Simulating Knowledge Worker Adoption Rate of KMS: An Organizational Perspective

Poornima P. Kundapur and Lewlyn L. R. Rodrigues

***Abstract*—The core research issue presented in this article is to study the factors that influence the knowledge worker's adoption of Knowledge Management System (KMS). The five-step System Dynamics research methodology was followed to design and develop the Knowledge worker adoption model. This model studies the transition of a knowledge worker from a non-user to an experienced user over a fixed time frame identified. Simulation experiments were conducted show that knowledge workers respond differently as they integrate the new technology into their work pattern. The results were analyzed for the different employee categories based on their level of expertise of usageof KMS in the organization and factors such as supervision, ease of use of technology were found to affect the knowledge worker's concerns for adopting KMS in their work. The current simulation model was built using the softwareVensim® and the outcome of the study should aid administrators and policy makers to evaluate the impact ofthe identified factors on adoption of KMS.**

***Index Terms*—Knowledge worker, knowledge management system, system dynamics, KWAM.**

I. Introduction

The impact of globalization and technological advances continue to change the competitive business environments, making knowledge and expertise primary sources to leverage the competitive advantage, at least in knowledge-intensive industries.

For most firms Knowledge Management (KM) is achieved through a series of initiatives that seek to build a culture and infrastructure that connects people and processes [1]. However, in the present competitive business settings, the manner in which organizations learn from past performances and manage knowledge through their most important tangible asset, the knowledge worker force, has a huge impact on future decisions.

The role of technology or that of knowledge strategy in an organization depends not only on the knowledge infrastructure of a company, but also on the attitude of knowledge workers towards knowledge sharing, creation and use of technology and towards the technology itself. Once implemented in an organization, the success of KMS implementation is determined based on the use and acceptance of the system by knowledge workers.

One way to better understand the factors underlying the acceptance and behavioural patterns of knowledge workers in an organization may be by applying the simulation approach. This paper attempts to understand this aspect of an organizational knowledge worker.

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A knowledge worker's concern of adopting a new technologylike KMSwhen disseminated into any intellectual marketplace such as the software sector or an IT company or any other knowledge based organization, can display a wide variety of behaviour. A number of dynamic variables play an important part in the successful adoption of KMS by the knowledge worker. It is seen that knowledge workers often may have quite a few concerns as they adopt the new technology, including factors like their individual training in technical skill sets, academic background. The more concerns they have, the more likely they are to be resistant in adoptingthe system. Thus, it becomes imperative to identify the factors that can affect the knowledge worker's adoption behaviour.

There is an inherent difficulty of testing such variables in real time scenarios mainly due to the cost of conducting such experiments. There is also the issue of knowledge workers unwilling to share these issues. In such cases, simulating the adoption process is a viable option that will provide trainers and decision makers with methods to assess the factors that support new technology use in any organization. Hence, the research methodology applied in this paper follows the principles of System Dynamics method (SD), first introduced by J. W. Forrester in the 1960s at the Massachusetts Institute of Technology (MIT), Boston[2]. The SD approach includes Problem identification, System conceptualization, Model formulation, Simulationand validation and Policy analysis and improvement.The stock and flow modelling and simulation are performed usingVENSIM PLE® software.Simulation models generate behaviour throughsimulation.The SD process is iterative and flexible [3].

II. Objectives

The main purpose of this research article is to propose a simulation model that tests the impact of factors that affect knowledge workers' adoption of KMS. To achieve this purpose, the following objectives have been formulated:

- Identifying and relating variables within the system
- Constructing the Stock and flow diagrams
- Formulating the governing equations
- Modeling and simulation of the Knowledge Worker Adoption Model (KWAM)

III. Literature Review

A. KM, KMS and Knowledge Worker

Knowledge Management is about creating, storing, accessing and reusing knowledge to accomplish organizational goals. In other words, Knowledge management (KM) is the process of identifying and leveraging the collective knowledge in an organization to help the organization compete [4].

Alavi and Leidner [4] referred to KMS as an emerging line of systems targeting professional and managerial activities by focusing on creating, gathering, organizing and disseminating an organization's 'knowledge' as opposed to 'information' or data.'

Any organization that has a KMS in place must require individuals to develop, use and apply the organizational knowledge. These individuals are termed "Knowledge Workers" in today's knowledge economy [5] [6].

B. The System Dynamics Approach

A KMS implementation would be based on a framework that identifies with the working objectives of that organization. In trying to understand how KM initiatives work towards achieving organizational goals there is a need to identify factors that influence knowledge workers' acceptance of knowledge available in KMS and how these factors in turn relate to the organizational environment. Many KM initiatives and the KM literature have lacked a theoretical foundation that can inform the process of KM system development and in particular the process of KM information systems development [1]. This aspect is where we feel the system dynamics approach may help to facilitate understanding and can enhance organizational KM practice. Figure 2 illustrates the model that will be referenced in this paper.

IV. Methodology

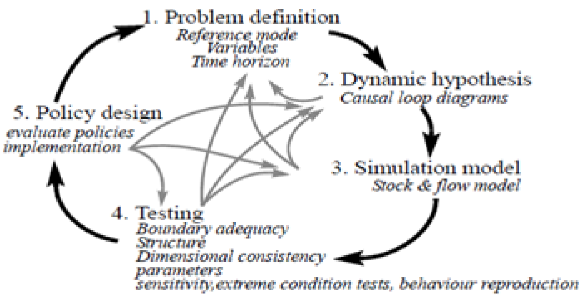

Fig. 1. Steps of system dynamics [8].

The research methodology adopted is in accordance to the modeling process methodology as proposed by Sterman3][8]. The steps as illustrated in the Fig 1 include:

C. Problem Articulation

The problem articulationis the initial and most important step of the system dynamic approach that involves defining the problem. In this paper, the problem identified is "To identify the factorsthat affect a knowledge worker's adoption rate of a KMS and to establish a relationship between the factors and the behavioural pattern". According to Sterman [3] a problem should never model a system, because the problem determines which factorsare important to include and which to exclude and therefore be used to find the relevant system boundaries of the problem

A reference mode (the hypothesized behaviour of the problem) and the time horizon of interest must be identified in this stage[3][7].

D. Dynamic Hypothesis

This is the second step in the system dynamics modeling process. Once the problem has been articulated and the initial characterization is done, it is necessary to develop a theory about the problem. This theory or hypothesis is called "dynamic hypothesis". The hypothesis is said to be "dynamic" because it characterizes the dynamics involved in the system to be modeled over the given time horizon. At this point, feedback mechanisms and the delays involved in the system are taken into account.

E. Formulation of a Simulation Model

The next step in the System dynamics methodology for modelling is to move from the conceptual realm of diagrams to a fully specified formal model, complete with equations, parameters and initial conditions that can be simulated via computerised software [3].

F. Testing of the Model

Sterman [3] explains that testing begins as soon as the first equation is formulated. Testing partly involves comparing the simulated behaviour of the system under study with the actual behaviour. It also involves something more where each equation is checked. Whether each variable under consideration has a meaningful concept in real time is also verified. Parametersensitivity checks are useful to decide how much effort should be dedicated to increasingthe precision of the parameters.

G. Policy Design and Evaluation

Once the structure and behaviour of the model have been finalised and there is a certain amount of confidence in the simulated model, the modeller can now move on to designing and evaluating policies for improvement [7].

V. The Model Construction

The model has been designed and developed based on the generic basic diffusion model incorporated into the KMS scenario of an organization [3][9][10].A knowledge worker's cycle of growth startsfrom a being a new employee with no experience in using a KMS to a trainee employee (undergoing training to use a KMS) to a new knowledge worker (trained and ready to apply his skills in using a knowledge repository like a KMS) to an experienced knowledge worker with years of experience in handling and applying KMS knowledge all treated as stock variables in the model.

Causal loop diagrams are powerful tools to map feedback structure of complex systems but they are limited by their inability to show stocks and flows. Hence we have used stock and flow diagrams to simulate the knowledge worker behavioral pattern.

A. Stock and Flow Diagram

A knowledge worker in any organization utilizes the KMS to capture contextual knowledge applicable to his area of work. A knowledge worker's competence depends on his understanding of his work profile together with the information or knowledge seeking attitude he possesses [9]. However this is made possible if the KMS existing in the organization provides access to all the available knowledge to the knowledge worker.

B. Stocks and Flows

In the system dynamics approach, causal loop diagrams are well suited to represent interdependencies and feedback processes however the drawback of using this tool is that it has nothing to offer in terms of capturing stock and flow structure of systems under study. Stocks and flows are an essential concept in system dynamics theory [3] and their importance lies in the

C. Identifying Stocks

The stock and flow diagram of the proposed KWAM is presented in Fig. 2. The four stocks identified are:

New Employees: Indicating pool of employees who have just joined the organization

Trainee employees: Indicating pool of employees who are undergoing training

New Knowledge workers: Indicating pool of employees who have completed training

Experienced Knowledge workers: Indicating stock of employees who have been using the technology and experienced users

D. The Adoption Process

All categories of knowledge workers whether they are new employees, trainees or experiencedwork in the same organization. The adoption process is about experienced workers creating awareness among non-users about the use of technology in their work. The model therefore focuses on this rate of this interaction.The variable “knowledge worker with non-user contacts” represents that pool of knowledge workers who have adopted the systemcoming into contact with employees who are non-users. Going ahead, there is a reasonable chance that this contact may result in the non-user adopting the system in future. “Adoption fraction” represents this probability of conversion.

“Application fraction” is the model variable that refers to the time fractionexperienced knowledge workers may devote to skill application development including the time they spend on doing research, publishing white papers or working on resolving their project problems.The variable “trainee conversions” is affected by any addition of trainee employees who complete their training period.

Apart from the variables used, this model also includes six constant values that determine the speed of transition of knowledge workersr from the training phase to gaining experience. The constant “Self-training time” represents the time required for an employee with no formal training tobecome sufficiently proficient to be a Knowledge worker and “Minimum training time”indicates the time required for a trained employee to become proficient in the technology used. It is also observed that as the experienced knowledge workerdevotesmore time to training, there is a change in the average training time which moves from self- training time, to minimum training time according to training productivity change. Fig.2. depicts the Knowledge worker adoption dynamics model.

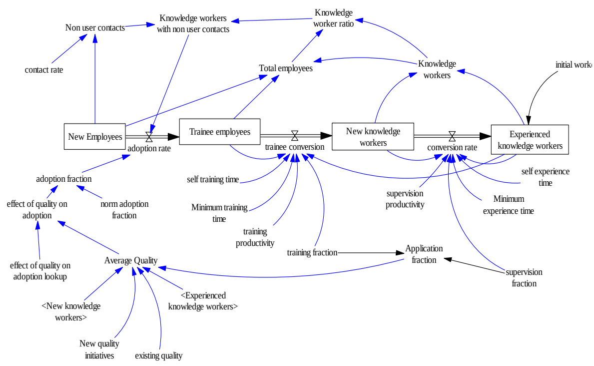

Fig. 2. Stock and flow of knowledge worker adoption dynamics.

E. The Governing Equations

There are causal relations between the variables of the model and these are linked in the form of equations for quantifying the simulation results. The units of variables are indicated in parentheses.

Knowledge workers =Experienced knowledge workers + New knowledge workers (Units: users)

Experienced knowledge workers= INTEG (conversion rate, initial workers) (Units: users)

Trainee employees= INTEG (adoption rate-trainee conversion, 0) (Units: users)

New knowledge workers= INTEG (trainee conversion-conversion rate, 0) (Units: users)

VI. Analysis

A. Model Scope

The variables defined in the model are endogenous to the model and serve the purpose specified as per the requirements of SD model boundary identification.

B. Time Horizon

System dynamics may be used as a prediction tool, and helps understand the problem being studied as well as the potential decisions that may be considered. Hence the modellr must be able to design for a particular purpose outside a narrow time zone. In this case the trend of technology life span averages around 10 to 15 years. However the study maintains a 10 year time horizon at TIME STEP=0.125[10].

C. Modeling Conditions and Results

This model is simulated at three extremes

1) application fraction = 1(all effort is devoted to work on the job and new employees must train themselves)
2) training fraction = 1(all effort is devoted to training new employees)
3) supervision fraction=1 (all effort is devoted to generation experienced knowledge workers)

The following section explains the various simulation experiments conducted and the results established thereafter.

Simulation 1: Effect of change in knowledge worker adoption behaviour varying 3 factors:

Application fraction =1, Training fraction=1 and Supervision fraction=1

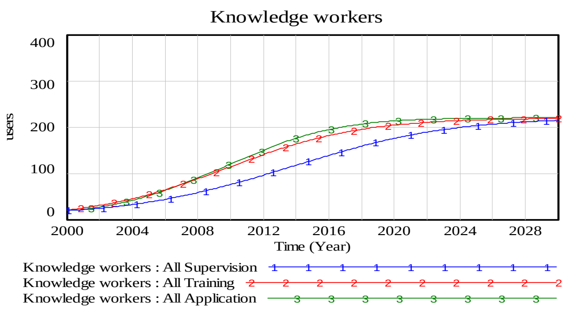

Fig. 3. Effect on knowledge workers.

In this simulation, the behaviour of the system is experimented by adjusting the value of three factors. When application fraction =1, the knowledge worker's effort is entirely devoted to work on the job and new knowledge workers must train themselves. Setting Training fraction to 1 means all the effort is devoted training new employees while setting Supervision fraction =1 implies all effort is devoted to generating experienced knowledge workers.The governing equations are:

Application fraction= INITIAL(1-supervision fraction-training fraction) (Units: Dmnl)
Supervision fraction=0 (Units: Dmnl)
Training fraction=0 (Units: Dmnl)

In case of new knowledge workers (refer Fig. 4), there is a steady rise when the training and application fraction are changed. The inference could be that the new knowledge worker has undergone sufficient training to utilise the KMS and apply the same in independently resolving issues or even researching on other areas of concern. The knowledge worker pool however shows a steady rise with the right amount of training leading to self-sufficiency in knowledge to enable applying this knowledge in work.

The experienced knowledge worker on the other hand, displays a gradual increase in the knowledge application curve over the training curve implying that an experienced knowledge worker makes adequate use of knowledge acquired.

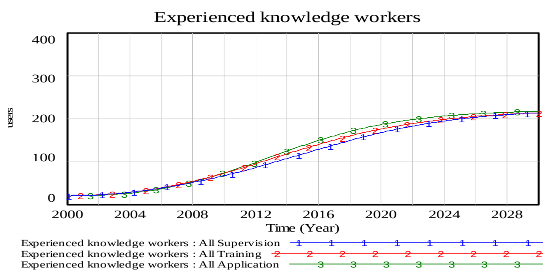

Fig. 4. Effect of simulation 1 on experienced knowledge workers.

Fig.4. shows this trend of experienced workers (in numbers) when changes to parameters are applied (users in the graph is the dimension for the stock experienced knowledge workers)

With new knowledge workers, there is an interesting trend as observed in Fig. 5. There will be a steep rise in the number of newly trained knowledge workers adopting the KMS technology with adequate training together with the application of the newly knowledge acquired in solving their work related issues. However, simulation shows the trend tends to dip over the next 10 years and stabilises towards the end of the time line indicating technology obsoleteness attributes to adoption patterns. Interestingly the supervision factor does not have any major impact on the increase in the adoption rate of new knowledge workers.

Simulation 2: To study the effect on knowledge workers when: New quality = 0.6 (quality initiatives to 6%)

Self-training and Minimum training time are set at half their values.

Supervision fraction and training fraction set at 0.1 (At 10% of experienced worker's time)

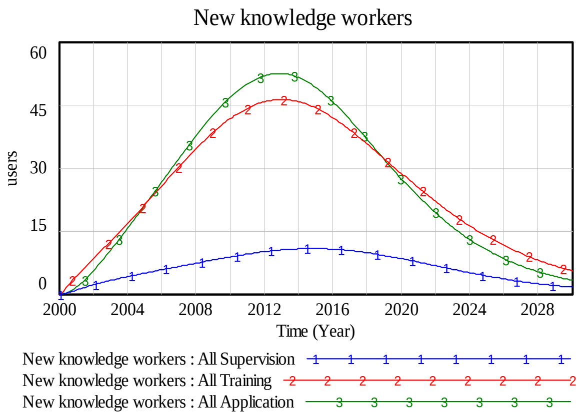

Fig. 5. Effect of simulation 1on knowledge workers.

Fig. 5 indicates that both ease of use and quality can have a significant impact on the speed of diffusion of a technology such as KMS in any organization.Additionally, when self-training time and Minimum training time was halved, the trend remains the same but the curvedoes show a significant increase as is the case when the supervision fraction and training fraction are balanced at 10% revealing a steady upward increase in KMS usage behaviour.

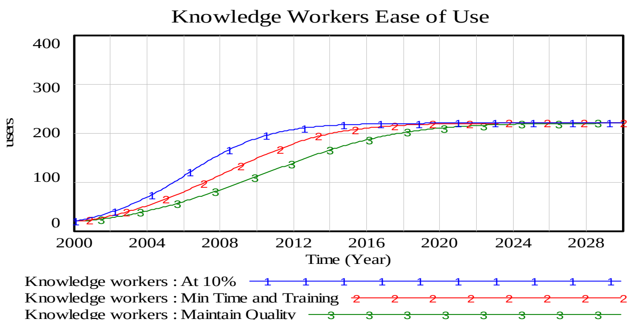

Fig. 6. Effect of change in quality and self-training time on knowledge workers.

VII. Testing and Validation of the Model

Testing of a system dynamics model is carried out so as to uncover errors and find out the model's limitations. This helps build confidence in the model for a modeler. Sterman[3] states verification means checking the truth or reality of the model whereas validation means to ensure that the model supports the objective truth. He further adds that no model can ever be verified and validated. The reason is because no model is ever an exact representation of reality or truth since it is based on many limiting assumptions. Thus the model can be verified and validated only based on a set of limiting assumptions. Also, though the model's validity cannot be proved, its falsity can surely be proved. Forrester [2] substitutes the term "validity" by "significance" and states that the validity should be judged by the model's suitability for a particular purpose.

Sterman and Forrester [3],[2] state various fundamental tests that can be carried out. Testing enables discovering of errors and limitations of the model and further sets the basis for modifying the model accordingly. However it is imperative to note that testing is not a process that is done at the end only after the model developed. It is a continuous and iterative process that starts right from the initial stages of model building. During every stage of model development, testing is either explicitly or implicitly carried out. Subsequently the model is continuously improvised and corrected based on the results and feedback from the tests the model.

Listed below are the tests that were carried out on the model as a part of the verification and validation process:

A. Face Validity

This is a test of consistency that answers the question "Does the model structure look like the real system? The model developed in this paper closely resembles the real time scenario of a knowledge worker's progression from a novice employee to an experienced knowledge worker and the corresponding level of expertise of usage of KMS.

B. Dimensional Consistency Test

This test is a Test of Suitability and deals with the dimensional units of stocks, flows and variables in the model. The simulation software performs the dimensional consistency check. Wherever, lack of units for variables or dimensional errors were found, they were suitably corrected to ensure that the dimensional inconsistencies were removed.

C. Structure Verification Test

This is another test of suitability that ensures whether the structure of the model is consistent with the relevant knowledge about the knowledge worker adoption process. The model development was based on the inputs gathered after an in-depth us literature review and the model is based on the generic growth process model. Every effort was made to keep the model structure consistent with the information collected.

D. Parameter Verification Test

The question "Do the numerical values of parameters have real system equivalents?" needs to be justified to successfully claim that the model clears this test of consistency. In this model, the parameters correspond conceptually and numerically to real life. All categories of Knowledge workers have their numerical value measured as number of users.

VIII. Conclusions and Implications

The KWAM developed and simulated in this research paper provides insight into understanding the behavioural factors that affect the knowledge worker's rate of adoption of based on training, ease of use and quality parameters. The work started with a set of written hypotheses and worked on building the KWAM.The simulation results indicate factors like supervision, training and user-friendly technology favour adoption among novice workers. Asteady rise in the number of new knowledge workers using the organizational KMS when the training and application fraction are set to a high of 1 was observed. There was a rise in adoption of KMS even with increased quality initiatives and ease of use. System dynamics provides methods for validation of the model. The model is validated using Face validity test, Dimensional consistency test and Parameter Sensitivity test. The model gives a basis understanding reality and action to work on this understanding, however to establish more confidence, data and reality checks need to be implemented which will be worked upon as the next phase of research. Further, KM researches may also refer to this model and explore dynamic structures not identified based on specific situation mapping.

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Her research interests include Knowledge Management and System Dynamics. Her present research is a trans-disciplinary work on Knowledge Managements Systems and System Dynamics, focusing on the factors that dynamically influence usage of KMS in any organization.

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