Research on Human Factors Affected College Teachers' Knowledge Collaborative Efficiency

——Based on the Perspective of System Dynamics

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Abstract: This research of college teachers' knowledge collaboration is from the human perspective by the system dynamics methods. First, the human factors, which affecting the knowledge collaboration efficiency, include three dimensions of the individual ability, psychological utility and social relations. Second, the casual loop diagram is depicted between the human factors' three dimensional and knowledge collaboration efficiency, and the differential equation is been build to express the relationship between the variables. Third, according to the trends change of the related variables, we put forward the three effective measures from the human perspective, that is improving individual capacity through the training system, improving psychological utility by incentive and constraints mechanism, and building a good relationship from the trust culture. Finally, we point out the limitations and prospects of this research.

Literature Review and Problem Definition

Knowledge collaboration which through knowledge identification, capture, sharing, collaboration and accumulation[1], to exploit and capitalize the past experience and expertise, then create new knowledge. And to change individual knowledge into organizational knowledge, ultimately realize organizational performance. Therefore, in the times of knowledge economy, the knowledge collaboration has become critical to the success of the organization, and has also naturally become a major research theme in different management disciplines including management, education, psychology and so on. In the field of education, because of higher colleges is the carrier which to create, share, and transfer the explicit and tacit knowledge[2]. It focuses on embedding the knowledge in organization, then generates and spreads to society. So, different disciplinary backgrounds of teachers are encouraged to cooperate with each other. Through the intersection of knowledge collaboration to achieve innovation, then conducive to improve and enhance the college's innovative potential[3].College teachers' knowledge collaboration which stores and absorbs the others knowledge, then transforms into their own knowledge, finally internalized the solving problem ability.Only through transferring and exchanging the knowledge, to obtain the knowledge and experience what they lack. Then improve the breadth and depth of teachers' knowledge, the level of scientific research, personnel training and the quality of social services.Once knowledge collaboration static, which means teachers can't react quickly to internal and external environmental changes, and then enter a state of chaos[4].

However, in colleges and universities, there exists an unimaginably queer phenomenon. That is, while the knowledge collaboration conducive to innovation, why teachers would rather to "do it alone"? Due to academic organizations have unique characteristics of the exclusiveness and individualism[5].So,teachers tend to focus on personal academic achievements, rather than organizational performance, that cause the college knowledge collaboration may be inefficient. Thus,knowledge collaboration is a test of human nature. Knowledge collaboration efficiency has been affected by psychological and individual capacity factors and so on. However, in terms of current research status, most literature analyze college teachers' knowledge collaboration from the technical aspects of the network construction and the management level of organizational system.

So, the study would research college teachers' knowledge collaboration from the human perspective by the system dynamics methods.

The Dimension of Individual Capacity

In addition to have professional knowledge and sharing willingness, senior teachers should also have the writing and expressing ability. Only in this way, we can systematically collate the possessed knowledge, and then spread to the young teachers in an appropriate way. Otherwise, it will hinder knowledge collaboration. At the same time, the higher level the individual young teachers' are, the knowledge absorbing ability gets stronger. If the quality of young teachers is low, then the deviation of knowledge understanding would thus hinder collaboration.

The Dimension of Psychological Utility

For senior teachers, the phenomenon of "the apprentice will replace the master" makes them to monopolize the knowledge and refuse knowledge collaboration in order to protect their social status of experts and intellectual property[6]. For young teachers with competitive characteristics, they are confident and arrogant of their learning ability, they would worry the others who derive effective message and overtake themselves[7].They would refuse the share physically and psychologically especially when the shared knowledge is closely related to self-interest. Instead, they will think that the best way is "free-rider" without input.

The Dimension of Social Relation

When the senior teachers believe young teachers will follow the principle of reciprocity to return favor, the senior teachers are willing to contribute and the knowledge collaboration will be better. When the young teachers trust senior teachers, they won't worry about their shortcomings will be mocked. And they would not rate themselves as experts, being blindly arrogant and complacent.

College Teachers' Knowledge Collaborative Efficiency Analyzed by System Dynamics

Causal Loop Diagrams

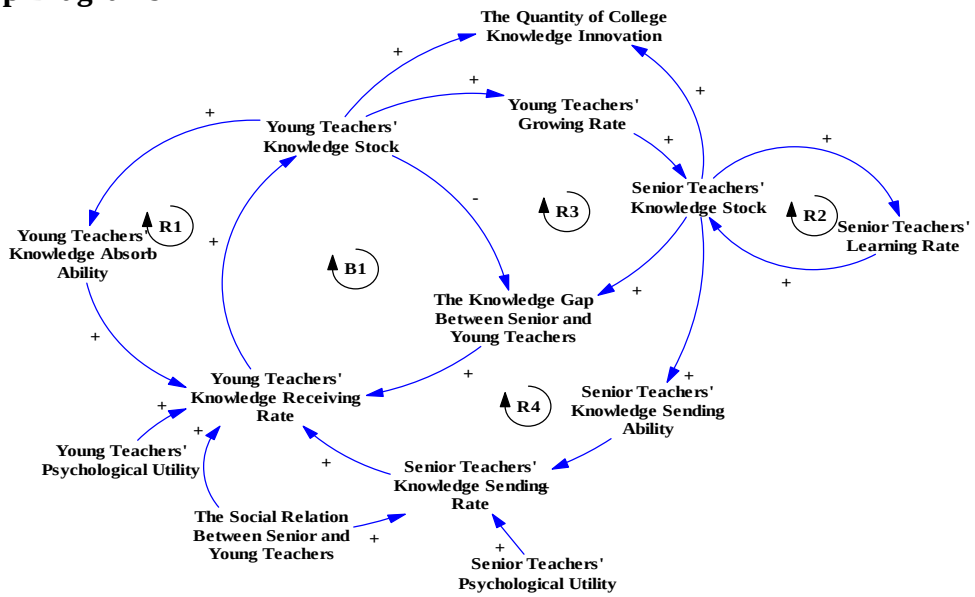

Fig.1 Causal Loop Diagrams of College Teachers' Knowledge Collaboration System

Fig.1 shows the causal relationship of college teachers' knowledge collaborative system. It describes the relationship of factors in knowledge collaborative system. A "+" is marked if the variables change in the same trend[8](e.g., improving "Senior Teachers' Knowledge Stock", will result in better "Senior Teachers' Knowledge Sending Ability").Vice versa, if variables change in an opposite direction, then a "-" will be marked(e.g, increasing the "Young Teachers' Knowledge Stock"will lower the "Knowledge Gap Between Senior and Young Teachers").In order to clarify the mechanism of college teachers' knowledge collaboration system, we introduce reinforcing loops and balancing loops to describe the relationship among the factors. Of which, Reinforcing loop's variables change in the same direction, increasing or declining at the same time, represented by "R".

For balancing loop, exists to stabilize the system, just like the thermostat trying to offset the change in order to maintain a steady temperature[9], represented by "B". In Fig.1, the model has four reinforcing and one balancing loop.

System Dynamics Equations

The relationship between the variables can be structurally described by stock and flow rate in system dynamics equations. Then, we can adopt VENSIM for simulation.

State Equation

State equation describes the change of stock, representing the accumulation of the flow change over time. On the same node of stock exist the inflow and outflow variable. The one with arrow pointing at stock is described as inflow variables and presented as "addition" in state equations. Conversely, the one with arrow deviating from the stock is described as outflow variables and presented as "subtraction"[10].

Now, the knowledge stock about young teachers and senior teachers are mentioned below:

(1)YKS represents the "Young Teachers' Knowledge Stock",its initial value is 30.That is $YKS(t_0)$=30.

$$YKS = \int_{t_0}^{t} (YRR - YGR)\,dt + YKS(t_0) \qquad (1)$$

of which:YRR represents the "Young Teachers' Knowledge Receiving Rate", and YGR represents the "Young Teachers' Growing Rate".

(2)SKS represents the "Senior Teachers' Knowledge Stock", its initial value is 60. That is $SKS(t_0)=60$. (NOTE: We hypothesize that the initial value of "Senior Teachers' Knowledge Stock" is twice as that of "Young Teachers' Knowledge Stock", and the initial value doesn't affect the system operation.)

$$SKS = \int_{t_0}^{t} (SLR + YGR)\,dt + SKS(t_0) \qquad (2)$$

Of which: SLR represents the "Senior Teachers' Learning Rate" add YGR refers to the young teachers will eventually grow into senior teachers.

Rate Equation

The rate equation is an equation that tells the flow formation in the unit time. The change of flow rate will affect the stock, just like the tap switch controls stock. Unlike the state equation, the rate equation has no standard format, but is created by the auxiliary variable and constant variable which point to the rate variable[10]. We will use "multiplication" to represent when they positively influence on the flow rate. On the contrary, we will use "division" to represent when they negatively effects on the flow rate. Specific examples are as follows:

(1)YRR represents the "Young Teachers' Knowledge Receiving Rate". Shown as Fig.1, in the node of the "Young Teachers' Knowledge Receiving Rate", from the output point, which influences on the enhancement of Teachers' Knowledge Stock. From the input point, it is positively correlated with five factors of the "Young Teachers' Knowledge Absorbing Ability", "Young Teachers' Psychological Utility", "the Social Relation between Senior and Young Teacher", "The Knowledge Gap Between Senior and Young Teachers" and "Senior Teachers' Knowledge Sending Rate". So, as follows, we will use "multiplication" to express:

$$YRR=YAA*YPU*SR*KG*SSR \qquad (3)$$

Among them: YAA represents the "Young Teachers' Knowledge Absorb Ability", is influenced by the young teachers' knowledge, which belongs to the auxiliary variables. We hypothesizes that the "Young Teachers' Knowledge Absorbing Ability" is changed by 1% rate of its knowledge stock in per unit time.(NOTE: This study hypothesizes that the teachers' ability is changed by 1% rate of its knowledge stock in unit time)

$$YAA=0.01*YKS \qquad (4)$$

And YPU represents the "Young Teachers' Psychological Utility", which belongs to the constant variables. SR represents the" Social Relation Between Senior and Young Teachers", which belongs to the constant variables. KG represents the "Knowledge Gap Between Senior and Young Teachers", is measured by the difference of the senior teachers knowledge stock and young teachers' knowledge stock, which belongs to the auxiliary variables, which as follows:

KG=SKS-YKS (5)

SSR represents the "Senior Teachers' Knowledge Sending Rate", which belongs to the auxiliary variables, it's affected by three variables of the "Senior Teachers' Knowledge Sending Ability", "Senior Teachers' Psychological Utility" and "The Social Relation Between Senior and Young Teachers", as follows:

*SSR=SSA*SPU*SR* (6)

Among them:SSA represents the "Senior Teachers' Knowledge Sending Ability", which belongs to the auxiliary variables, it has positively correlated with Senior Teachers' Knowledge in certain proportion. This study hypothesizes that Senior Teachers' Knowledge Sending Ability is changed by 1% rate of its knowledge stock in per unit time.SPU represents the "Senior Teachers' Psychological Utility", which belongs to the constant variables.

*SSA=0.01*SKS* (7)

(2)YGR represents the "Young Teachers' Growing Rate". It indicated that the "Young Teachers' Knowledge Stock" reaching a certain extent, will be transformed into senior teachers. The growth rate is affected by its own knowledge stock and growth time.

YGR=YKS/YGT=YKS/24 (8)

Of which: YGT represents the "Young Teachers' Growing Time". Generally, an assistant professor with a doctorate need more than two years to become a lecturer, so YGT=24(month).

(3)SLR represents the "Senior Teachers' Learning Rate", it has positively relationship with "Senior Teachers' Knowledge Stock" in a certain proportion. This study hypothesizes that "Senior Teachers' Learning Rate" is changed by 1% rate of its knowledge stock in per unit time.

*SLR=0.01*SKS* (9)

Research Objectives

The objective of this study is the "Quantity of College Knowledge Innovation",represented by CKI, is also the ultimate measuring indicator of knowledge collaboration effect that can be used to describe the individual knowledge stock which will enhance the college knowledge innovation. It's affected by young teachers' and senior teachers' knowledge stock and knowledge innovation rate.

*CKI=YKS*YIR+SYK*SIR* (10)

Among them: YIR represents the "Young Teachers' Innovation Rate".SIR represents the "Senior teachers' innovation Rate".

The Description of Constant Variables

Considering teacher's psychological utility is one of psychological perceptions, and in the current market economy, teachers are featured with stronger self-awareness and pursuit of free choice and self-improvement, but low degree of mutual trust and interpersonal relationship. So, we hypothesize the initial value of YPU, SPU and SR all reached 60 points, that is, YPU=0.6, SPU=0.6, SR=0.6.

Generally speaking, the innovation rate of senior teachers is higher than young ones. Therefore, the research hypothesizes that the initial values of SIR and YIR are: SIR=0.5, YIR =0.2 (NOTE: The initial value does not affect the system operation).

Analysis On Simulation Model

Put the constructed model into the VENSIM simulation software to simulate. The exquisite of system dynamics lies in revealing the dynamic process of variables which change over time. This study analyzed how knowledge stock is influenced by the dimensions of college teachers' ability, psychological utility and social relations inside this "Social System lab", so, we can scientifically point out measures to improve college teachers' knowledge collaboration.

Analysis on individual ability effects on individual knowledge stock

The simulation diagrams of the young teachers' knowledge absorbing ability and knowledge stock are shown in Fig.2. And the simulation diagrams of the senior teachers' knowledge sending ability and knowledge stock are shown in Fig.3.They all showed an upward trend over time. Therefore, the young teachers' knowledge absorbing ability and the senior teachers' knowledge sending ability are both improved along with better knowledge stock.

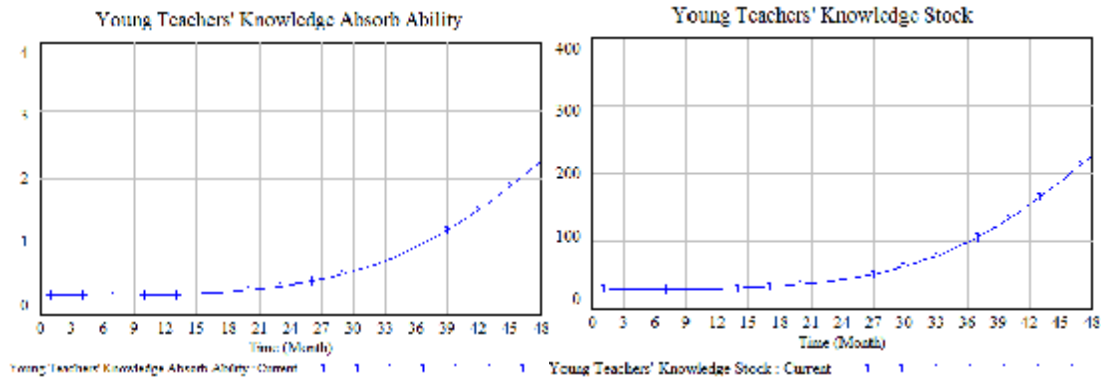

Fig.2 The system simulation of the young teachers' knowledge absorbing ability" and knowledge stock

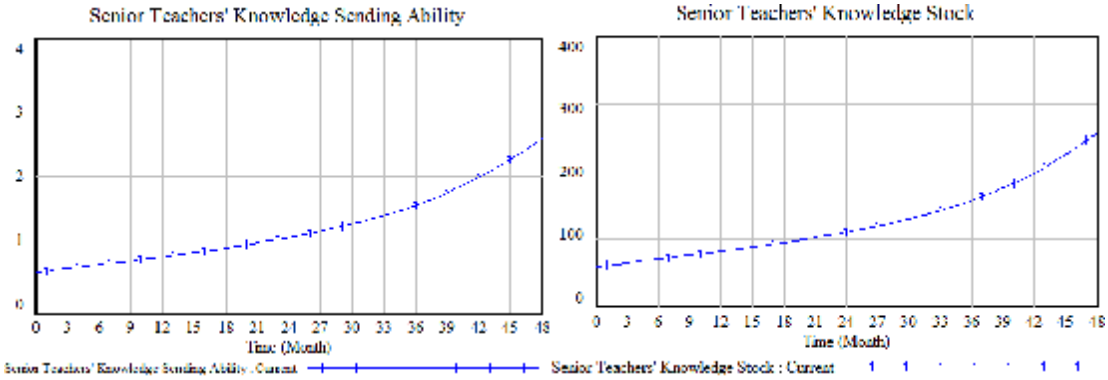

Fig.3 The system simulation of the senior teachers' knowledge sending ability and knowledge stock

At the same time, the advancement of individual ability will further recognize and absorb the external knowledge, which continuously promote the knowledge sharing and the teachers' knowledge stock. It concludes that the teachers' individual ability and knowledge stock is complementary. Conversely, a lower "Young Teachers' Knowledge Absorbing Ability" will make knowledge absorbing and integrating harder and not conducive to the growth of the knowledge stock. If the "Senior Teachers' Knowledge Sending Ability" is not enough, it would also hinder the young teachers from receiving knowledge and the development of young teachers, which finally will decrease the knowledge stock. In short, the teacher’s individual ability is the foundation of the knowledge collaboration success.

Analysis on psychological effects on the individual knowledge stock

This study adopts sensitivity analysis to analyze how individual knowledge stock is affected by psychological utility. The relationship between psychological utility and knowledge stock is shown in Fig.4. The "Curve 1" represents the trend of knowledge stock with the initial values of young and senior teachers' psychological utility are 0.6. The "Curve 2" refers to keeping the value of the senior teacher’s psychological utility unchanged and improving the young teachers' psychological utility value to 0.7. The "Curve 3" refers to keeping the value of the young teachers' psychological utility unchanged, and improving the senior teachers' psychological utility value to 0.7. The "Curve 4" represents the psychological utility values of both types change to 0.7. The picture reveals that the enhancement of the individual psychological utility would facilitate the improvement of the knowledge stock. However, it is quite interesting that the "Curve 2" overlap with "Curve 3". Unlike the fact that the level of knowledge innovation is determined by seniority of individual, the cooperation psychological impact on the amount of knowledge or the level of innovation has nothing to do with the seniority. Therefore, the young and senior teachers are both required to follow the principle of reciprocity and mutual benefit.Collaboration requires bilateral cooperation, otherwise, if one party acts, the other will cease cooperation, and the teachers' knowledge collaborative community will be difficult to reach. So the cooperation willingness is the foundation of knowledge collaboration success.

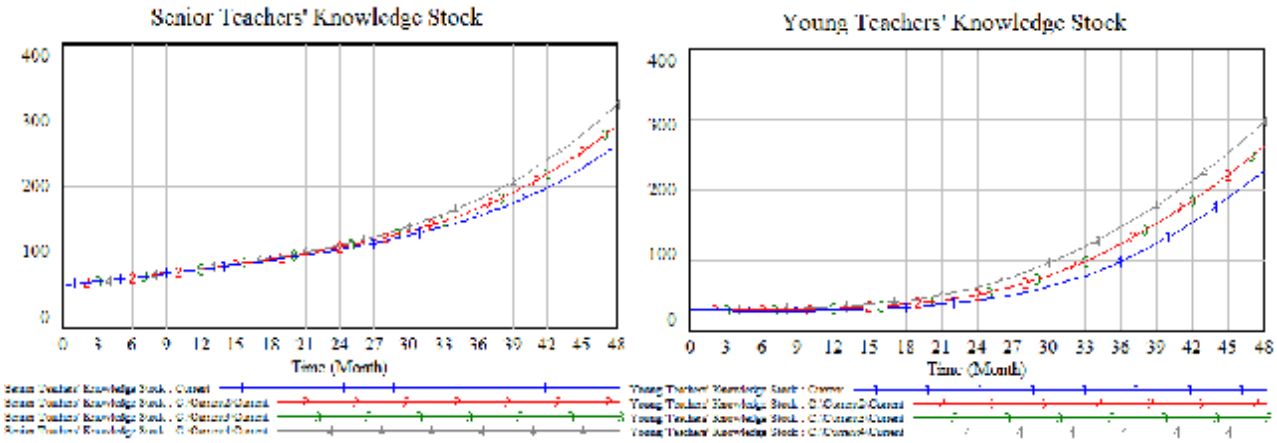

Fig.4 The simulation diagrams of psychological effect on individual knowledge stock

Analysis on social relationship effects on the individual knowledge stock

The first thing to note that the psychological utility is different individual evaluating the problem, but the social relations is the common cognition of cooperation. When facing the subject of the social relations affecting the individual knowledge, the study still adopts sensitivity analysis method. Fig.5 describes the relationship between social relations and the knowledge stock. The "Curve 1" represents the trend of the knowledge stock, when the value of the senior teachers and young teachers' social relations is 0.6. The "Curve 2" represents the trend of both knowledge stock, when the social relations increased to 0.7.Thus, positive social relationship among the teachers can contribute to knowledge collaboration. If it lacks of trust, no matter how many systems there are, they only ends up as formality, Therefore, the interpersonal trust and interaction is the key of knowledge collaboration.

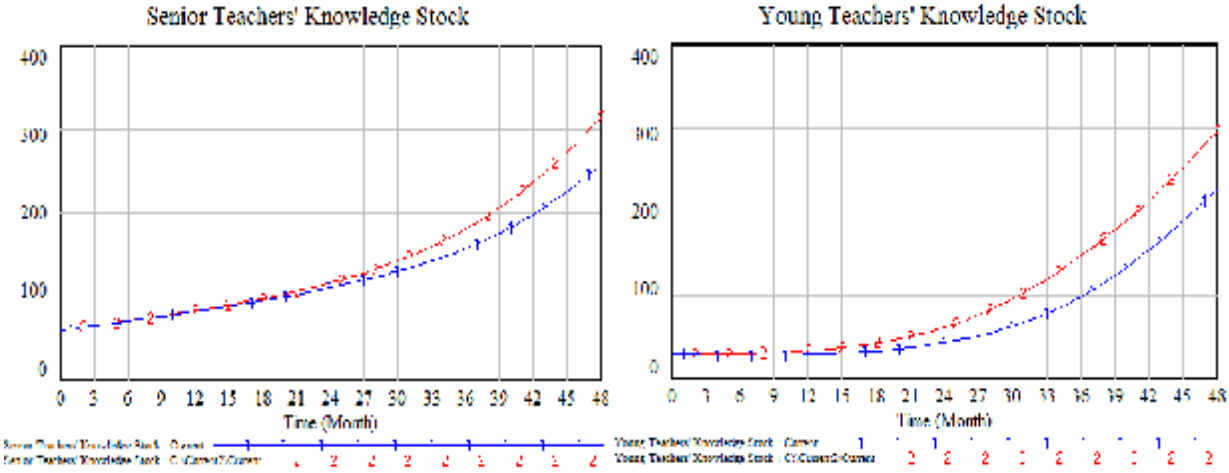

Fig.5 The simulation of the social relationship influence on the individual knowledge stock

Analysis on the implementation of college teachers' knowledge collaboration

The goal of knowledge collaboration aims to increase the colleges teachers' knowledge stock, reduce the knowledge gap, and facilitate effective communication and collaborative innovation, so as to improve the quantity of college knowledge innovation. The simulation results shown as follows: the curve of "The Knowledge Gap between Senior and Young Teachers" is shown in Fig.6, and the curve of "The Quantity of College Knowledge Innovation" is shown in Fig.7.

As Fig.6 shown, the knowledge gap between senior and young teachers is a parabola with downward opening. The increasing trend in the early collaboration period, represents the young teachers who just start to work, so they are in the running-in period. Senior teachers are familiar with the environment, with more knowledge and stronger study ability. So the knowledge gap is widening. The decreasing trend in the later collaboration period reveals that the young teachers' ability is improved and become more familiar with the environment, and the knowledge gap is narrowing. As the old saying goes, "It takes ten years for trees to grow up, but a hundred year for people to become comprehensively knowledgeable". If a person believes he has already made a

progress and then stop learning, he will fail to realize the progress that other makes. Young people should not be arrogant, and always reminder themselves to keep up with the changing times in order to avoid elimination by the times. Changes always exist, and people should always learn, in order to narrow the knowledge gap with senior teachers, which will become a solid foundation of the realization of collaborative innovation.

As Fig.7 Shown, the quantity of college knowledge innovation is increased over time. However, in the early collaboration period, the rate of collaborative knowledge innovation is slower than late period. This is because in the early collaboration period, the knowledge gap is larger, and the level of team's research innovation is lower. In the period of later cooperation, young and senior teachers have established friendship and trust. The cooperation willingness facilitate the formation of conscious cooperation, and in the collaboration, both young and senior teachers ability are improved, which resulting in the increment of the quantity of college knowledge innovation, that would ultimately meet the requirements of the rapid development of science and technology times.

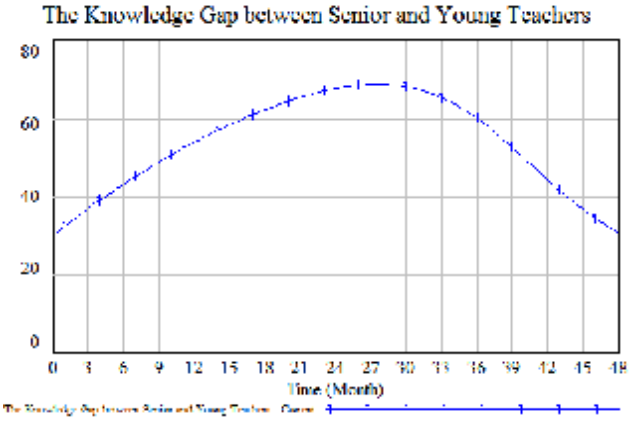

Fig.6 The Knowledge Gap's simulation diagrams

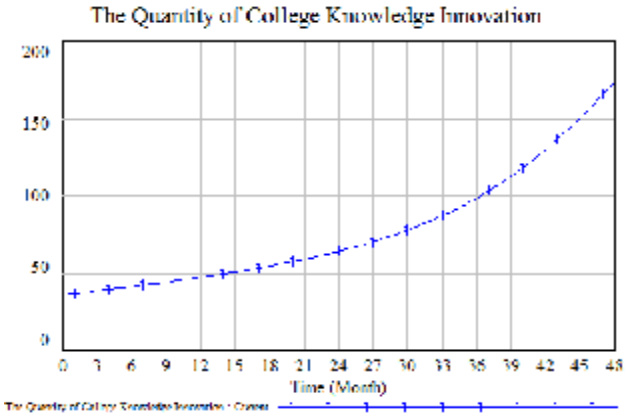

Fig.7 The Innovation Quantity's simulation diagrams

Conclusions

Improving Individual Capacity through Training System

It is critical to know one's own limitations. For young teachers, they should realize their insufficiency of experiences and need to properly position themselves. Only when they successfully receive the tacit knowledge from senior ones and finish the knowledge accumulation, then they can make contribution in the knowledge collaboration. For the senior teachers, they must improve their communicate ability and choose a more suitable way for knowledge sharing based on the receiver's condition, so that young teachers can correctly and quickly get the required knowledge and improve their knowledge stock. Therefore, tacit knowledge absorbing capacity and the knowledge transmission and expressing ability are the key of teachers' training.

Improving Psychological Utility by Incentive and Constraints Mechanism

According to the Game Theory, when teachers think collaboration utility is better than private utility, they will choose the knowledge collaboration. Conversely, they will do it alone. Therefore, colleges and universities should encourage cooperation in the teacher management system,use "strict system" to regulate "living persons",and promote the knowledge integration and collaborative innovation of the different disciplines background. First, Build differentiated incentive reward system, set up "Award of Cultivation" to encourage cooperating and mentoring. And set up the "Award of New-hand" to encourage young teachers to integrate into the collaboration team. Second, a strict selection system shall be adopted to restrict the "hitchhike" behavior, and refuse the opportunistic to join the team, so that to improve the efficiency of knowledge collaboration.

Building a Good Relationship from the Trust Culture

To make a worldwide contribution in scientific research, colleges and universities need to encourage the trust culture featured with collaboration in their highly competitive environment, so as to facilitate communication among faculty. First, select an academic leader with abundant knowledge, who will get support and trust from team members, then they should spread both trust

culture and academic ideology to the entire team . Second, building a platform of communication to encourage the spontaneous formation of a team with the same perspective of value during dialogues and interactions that allows teachers to open their minds and modestly cooperate and communicate with others, so as to improve the degree of knowledge collaboration.

Limitations of the Study

The simulation software VENSIM system, which has been widely used in the fields of medicine, biology and engineering, is recently applied to human resource management and knowledge collaboration. As human behavior is influenced by multidimensional factors, VENSIM would further require update and rewrite to enhance its creditability. Second, the model of System Dynamics equations only describe the trend that how the target value is impacted by each variable, but cannot adopt function to accurately describe the relationship of each variable which influence on the research objectives. So the simulation results also remain in the level of trend analysis. In addition, the selection of variables' initial values needs to be supported by more data from statistical survey. All of these constitute the direction of future research.

Acknowledgements

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