Analysis of Influencing Factors of Knowledge Dissemination and Sharing Based on SEIRR Model

Yiwen Zhou

School of Information Management, Wuhan University, Wuhan, 430072,China

Abstract: To study the key factors affecting knowledge sharing and knowledge dissemination is helpful to promote knowledge innovation. Based on the probability of acquiring knowledge from the environment, learning willingness, learning ability, and the speed of forgetting knowledge, a knowledge dissemination model SEIRR is proposed. Through the simulation network analysis, the influence of the above four factors on knowledge transmission and sharing is revealed. It is found that improving the probability of acquiring knowledge from the environment, learning willingness, and learning ability can help improve the effect of knowledge dissemination and knowledge sharing. Reducing the speed of forgetting knowledge is also effective. Thus, it is helpful to improve knowledge sharing by establishing open library and database, promoting group's learning willingness, cultivating group's learning ability, and strengthening group's application of knowledge.

Key Words: knowledge dissemination; knowledge sharing; learning willingness; learning ability; propagation model

Introduction

Knowledge is an intangible asset. It won't diminish with consumption. On the contrary, the consumption of knowledge may lead to an increase in the quantity of knowledge. The dissemination and sharing of knowledge can lead to new theories or technologies. Knowledge can promote the progress and development of technology. It is a key resource for enterprises and other organizations (Chuluun, Prevost & Upadhyay, 2017). The group's executive ability and decision-making ability depend on the knowledge dissemination and sharing mode. A good knowledge dissemination and sharing mode helps to enhance the competitiveness of an organization. Thus, it is of great practical significance to study the dissemination mode of knowledge in organizations and improve the level of knowledge sharing in organizations. To study the key factors affecting knowledge sharing and knowledge dissemination is helpful to promote knowledge innovation.

There are many transmission models are used to describe the process of information transmission（Wang, Jiang, Ma, & Hu, 2019; Zhang &Sun, 2020). There are differences between knowledge transmission and information transmission. In the process of knowledge dissemination and sharing, groups have a process of understanding knowledge. In addition, people may forget knowledge that is not often used. Most transmission model fails to reflect the characteristics of knowledge and failed to reflect the level of knowledge sharing. People often gain knowledge from social activities. The dissemination and sharing of knowledge depend on the influence of group culture in social networks. For example, the group's willingness to learn and ability to understand knowledge, and the forgetting speed of knowledge will affect the spread of knowledge. In addition, many transmission models ignore the possibility that people acquire knowledge through books and other carriers. Thus, it is necessary to study the influence of the above factors on knowledge dissemination and sharing.

The structure of small world network is between regular network and random network. Social networks generally have the characteristics of small-world networks (Watts & Strogatz, 1998). The distance between any two nodes in a small world network is short. The network has shorter even-path and larger clustering coefficient. Small-world networks are often used to simulate real-world social relationships

In this paper, the SEIRR (susceptible, exposed, infectious, recovered with the knowledge and recovered without the knowledge) model is proposed which considering the probability of acquiring knowledge from the environment, learning willingness, learning ability, and the speed of forgetting knowledge. Through the simulation experiment on small world network, the influence of the above four factors on knowledge transmission and sharing is revealed.

Method

The structure of SEIRR Model

Because the diffusion of disease is similar to the diffusion of information, epidemic spreading models are used to describe the dissemination of information. The epidemic spreading model SEIR (Schwartz & Smith, 1983) is a classic model. The structure of SEIR is shown in Fig 1.

In SEIR model, S represents people at risk of being infected by the disease. E represents people in the incubation period of the disease. I represents people infected with the disease. R represents people who are immune to disease. The letter a represents the probability of exposure to the virus. The letter b represents the probability of getting sick after exposure to the virus. The letter c represents the probability of acquiring immunity after exposure to the virus. The letter d represents the probability of acquiring immunity after getting sick.

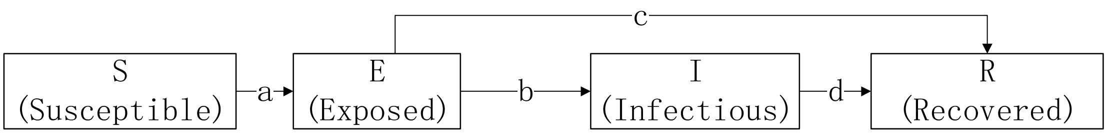

Fig 1 The SEIR Model

The SEIR model has many applications in communication (Liu, Li & Tian, 2018; Liu, Shi & Sheng, 2021). However, knowledge and information are not identical concepts. People need to master knowledge in order to accurately spread knowledge. Based on the epidemic model SEIR, this study proposes the SEIRR model and uses cellular automata to conduct simulation experiments. SEIRR model divides the recovered people into two classes according to whether they have mastered knowledge. The SEIRR model is shown in Fig 2.

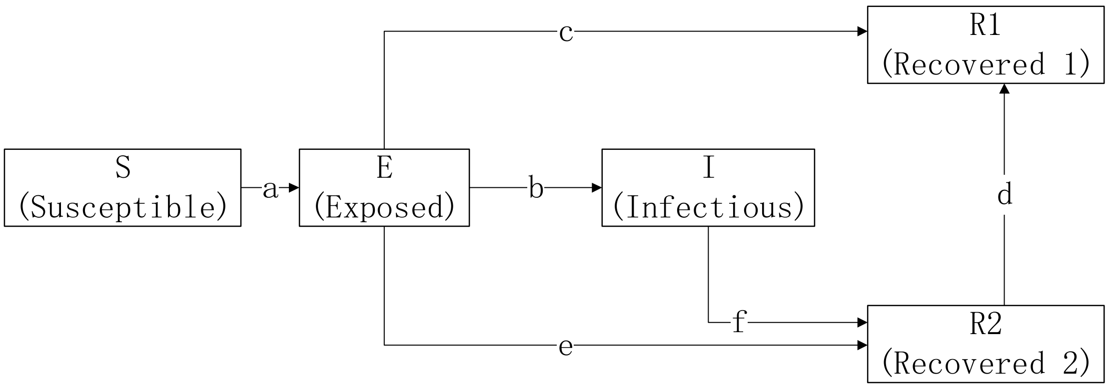

Fig 2 The SEIRR Model

In Fig 2, the letter S represents for susceptible people. If person P is in state S, it indicates person P is not exposed to the knowledge. The letter E represents for exposed people. If person P is in state E, it indicates that person P has been exposed to the knowledge but has not yet decided whether to learn it or has decided to learn the knowledge but has not yet understood the knowledge. The letter I represents for infectious people. If person P in state I, it indicates person P is spreading the knowledge. The letters R1 and R2 represent the people who have been exposed to the knowledge but are reluctant to pass it on. The people in state R1 do not understand the knowledge. The people in state R2 have acquire the knowledge but are reluctant to disseminate it.

Cellular automata can judge the future state of a node according to its current state and the state of its neighbors. Based on cellular automata, SEIRR model can describe the trend of knowledge dissemination between individuals. The following content will introduce the node state transition and transition probability.

State Transition Rules

A Person P in the state S may change into the state E due to the acquisition of knowledge through social interaction or autonomous learning. The probability that the person P change from state S to state E is a. The calculation method is as formula (1).

$$a = 1 - [(1-\beta)^{n(I)} * (1-\alpha)] \quad (1)$$

β represents the probability that a person in I state pass knowledge to another neighboring person. n(I) represents the number of neighbors of state I of person P in a social network. α represents the probability of acquiring knowledge from the environment, such as a book. $(1-\beta)$ represents the probability that the person P does not get knowledge from a neighbor of state I. The acquisitions of knowledge from any two different neighbor nodes are independent events. Thus, $(1-\beta)^{n(I)}$ represents the probability that the person P does not get knowledge from any of the neighbors of state I. $(1-\alpha)$ is the probability that person P is not exposed to the knowledge in the environment. Knowledge acquisition from neighbor nodes and knowledge acquisition from environment are independent events. The probability that people acquire knowledge is equal to the total probability minus the probability that people P does not acquire knowledge from both the environment and the neighbor nodes of state I. $[(1-\beta)^{n(I)} * (1-\alpha)]$ is the probability that people P does not acquire knowledge from both the environment and the neighbor nodes of state I.

When the person P is in the state E, the person P has a probability to transition to the state I, state R1, or sate R2. People can only spread correct knowledge after they have acquired it. Thus, learning willingness and learning ability are used to measure persons' ability to master knowledge. The letter b represents the probability that the person P changes from state E to state I. The calculation formula is as formula (2).

$$b = LC * LW * \theta \quad (2)$$

θ represents the average probability of a group's willingness to disseminate knowledge. LC represents average learning capability of a group. LW represents average learning willingness of a group. $LC * LW$ represents the average probability that a person understands the knowledge.

The letter c represents the probability that person P does not have learning willingness after exposure to knowledge. The calculation formula is as formula (3).

$$c = 1 - LW \quad (3)$$

LW represents average learning willingness of a group.

The letter e represents the probability that person P in state E has mastered the knowledge but is unwilling to spread it. The calculation formula is as formula (4).

$$e = LC * LW * (1 - \theta) \quad (4)$$

$(1 - \theta)$ represents the average probability of a group being unwilling to disseminate knowledge. LW represents average learning willingness of a group. LC represents average learning capability of a group.

When people do not use knowledge for a long time, knowledge will be forgotten. Thus, people in state R2 has a certain probability to transform into R1. The probability of transformation is d. Probability d is a variable parameter, which is affected by many factors.

As time goes by, the person's communication intention decreases, and the person in state I may switch to state R2.The probability of transformation is f. Probability f is a variable parameter affected by many factors such as learning atmosphere and interaction intensity in the group.

Result Analysis and Discussion

With Python, a small world network with 1000 nodes is constructed that simulates social relationships. The default value of all the parameters is set to 0.5. Some parameters in the propagation model have been verified by other studies, this study focuses on analyzing the parameters proposed by us. α, LC, LW, and d are adjusted respectively to detect the influence of the probability of acquiring knowledge from the environment, learning willingness, learning ability, and the speed of forgetting knowledge. The simulation results are shown in Fig 3. The horizontal coordinate represents the number of iterations. The ordinate represents the total number of nodes. The blue curves represent the curves of R1. The curves of R1 can reflect the duration of knowledge within a group. The red curves represent the curves of I. The green curves represent the curves of R2. The curves of R2 and I can reflect the number of people in a group master the knowledge. The purple curves represent the curves of S. The curves of S can reflect the declining trend in the group of people not exposed to knowledge. The pink curves represent the curves of E. The text at the top of the line charts describes the parameters being adjusted and their specific values. The curves of E can reflect the number of people in a group exposed to knowledge.

With the increase of α, the descending speed of the curve of S increases, while the ascending speed of the curve of R1 increases. The peaks of the curve of E, the curve of I, and the curve of R2 increase. These results indicate that the increase of the probability of acquiring knowledge from the environment can accelerate the rate of knowledge dissemination. This factor is also helpful to improve the number of people who master knowledge at the same time.

From Fig 3 (a),(b),and (c), the curve of S change more obviously when α is changed from 0.1 to 0.5 than when α is changed from 0.5 to 0.9. It indicates that when the total amount of knowledge in the environment reaches a certain proportion, the effect of knowledge in the environment on improving the efficiency of knowledge transmission is weakened. Thus, more knowledge in the environment is not always better when considering the economic costs. For example, the building of more libraries clearly facilitates the dissemination and sharing of knowledge. However, the benefits of knowledge dissemination and sharing are not necessarily higher than the cost of building libraries.

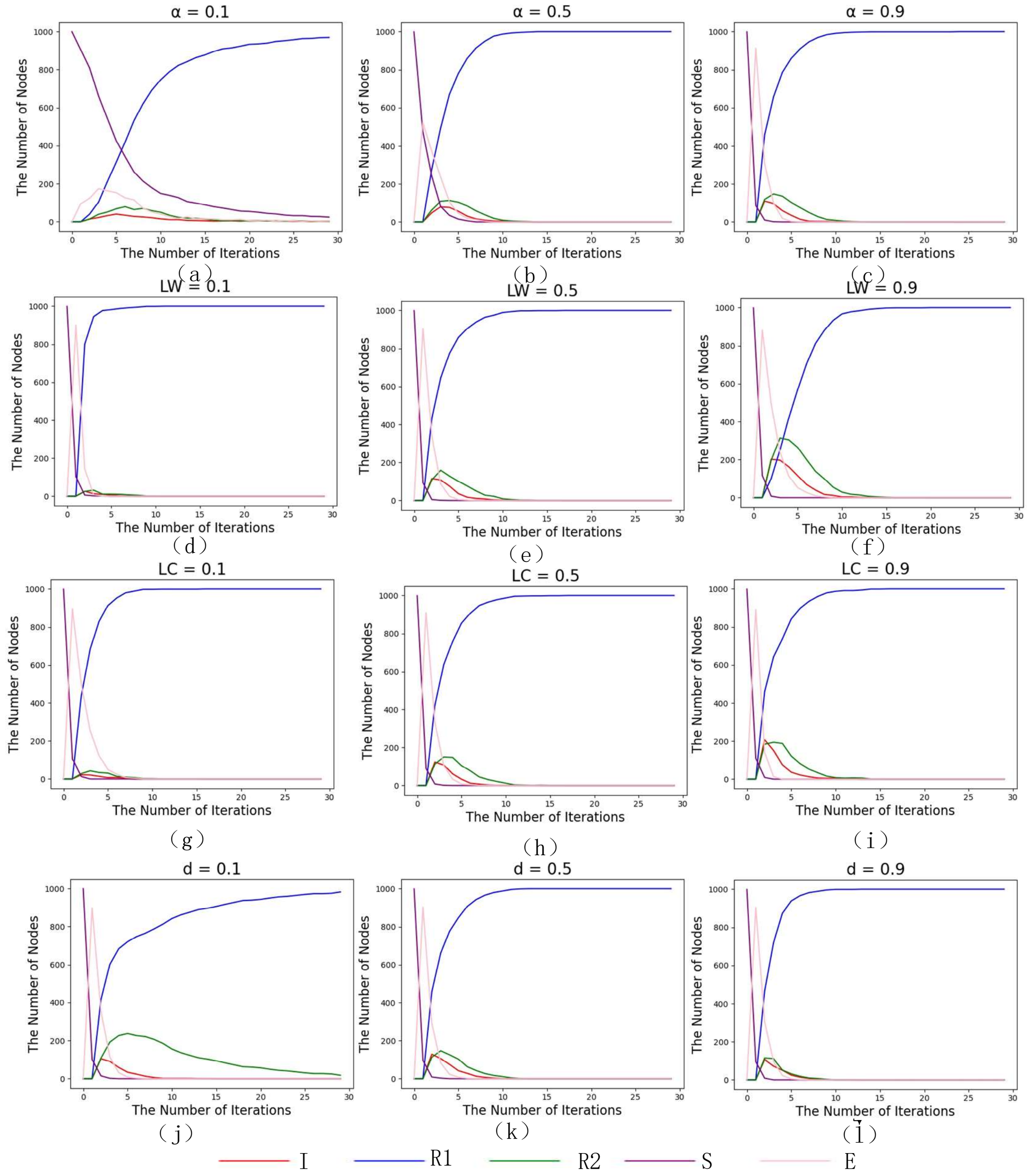

Fig 3 Simulation Results

With the increase of LC and LW, the ascending speed of the curve of R1 decreases. The descending speed of the curve of S is essentially unchanged. The peaks of the curve of I, and the curve of R2 increase. The peaks of the curve of is essentially unchanged. These results indicate that the increase of learning willingness and learning ability has little influence on the speed of knowledge dissemination. However, the two factors can reduce the growth rate of people in a group who don't care about the knowledge. They are helpful to improve the number of people who master knowledge at the same time. Strengthening these factors can facilitates knowledge sharing.

From the peak changes in the curve of I and the curve of R2, learning willingness has a greater influence on knowledge dissemination and sharing than learning capability. It shows that the group learning atmosphere has a great influence on the effect of knowledge transmission.

Compared with the probability of acquiring knowledge from the environment, learning capability has a greater impact on the effect of knowledge transmission and sharing. It shows that groups with strong learning capability are likely to form knowledge sharing. The influence of the probability of acquiring knowledge from the environment cannot be ignored. The establishment of open libraries and databases contributes to knowledge dissemination and knowledge sharing.

As the speed of forgetting knowledge increase, the ascending speed of the curve of R1 increases and the peaks of the curve of R2 decrease. This shows that the existence time of knowledge in the group is related to the speed of forgetting knowledge. The slower people forget knowledge, the more people simultaneously master it.

Conclusion

This study constructs a knowledge transmission model based on the infectious disease model SEIRR. Based on the cellular automata principle, a simulation experiment is carried out on a small world network. The influence of the four new parameters proposed in SEIRR model on knowledge sharing and propagation is analyzed.

It is found that the probability of acquiring knowledge from the environment, learning willingness, learning ability, and the speed of forgetting knowledge all have great influence on knowledge transmission and sharing. Improving group learning willingness and ability, building open library and database, and reduce the speed of forgetting knowledge can help improve the effect of knowledge dissemination and knowledge sharing. Apart from that, we have found out that learning willingness are more importance than learning capability. Adding knowledge to the environment helps knowledge sharing . However, when considering the economic costs, more knowledge in the environment is not always better.

This study will continue to verify the validity of the model on real data sets, and compare the performance of the model in scale-free network and small-world network to further analyze the impact of network structure on knowledge transmission and sharing.

References

Chuluun,T., Prevost, A & Upadhyay,A.(2017). Firm network structure and innovation. *Journal of Corporate Finance*, 44,193-214.

Liu, Q.Q., Shi, G. & Sheng, Y.H. (2021).An uncertain SEIR rumor model.*Journal of Intelligent & Fuzzy Systems*, 41 (1) , 399-412.

Liu, X.D ., Li, T. & Tian, M. (2018).Rumor spreading of a SEIR model in complex social networks with hesitating mechanism, *Advances in Difference Equations*,2018,391.

Schwartz,I.B. & Smith,H.L.(1983).Infinite subharmonic bifurcation in an SEIR epidemic model. *Journal of Mathematical Biology*,18, 233–253.

Watts D.J.& Strogatz S.H. (1998).Collective dynamics of small-worlds networks. *Nature*, 393(6684),440-442.

Wang, J.L., Jiang, H.J. , Ma, T.L. & Hu, C.(2019). Global dynamics of the multi-lingual SIR rumor spreading model with crosstransmitted mechanism.*Chaos Solitons and Fractals* ,126, 148–157.

Zhang,D.S. & Sun,D.D.(2020). A model for art communication and development under the influence of social network. *Transinformacao*,32, e200047.