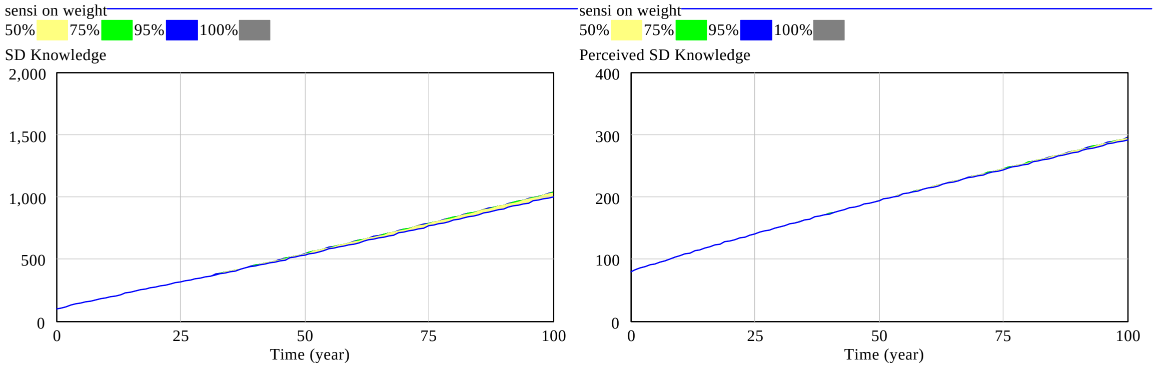


(a) (b)

(c) (d)

Figure 24. Population sensitivity runs for changes in weight on junior.

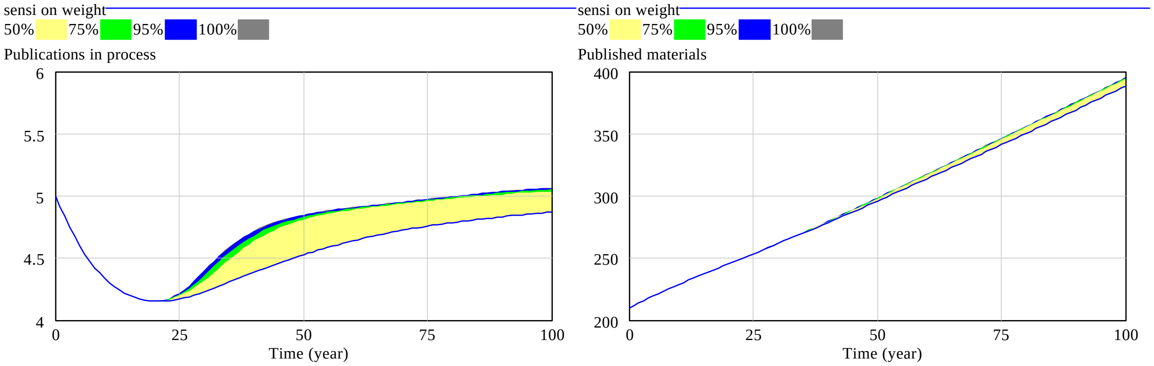
We can see that the changes on the weight on junior affect principally the advanced people and the juniors (figure 24). The increments achieved are not dramatic because the actual capacity per advanced remains constant in this run.



(a) (b)

Figure 25. Population sensitivity runs for changes in weight on junior.

The effect on SD Knowledge and perceived knowledge is very small (figure 25). The higher disposition to work with juniors is not enough by itself to influence the development of SD Knowledge in this model.



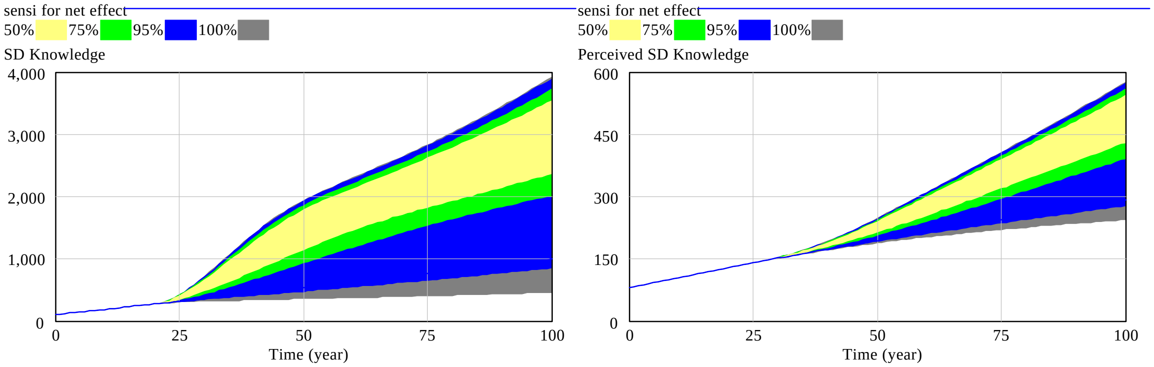
(a) (b)

Figure 26. Publication sensitivity runs for changes in weight on junior.

Publications in process and published materials are not very much influenced by the changes in the relative attention of advanced to juniors or intermediate.

Run 5 Changes in Network Effect

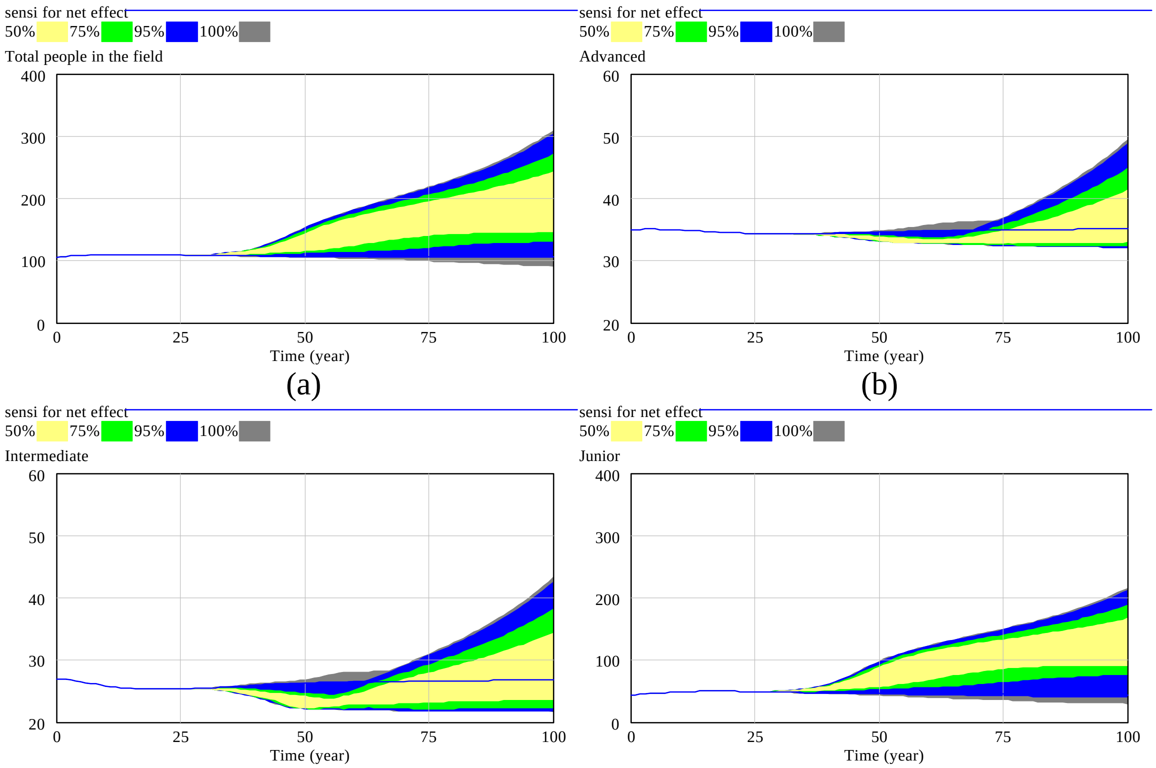
The fifth sensitivity analysis performed is related to changes in the *network effect*. The base effect used is 0.50. This effect has two effects, (1) is a multiplier for idea generation and (2) creates the adequate environment to reduce the maturation time of ideas due to interchange and crossbreeding of ideas amongst individuals and networks. We thinks that this variable is one of the relevant ones to clarify further and explore new ways to properly model it. The change is introduced in time=20 using a step function of size "*effect for sensitivity*" which varies from –0.49 to +15.5 using a random uniform distribution. This means that the actual *network effect* in the model will vary from **0.01**(0.50 + -0.49) to **16** (0.50 + 15.5). This range was selected to represent the most difficulty to interact in networks represented by a virtual cero (0) to a high interact ability represented by a 16. This parameter, up to now, does not have a real counterpart to identify. This is a conceptual tool to reflect the notion of the importance of the networking activities.



(a) (b)

Figure 27. Knowledge sensitivity runs for changes in Network effect.

The model resulted to be extremely sensitive to this parameter generating very high changes in the variables of knowledge, population and publications. This is evidence of the importance of pursuing further investigation in this matter for the future.



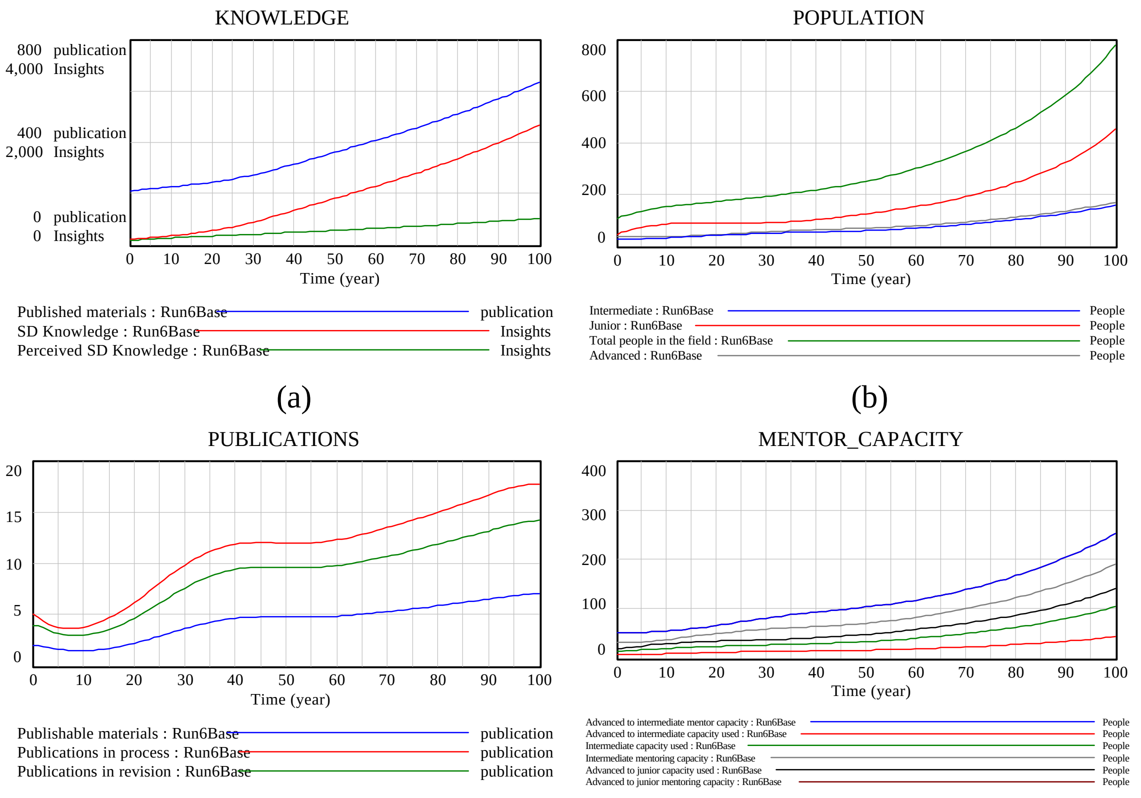
(a) (b)

(c) (d)

Figure 28. Population sensitivity runs for changes in Network effect.

Run 6 New Parameters and Changes in Time to Integrate Ideas

This run will use a combination of changes derived of the previous runs. We came to know that changes in time to integrate ideas attracted many juniors to the field, which will be acknowledged by changing three parameters, and then perform a sensitivity analysis on time to integrate ideas identical to that of run number one. The parameters to change are (1) mentoring capacity per mentor from 3 to 6 persons, (2) weight on juniors from 20% to 50% and, (3) network effect from 0.5 to 1 recognizing the added activity to the field through doubling the mentoring. The base run was performed with a time to integrate ideas of 20 years.

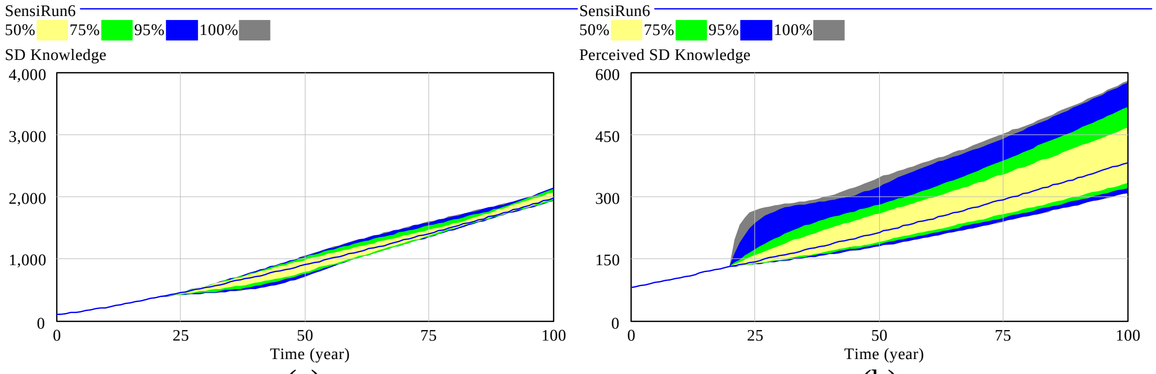


(a) (b)

(c) (d)

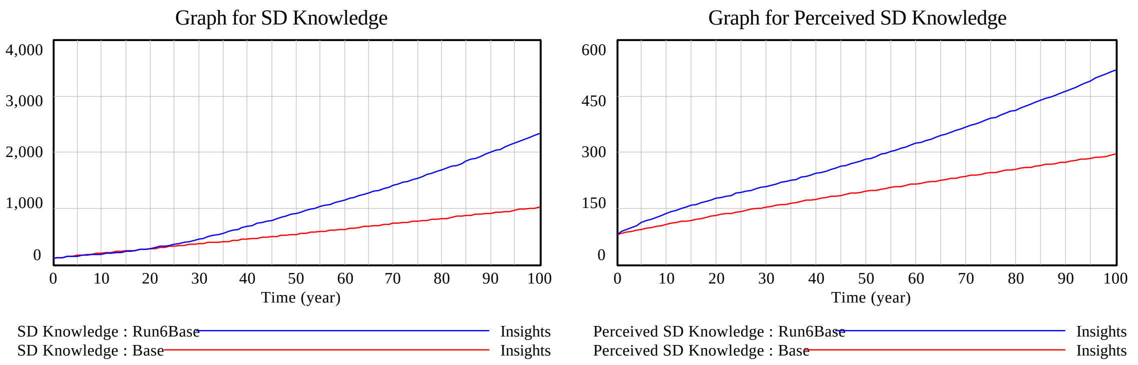
Figure 29. Model behavior with a combined set of variable changes (new base run).

As we can see, the behavior of the model indicates a constant growth in the population sector and the knowledge variables. The publications grow, and then get to a period of stagnation to then continue growing. The field is enjoying a continuous growing capacity in mentorship with this combination of levels (figure 29).



(a) (b)

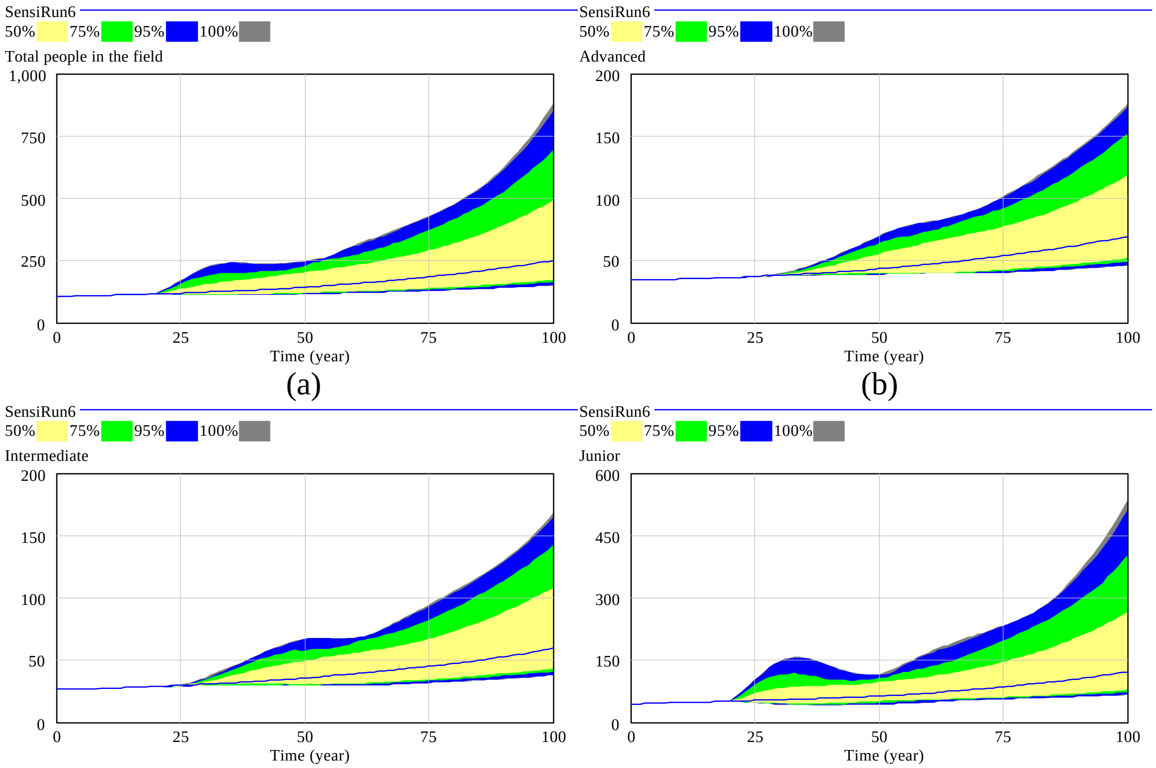
Figure 30. Sensitivity runs for changes in time to perceive knowledge.



(a) (b)

Figure 31. Comparison between the base run and run 6.

SD Knowledge is increased with respect to the base run and exhibits low sensitivity to the changes in time to integrate ideas while in perceived change there is a larger influence (figure 30 and 31).



(a) (b)

(c) (d)

Figure 32. Population sensitivity runs for changes in time to perceive knowledge.

Population variables are clearly affected by these changes generating large varying outcomes depending on the time to integrate ideas (figure 32).

Run 7 Systematic Exploration using a full factorial 2^3 Design of Experiments in standardized factors c_{ik}

Lastly, we will use a systematic approach to explore the best combination of factors varying three of them in two different predetermined levels. This approach seeks to identify further ways to systematically approach the sensibility analysis of the model and a way to identify combinations of factors that would generate the greater response possible (Kleijnen 1995). The array that we will use allows us to design experiments to test the combinations. The total number of experiments is eight and the variable used to measure efficiency of the experiment will be the amount of SD Knowledge accumulated at year 100[2]. We could have selected any variable as measure of efficiency or even a combination of them using a weighted average function or a multiple attribute model (MAU) to measure the efficiency of the model in each experiment. The latter represents the best way to measure the output. We chose the first for simplicity sake and due to the nature and purpose of the model. The full factorial 2^3 is represented as the matrix c shown below and the results of the experiments will be collected in the vector containing the elements c_i leading us to the final maximum $c_{i(\max)}$. The elements in the matrix represent the levels at which the variables will be tested in each experiment. We will use “high level” for 1 and “low level” for 0.

$$c = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \Rightarrow \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \\ c_6 \\ c_7 \\ c_8 \end{bmatrix} \mapsto c_{i(\max)}$$

The three variables used for the experimental design are (1) mentoring capacity per mentor {3,6}, (2) weight on juniors from {0.2,0.8} and, (3) time to integrate ideas from {10,40}. For this experiments the network effect will remain constant and equal to 1 and the normal growing fraction will remain constant and normal in 0.1. The next matrix contains the actual levels for the variables and the results of the experiments measured in the units of the output reference variable (*SD Knowledge*).

---

[2] This simple measure of the efficiency of the model will generate simple solutions that will allow us to understand how to proceed further.

$$c = \begin{bmatrix} 6 & 0.7 & 20 \\ 3 & 0.7 & 20 \\ 6 & 0.4 & 20 \\ 3 & 0.4 & 20 \\ 6 & 0.7 & 35 \\ 3 & 0.7 & 35 \\ 6 & 0.4 & 35 \\ 3 & 0.4 & 35 \end{bmatrix} \Rightarrow \begin{bmatrix} 2{,}740 \\ 1{,}537 \\ 2{,}092 \\ 1{,}321 \\ 2{,}301 \\ 1{,}593 \\ 1{,}925 \\ 1{,}447 \end{bmatrix} \mapsto c_{i(\max)} = Exp1$$

To test the totally decision dependent variables we made four new experiments. We argue that the number of people that mentor can see and the relative weight that he puts into juniors and intermediate are decisions that are made by the mentor. This is that the levels of the variables represent different preferences of the advanced. We replicated four experiments shown in the matrix o three times to "*test*" how the "*integrative*" environment can affect the preferences of the advanced related to which alternative generates a more robust outcome changing the "time to integrate ideas" from 10 to 20 and finally to 30 years as a measure of possibilities.

$$o = \begin{bmatrix} 1 & 1 \\ 0 & 1 \\ 1 & 0 \\ 0 & 0 \end{bmatrix} \Rightarrow \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{bmatrix} \mapsto c_{i(\max)}$$

We generated three sets of results of the four experiments using a full factorial designs of two variables with two levels. The results are shown below.

$$c_{Time=10\,years} = \begin{bmatrix} 6 & 0.7 \\ 3 & 0.7 \\ 6 & 0.4 \\ 3 & 0.4 \end{bmatrix} \Rightarrow \begin{bmatrix} 2{,}990 \\ 1{,}545 \\ 2{,}134 \\ 1{,}317 \end{bmatrix} \mapsto c_{i(\max)}$$

$$c_{Time=20\,years} = \begin{bmatrix} 6 & 0.7 \\ 3 & 0.7 \\ 6 & 0.4 \\ 3 & 0.4 \end{bmatrix} \Rightarrow \begin{bmatrix} 2{,}740 \\ 1{,}537 \\ 2{,}092 \\ 1{,}321 \end{bmatrix} \mapsto c_{i(\max)}$$

$$c_{Time=30\,years} = \begin{bmatrix} 6 & 0.7 \\ 3 & 0.7 \\ 6 & 0.4 \\ 3 & 0.4 \end{bmatrix} \Rightarrow \begin{bmatrix} 2{,}402 \\ 1{,}577 \\ 1{,}965 \\ 1{,}402 \end{bmatrix} \mapsto c_{i(\max)}$$

The complete set of results is shown including the mean and the standard deviation of the results for each experiment using different levels of “time to integrate ideas” as general conditioners of the results.

$$\begin{bmatrix}1\\2\\3\\4\end{bmatrix}\underline{\underline{\overline{\overline{\begin{bmatrix}2{,}990 & 2{,}740 & 2{,}402\\1{,}545 & 1{,}537 & 1{,}577\\2{,}134 & 2{,}092 & 1{,}965\\1{,}317 & 1{,}321 & 1{,}402\end{bmatrix}\Rightarrow\begin{bmatrix}2{,}711 & 295\\1{,}553 & 21\\2{,}064 & 88\\1{,}347 & 48\end{bmatrix}}}}}$$

We can see that experiments 1 and 3 generate the larger average output in SD Knowledge. This two experiments use 6 as the number of people that each mentor can see at a time. Experiments 2 and 4 generate lower average outputs but with significantly lower standard deviations. This gives us the idea that a preference related to lower people per mentor can be more robust across different “integrative” environments. This is that independently of the environment in which the mentorship is taking place, lower numbers of mentors generate more stable SD Knowledge in the end. To be sure, about the added robustness, we included a metric of dispersion over the mean of the results of the experiments to correct for the effect of the lower average results of experiments 2 and 4. The results are shown below.

$$\begin{bmatrix}1\\2\\3\\4\end{bmatrix}\Rightarrow\frac{s}{m}=\begin{bmatrix}0.1088\\0.0135\\0.0426\\0.0356\end{bmatrix}$$

With this new results we confirm that the “*best*” preference to maximize the average result (SD Knowledge) across different levels of “ability to integrate ideas” would be the one related to experiment number 1. This is to have 6 people per mentor and to devote 70% percent of the mentorship to Juniors in the field. If the idea is to generate a preference that would be less variable (more robust) across different integrative environments the alternative would be the one related to experiment 2 having 3 people per mentor and also devoting 70% of the time with juniors in the field. This tells us that the orientation to juniors as the targets of intensive mentorship is highly recommended. The number of people per mentor should be analyzed with respect to the risk taking strategy of the mentor or the field.

Conclusions

The use of a model approach for the research of knowledge dynamics makes a lot of sense. The exploration of best practices and the creation and dynamics of knowledge threw light at some important processes of the different fields of knowledge. Among others, (1) mentoring, (2) networking, (3) knowledge management and, (4) mechanisms of perception and integration in the fields are crucial. This can be of major impact on the cohesiveness and alignment of the communities if studied and acknowledged as important. The way people perceive knowledge and the time that passes between knowledge is generated and one has the opportunity and capacity to integrate the ideas and “perceive” it can lead people to think that knowledge is not being generated, that the field is *static*. What the model shows is that knowledge is growing very rapidly but the perception of it cannot keep up with this growth, and most probably will not do it in the future. We argue that the networking effect increases dramatically the capacity of the individual to learn but also generates a giant blockade that prevents people to see beyond their networks of influence generating *operating blindness* that prevents learning. Many people think that the knowledge that they know of is the *only* knowledge out there, and by doing so they rest momentum to the whole field of knowledge that they belong.

Implications for Future Research

No model is right, because all of them constitute simplifications of reality. However, it is possible to learn and get insights about reality through the analysis of these simplifications as it was shown in the preceding sections. Thus, this model dualism leads System Dynamicists to get conclusions about every simple model, but always produces a parallel set of dynamic behaviors and structures to be added to the model. The main areas of interest that are not addressed in this study are:

(1) The knowing – doing gap (Pfeffer and Sutton 2000) understood as the gap between perceived knowledge in the field and the actual utilization of the core knowledge in practice.
(2) The influence of power and politics in the generation of new knowledge and practice.
(3) Network dynamics and knowledge transfer inside them. This area could imply the collaboration of a SD model with an Agent-Based model.
(4) Project initiation is constrained by financial resources too. Future versions of the knowledge model can explore the effects of funding on knowledge generation.
(5) Psychologists think that previous knowledge can both, facilitate and limit the learning capability. It could be interesting to explore the structure of the impact of perceived and actual SD knowledge on learning.
(6) The dynamics of System Dynamics in its contribution to other fields is only partially addressed by knowledge1, and it constitutes another way to go.
(7) Improving knowledge management activities is related with the effectiveness of mentoring and training programs.
(8) In the present model, core knowledge is the result of a continuous process of ideas and insights selectivity through the knowledge management effort. Benchmarking and best practices approaches consider a different approach not implemented in the model.

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Appendix – Model equations.

****
.Human Resources – Aging chain
****

(002) Advanced = INTEG(Intermediate promotion - Advanced moving to other fields
- Advanced retirement , Advanced initial)
Units: People

(003) Advanced initial = 35
Units: People

(004) Advanced moving to other fields = Advanced * Normal migration fraction
* Effect of conflict over migration
Units: People/year

(005) Advanced proportion = Advanced / Total people in the field
Units: Dmnl

(006) Advanced retirement = Advanced / Average retirement time
Units: People/year

(007) Average project duration = 1
Units: year

(008) Average retirement time = 20
Units: year

(009) Disenchant time normal = 8
Units: year

(010) ECOM f ([(0,0)-(1,5)],(0,1),(0.1,1),(0.2,1),(0.3,1),(0.4,1),(0.5,1.3)
,(0.6,1.8),(0.7,2.5),(0.8,3.6),(0.9,4.4),(1,5))
Units: Dmnl

(011) Effect of conflict over migration = ECOM f (Probability of conflicting approaches
)
Units: Dmnl

(012) Effect of field visibility on growing fraction = EFVGF f (Field visibility
)
Units: Dmnl

(013) Effect of int prom time = EIPT f (Intermediate average maturation time
/ Intermediate Mat time normal)
Units: Dmnl

(014) Effect of jun prom time = EJPT f (Junior average maturation time / Junior Maturation time normal
)
Units: Dmnl

(015) Effect of mentoring on int maturation time = EMIMT f (Intermediate in mentoring to intermediate ratio
)
Units: Dmnl

(016) Effect of mentoring on Junior maturation time = EMJMT f (Juniors in mentoring to junior ratio
)
Units: Dmnl

(017) EFVGF f ([(0,0)-(2,2)],(0,1),(0.2,1.03),(0.4,1.1),(0.6,1.2),(0.8,1.33)
,(1,1.5),(1.2,1.67),(1.4,1.8),(1.6,1.9),(1.8,1.97),(2,2))
Units: Dmnl

(018) EIPT f ([(0,0)-(2,6)],(0,5),(0.110092,3.97368),(0.299694,2.65789),(0.556575,1.86842)

,(0.788991,1.31579),(1,1),(1.21101,0.982456),(1.41284,0.921053)

,(1.60245,0.877193),(1.81651,0.789474),(1.98777,0.684211),(5,0.25)
)
Units: Dmnl

(019) EJPT f ([(0,0)-(2,6)],(0,5),(0.110092,3.97368),(0.299694,2.65789),(0.556575,1.86842)

,(0.788991,1.31579),(1,1),(1.21101,0.982456),(1.41284,0.921053)

,(1.60245,0.877193),(1.81651,0.789474),(1.98777,0.684211),(5,0.25)
)
Units: Dmnl

(020) EMIMT f ([(0,0)-(1,2)],(0,2),(0.1,1.98),(0.2,1.95),(0.3,1.9),(0.4,1.6)

,(0.5,1.2),(0.6,0.95),(0.7,0.75),(0.8,0.6),(0.9,0.55),(1,0.5))
Units: Dmnl

(021) EMJMT f ([(0,0)-(1,2)],(0,2),(0.1,1.98),(0.2,1.95),(0.3,1.9),(0.4,1.6)

,(0.5,1.2),(0.6,0.95),(0.7,0.75),(0.8,0.6),(0.9,0.55),(1,0.5))
Units: Dmnl

(022) Field visibility = Perceived change in actual perceived knowledge / Perceived change in other fields
Units: Dmnl

(023) Growing fraction = Normal growing fraction * Effect of field visibility on growing fraction
Units: 1/year

(024) Increases in perceived knowledge = ((Published materials / Insights per publication
) - Perceived SD Knowledge) / Time to integrate ideas
Units: Insights/year

(025) Insights per publication = 1
Units: publication/insight

(026) Intermediate = INTEG(Junior promotion - Intermediate moving to other fields
- Intermediate promotion , Intermediate initial)
Units: People

(027) Intermediate average maturation time = Intermediate Mat time normal *
Effect of mentoring on int maturation time
Units: year

(028) Intermediate in mentoring to intermediate ratio = Intermediate in mentoring
/ Intermediate
Units: Dmnl

(029) Intermediate initial = 27
Units: People

(030) Intermediate Mat time normal = 4
Units: year

(031) Intermediate moving to other fields = Intermediate / Time for intermediate to disenchant

Units: People/year

(032) Intermediate promotion = Intermediate / Intermediate average maturation time

Units: People/year

(033) Intermediate proportion = Intermediate / Total people in the field
Units: Dmnl

(034) Junior = INTEG(New practitioners - Junior moving to other fields - Junior promotion
, Junior initial)
Units: People

(035) Junior average maturation time = Junior Maturation time normal * Effect of mentoring on Junior maturation time

Units: year

(036) Junior initial = 44
Units: People

(037) Junior Maturation time normal = 8
Units: year

(038) Junior moving to other fields = Junior / Time for juniors to disenchant

Units: People/year

(039) Junior promotion = Junior / Junior average maturation time
Units: People/year

(040) Junior proportion = Junior / Total people in the field
Units: Dmnl

(041) Juniors in mentoring to junior ratio = Total Juniors in mentoring / Junior

Units: Dmnl

(042) New practitioners = Total people in the field * Growing fraction
Units: People/year

(043) Normal growing fraction = 0.1
Units: 1/year

(044) Normal migration fraction = 0.05
Units: 1/year

(045) Perceived change in actual perceived knowledge = SMOOTH (Increases in perceived knowledge
, Time to avg)
Units: Insights/year

(046) Perceived change in other fields = 5
Units: Insights/year

(047) Perceived SD Knowledge = INTEG(Increases in perceived knowledge , 80
)
Units: Insights

(048) Probability of conflicting approaches = Advanced proportion
Units: Dmnl

(049) Published materials = INTEG(Publishing - Obsolescing , 210)
Units: publication

(050) Time for intermediate to disenchant = Disenchant time normal * Effect of int prom time

Units: year

(051) Time for juniors to disenchant = Disenchant time normal * Effect of jun prom time

Units: year

(052) Time to avg = 1
Units: year

(053) Time to integrate ideas = 50
Units: year

(054) Total people in the field = Advanced + Intermediate + Junior
Units: People

****
.Control
****

Simulation Control Parameters

(056) FINAL TIME = 100
Units: year

(057) INITIAL TIME = 0
Units: year

(058) SAVEPER = 1
Units: year

(059) TIME STEP = 0.125
Units: year

****
.Knowledge
****

(061) Applied knowledge = INTEG(Insight tranfer - Insight obsolescence , 21.28
)
Units: Insights

(062) Avg time to become obsolete = 20
Units: year

(063) EABKG f ([(0,0)-(1,1)],(0,0),(0.1,0.02),(0.2,0.1),(0.3,0.2),(0.4,0.33)

,(0.5,0.5),(0.6,0.67),(0.7,0.8),(0.8,0.9),(0.9,0.98),(1,1))
Units: Dmnl

(064) EEPI f ([(0,0)-(1,1)],(0,0.1),(0.1,0.12),(0.2,0.2),(0.302752,0.280702)

,(0.4,0.38),(0.5,0.5),(0.6,0.67),(0.7,0.8),(0.8,0.9),(0.9,0.98)
,(1,1))
Units: Dmnl

(065) Effect of advanced proportion on basic knowledge generation = EABKG f
(Advanced proportion)
Units: Dmnl

(066) Effect of experienced proportion on insights = EEPI f (Experienced fraction
)
Units: Dmnl

(067) Effect of people living over obsolescence time = EPLOKL f (Human resource rotation index
)
Units: Dmnl

(068) EOIO f ([(0,0)-(2000,2)],(0,0),(244.648,0.0350877),(495.413,0.0789474)

,(770.642,0.140351),(984.709,0.192982),(1168.2,0.350877)
,(1333.33,0.789474)

,(1486.24,1.31579),(1645.26,1.7193),(1798.17,1.91228),(2000,2))
Units: Dmnl

(069) EPLOKL f ([(0,0)-(40,2)],(0,0.1),(5,0.25),(10,0.5),(15,0.75),(20,1),
(25,1.25),(30,1.5),(35,1.75),(40,2))
Units: Dmnl

(070) Experienced fraction = Advanced proportion + Intermediate proportion
Units: Dmnl

(071) Forgetting time = Time to become obsolete
Units: year

(072) Fraction of transferred insights = 1 - Fraction SD basic Knowledge
Units: Dmnl

(073) Human resource rotation index = Total people in the field / (Junior moving to other fields
+ Advanced moving to other fields + Intermediate moving to other fields)
Units: year

(074) Ideas becoming real = Mature project ideas / Time to start new projects

Units: Idea/year

(075) Insight obsolescence = Applied knowledge / Forgetting time
Units: Insights/year

(076) Insight per project normal = 4
Units: Insights/Project

(077) Insight tranfer = Fraction of transferred insights * Total insights
Units: Insights/year

(078) Insights per project = Insight per project normal * Effect of experienced proportion on insights

Units: Insights/Project

(079) Normal SD knowledge fraction = 0.2
Units: Dmnl

(080) Perceived change of the field = SMOOTH (Learning , Time to perceive
)
Units: Insights/year

(081) Project failure = (1 - Project success fraction) * Total project outflow

Units: Project/year

(082) Project generation per idea = 1
Units: Project/Idea

(083) Project success fraction = 0.5
Units: Dmnl

(084) Projects ending = Total project outflow * Project success fraction
Units: Project/year

(085) Projects in progress = INTEG(Projects starting - Project failure - Projects ending
, 160)
Units: Project

(086) Projects starting = Ideas becoming real * Project generation per idea

Units: Project/year

(087) Time to perceive = 5
Units: year

(088) Total project outflow = Projects in progress / Average project duration

Units: Project/year

(089) Work group total capacity = Work group productivity * Work groups
Units: Project/year

****
.Knowledge Management
****

(091) Acceptance time = 1
Units: year

(092) Accepted publications = Fraction accepted * Total paper rate
Units: publication/year

(093) Actual obsolescence time = SD Knowledge / Obsolescence
Units: year

(094) Deciding to publish = Learning * Fraction of new Knowledge perceived as valuable to be published
* Insights per publication
Units: publication/year

(095) Effect over insight obsolescence = EOIO f (Perceived change of the field
)
Units: Dmnl

(096) Failing publications = (1 - Fraction finished) * Total pub rate
Units: publication/year

(097) Fraction accepted = 0.5
Units: Dmnl

(098) Fraction finished = 0.8
Units: Dmnl

(099) Fraction of new Knowledge perceived as valuable to be published = 0.5
Units: Dmnl

(100) Fraction SD basic Knowledge = Effect of advanced proportion on basic knowledge generation
* Normal SD knowledge fraction
Units: Dmnl

(101) Learning = Fraction SD basic Knowledge * Total insights
Units: Insights/year

(102) Obsolescence = (SD Knowledge / Time to become obsolete) * Effect over insight obsolescence

Units: Insights/year

(103) Obsolescing = Published materials / Actual obsolescence time
Units: publication/year

(104) Publications in process = INTEG(Deciding to publish - Failing publications
- Sending to revision , 5)
Units: publication

(105) Publications in revision = INTEG(Sending to revision - Accepted publications
- Rejected papers , 4)
Units: publication

(106) Publishable materials = INTEG(Accepted publications - Publishing , 2)
Units: publication

(107) Publishing = Publishable materials / Publishing time
Units: publication/year

(108) Publishing time = 1
Units: year

(109) Rejected papers = (1 - Fraction accepted) * Total paper rate
Units: publication/year

(110) SD Knowledge = INTEG(Learning - Obsolescence , 100)
Units: Insights

(111) Sending to revision = Fraction finished * Total pub rate
Units: publication/year

(112) Time to become obsolete = Avg time to become obsolete * Effect of people living over obsolescence time

Units: year

(113) Total insights = Insights per project * Projects ending
Units: Insights/year

(114) Total paper rate = Publications in revision / Acceptance time
Units: publication/year

(115) Total pub rate = Publications in process / Writing time
Units: publication/year

(116) Writing time = 1
Units: year

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.Human Resources – Mentoring

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(119) Intermediate in mentoring = Advanced to intermediate capacity used
Units: People

(120) Total Juniors in mentoring = Advanced to junior capacity used + Intermediate capacity used

Units: People

(122) Advanced mentoring capacity = Advanced willing to mentor * Mentoring Capacity per mentor

Units: People

(123) Advanced to intermediate capacity used = INTEG(Int joining mentoring programs
- Int leaving mentoring , 8)
Units: People

(124) Advanced to intermediate mentor capacity = Advanced mentoring capacity
* (1 - Weight on junior)
Units: People

(125) Advanced to junior capacity used = INTEG(Junior joining ment programs
- Jun leaving adv mentoring , 19)
Units: People

(126) Advanced to junior mentoring capacity = Advanced mentoring capacity *
Weight on junior
Units: People

(127) Advanced willing to mentor = Advanced * Fraction of advanced willing to mentor

Units: People

(128) Average mentoring time = 4
Units: year

(129) Avg int leaving mentoring = SMOOTH (Int leaving mentoring , Time to avg
)
Units: People/year

(130) Avg jun leaving adv mentoring = SMOOTH (Jun leaving adv mentoring ,
Time to avg)
Units: People/year

(131) Avg junior leaving mentoring = SMOOTH (Jun leaving mentoring , Time to avg
)
Units: People/year

(132) EACS f ([(0,0)-(1,1e+010)],(0,1),(0.1,1.03),(0.2,1.11),(0.3,1.25),(0.4,1.53)

,(0.5,2),(0.6,2.86),(0.7,5),(0.8,10),(0.9,34),(1,1e+010))
Units: Dmnl

(133) EAJS f ([(0,0)-(1,1e+010)],(0,1),(0.1,1.03),(0.2,1.11),(0.3,1.25),(0.4,1.53)

,(0.5,2),(0.6,2.86),(0.7,5),(0.8,10),(0.9,34),(1,1e+010))
Units: Dmnl

(134) Effect of advanced capacity saturation on time = EACS f (Saturation of advanced capacity
)
Units: Dmnl

(135) Effect of advanced to junior saturation on time = EAJS f (Saturation of advanced to junior capacity
)
Units: Dmnl

(136) Effect of intermediate capacity saturation on time = EICS f (Saturation of intermediate capacity
)
Units: Dmnl

(137) Effect of intermediate saturation on time = EIS f (Saturation of intermediate on mentoring
)
Units: Dmnl

(138) Effect of Junior saturation on time = EJS f (Saturation of junior in mentoring)
Units: Dmnl

(139) EICS f ([(0,0)-(1,1e+010)],(0,1),(0.1,1.03),(0.2,1.11),(0.3,1.25),(0.4,1.53)

,(0.5,2),(0.6,2.86),(0.7,5),(0.8,10),(0.9,34),(1,1e+010))
Units: Dmnl

(140) EIS f ([(0,0)-(1,1e+010)],(0,1),(0.1,1.03),(0.2,1.11),(0.3,1.25),(0.4,1.53)

,(0.5,2),(0.6,2.86),(0.7,5),(0.8,10),(0.9,34),(1,1e+010))
Units: Dmnl

(141) EJS f ([(0,0)-(1,1e+010)],(0,1),(0.1,1.03),(0.2,1.11),(0.3,1.25),(0.4,1.53)
,(0.5,2),(0.6,2.86),(0.7,5),(0.8,10),(0.9,34),(1,1e+010))
Units: Dmnl

(142) Fraction of advanced willing to mentor = 0.5
Units: Dmnl

(143) Fraction of intermediate willing to be mentored = 0.3
Units: Dmnl

(144) Fraction of intermediate willing to mentor = 0.2
Units: Dmnl

(145) Fraction of junior willing to be mentored = 0.8
Units: Dmnl

(146) Int joining mentoring programs = (Advanced to intermediate mentor capacity
- Advanced to intermediate capacity used) / Time to acquire an advanced mentor
+ Avg int leaving mentoring
Units: People/year

(147) Int leaving mentoring = Advanced to intermediate capacity used / Average mentoring time

Units: People/year

(148) Intermediate capacity used = INTEG(Junior joining mentoring programs
- Jun leaving mentoring , 14)
Units: People

(149) Intermediate mentoring capacity = Intermediate willing to mentor * Mentoring Capacity per mentor

Units: People

(150) Intermediate willing to be mentored = Intermediate * Fraction of intermediate willing to be mentored

Units: People

(151) Intermediate willing to mentor = Fraction of intermediate willing to mentor
* Intermediate
Units: People

(152) Jun leaving adv mentoring = Advanced to junior capacity used / Average mentoring time

Units: People/year

(153) Jun leaving mentoring = Intermediate capacity used / Average mentoring time

Units: People/year

(154) Junior joining ment programs = (Advanced to junior mentoring capacity
- Advanced to junior capacity used) / Time for jun to acquire advanced mentor
+ Avg jun leaving adv mentoring
Units: People/year

(155) Junior joining mentoring programs = (Intermediate mentoring capacity
- Intermediate capacity used) / Time to acquire an intermediate mentor
+ Avg junior leaving mentoring
Units: People/year

(156) Junior willing to be mentored = Junior * Fraction of junior willing to be mentored
Units: People

(157) Mentoring Capacity per mentor = 3
Units: 1

(158) Saturation of advanced capacity = Advanced to intermediate capacity used
/ Advanced to intermediate mentor capacity
Units: Dmnl

(159) Saturation of advanced to junior capacity = Advanced to junior capacity used
/ Advanced to junior mentoring capacity
Units: Dmnl

(160) Saturation of intermediate capacity = Intermediate capacity used / Intermediate mentoring capacity

Units: Dmnl

(161) Saturation of intermediate on mentoring = Advanced to intermediate capacity used
/ Intermediate willing to be mentored
Units: Dmnl

(162) Saturation of junior in mentoring = (Intermediate capacity used + Advanced to junior capacity used
) / Junior willing to be mentored
Units: Dmnl

(163) Time for jun to acquire advanced mentor = Time to get a mentor normal
* Effect of advanced to junior saturation on time * Effect of Junior saturation on time

Units: year

(164) Time to acquire an advanced mentor = Time to get a mentor normal * Effect of advanced capacity saturation on time
* Effect of intermediate saturation on time
Units: year

(165) Time to acquire an intermediate mentor = Time to get a mentor normal
* Effect of intermediate capacity saturation on time * Effect of Junior saturation on time

Units: year

(166) Time to get a mentor normal = 2
Units: year

(167) Weight on junior = 0.2
Units: Dmnl

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.Project Sector
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(169) Average cooking time = 1
Units: year

(170) Average people per group = 5
Units: People/group

(171) Cooking time = Average cooking time / Network effect
Units: year

(172) Idea generation = People idea productivity * Total people in the field
* Network effect
Units: Idea/year

(173) Idea maturation = Project ideas cooking / Cooking time
Units: Idea/year

(174) Mature project ideas = INTEG(Idea maturation - Ideas becoming real ,
600)
Units: Idea

(175) Network effect = 0.5
Units: Dmnl

(176) People idea productivity = 3
Units: Idea/(People*year)

(177) Project ideas cooking = INTEG(Idea generation - Idea maturation , 320
)
Units: Idea

(178) Time to start new projects = Projects in progress / Work group total capacity

Units: year

(179) Work group productivity = 2
Units: Project/(year*group)

(180) Work groups = Total people in the field / Average people per group
Units: group