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Widening Students' Perspective: Empowering Them with Systems Methodologies

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***Abstract*—**Benefits to the organization are just as important as technical ability when it comes to software success. The challenge is to provide industry with professionals who understand this. In other words: How to teach computer engineering students to look beyond technology, and at the benefits of software to organizations? This paper reports on the conceptual design of a section of the computer networks module aimed to sensitize the students to the organizational f a set

Checkland focuses on different worldviews represented by various role players in the organization. He developed the Soft Systems Methodology that guides purposeful action in organizations, while incorporating different worldviews in the modeling process. If we can sensitize students to these methods, they are likely to appreciate the wider context of application of system software. This paper will provide literature on these concepts as well as detail on how the students will be guided to adopt these concepts.

***Keywords*—**Checkland, Soft Systems Methodology, Systems Approach, System Software.

I. Introduction

STUDENTS do not have a wide enough view of the problem environment where system software is used. Information technology students initially understand computers with a rather restricted view of what computers and system development are. They only realize the role of humans when they put their technology to good use. As soon as they bring in the users, the focus change and organizational problems appear. Ways to rethink computers, as to obtain a deeper constructive understanding of the role of technology in organizations, have to be found [1].

The success of systems software implementation, relies on the ability of the solution to incorporate the larger context of the organization [2]. An information technology (IT) plan for an organization, results from a process where consideration is given to development strategies, the purpose of IT and the coordination of the IT resources with the business strategies and structure. This implies that the organization as a whole must be considered when drafting an IT plan. The IT plan is fundamental to the development of IS applications, data, IT infrastructure and networks in the organization. To successfully evaluate the use of IT resources the corporate culture of the organizations also have to be considered [3].

Our students are in the future going to be instrumental in designing corporate architecture for networking and other system software applications; therefore they have to acquire skills beyond just technical knowledge. If our students are sensitive to the wider context of use of these products in terms of organizational goals, structures and cultures, they will propose better solutions.

The systems approach of C. West Churchman provides a perspective of the world in terms of systems. Different role players have different perspectives on problematic situations. Checkland focuses on different worldviews represented by different role players in the organization. He developed the now mature Soft Systems Methodology (SSM) that guides purposeful action in organizations, while incorporating different world views in the modeling process. If we can sensitize our students to these methods, they are likely to appreciate the wider context of application of system software.

This paper will present a review of system software (SS) and how it differs from application software, as well as the role of system software in terms of the organizational goals. Back ground knowledge on the systems approach of Churchman will be presented followed by a literature review and example of the soft systems methodology as presented by Checkland.

II. System Software

The hardware of a computer is only as effective as the software that controls it. The software is a sequences of instructions that manage the operation of the computer and is referred to as a computer program[4]. There are two types of software, system software and application software. System software controls the basic operation of a computer, while application software allows the user to accomplish specific tasks on a computer [5]. Fig. 1 illustrates the relationship between hardware, system software and application software.

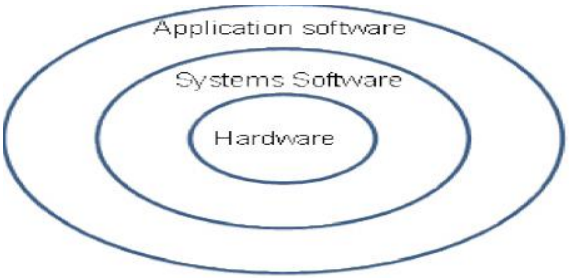

Fig. 1 Relationship between hardware, system software and application software[4]

System software is programs that are used to control the operation of the computer hardware. They also function as the

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interface between the computer hardware and the application software [5]. According to Rainer and Celgielski [4], system software is grouped into two functional categories, the system control programs and the system support programs. The main system control programs are the operating systems, which supervises the complete operation of the computer. An operating system is a collection of programs, which will perform different activities, which includes hardware functions such as getting an input from a keyboard, retrieving and storing of data from and onto a disk and displaying data on a monitor or printer. Typical support programs are system utility programs, performance monitors and security monitors. Application software on the other hand, directs the computer system to perform more specific processing activities in order to provide functionality to users [6]. Users are more involved with the application programs, while the system software is programs working in the background. The application programs interact with the system software, which then direct commands to the system hardware to perform certain tasks. The application programs could be more general purpose programs such as word processing programs or programs more tailored for a specific function such as an organizations' payroll program [5].

Software selection and evaluation is affected by many organizational factors, which involves organizational needs and software capabilities. Factors include the size and location of user base, as well as present and anticipated future needs. Other goals to consider is the affordability of software, including training, maintenance and installation cost. Factors such as in-house technical skills, existing computer environment and security levels are reflected in organizational goals and are major considerations when selecting and maintaining software [4]. A prioritized list of the organizational goals has to be acquired before starting to plan any project [7].

III. The Systems Approach

Systems consist of a set of components that works together towards the overall objective of the system [8]. The systems idea is a whole consisting of parts that interact with each other to form the whole and it is this interaction that makes real situations so complex [9]. This whole can survive over time, only if it can adapt to changes in its environment. To survive it needs communication processes to determine what is going on and control processes to adapt to environmental changes. A system also have a layered structure which is fundamental in systems thinking and emergent properties which is the properties that only the single whole has [10].

The total systems topology consist of four kinds of systems: natural, designed physical, designed abstract and human activity systems. Once manifested, natural and designed system do not change, but human activity systems is revealed only through the perception attributed to them by human actors [9]. A human activity system has many different appearances, all valid and all according to a specific worldview.

The systems approach is a way of thinking about the total system and all its components. According to Churchman[8] the systems approach begins with philosophy, in other words, it starts with how one see the world through the eyes of another. Every worldview is very restricted since it only looks at a portion of some or other system, therefore in the systems approach there are no experts. Checkland [9], defines a systems approach as an approach to a problem which takes a wide view, which attempts to encompass all aspects and which concentrates on the interactions between all the parts of the problem. SSM, developed by Checkland, is a systems approach that could be used to broaden the students' framework of understanding. It is anticipated that this systems methodology should widen students' perspective on the organization as a whole, as to include organizational goals and the rethinking of designs in terms the whole system.

IV. Soft Systems Methodology

The failure of systems engineering, when applied to ill-structured real world situations, led to the development of SSM [11]. Systems engineering, also referred to as hard systems, is a methodology based on setting objectives and goals. In the world of work, students will find themselves frequently in real-world problematic situations, which they will be expected to act upon. They need to be prepared to approach these problematic situations holistically with the intention of taking action to improve. One way is through the use of SSM, an organised action orientated approach to problematic situations. Real life problematic situations is very complex, due to the fact that different people have different worldviews and because the situations involves people who are trying to act purposefully [12]. The two characteristics, different worldviews and purposeful action, is the foundation of the SSM approach. The application of SSM in information systems

Checkland and Poulter [10] describe the SSM process as a cyclic process, which takes the form of a learning cycle, starting with finding out about the problematic situation, up to the defining/taking action point. This is not a sequential activity, but a forward and backward movement between the activities as part of the learning process. The SSM learning cycle presented in Fig. 2 contains the following four different activities: finding out, modeling, debate and defining/taking action. A discussion will now follow to explain how a user will progress through the four basic activity learning cycles of SSM.

A. Activity 1: Finding Out

In SSM there are four ways of finding out about the problematic situation which include: making rich pictures, analysis one (focus on intervention), analysis two (a social analysis) and analysis three (a political analysis) [10].

A rich picture is an explanation of the problematic situation as a picture. The aim is to capture the entities, viewpoints and structures of the situation. Rich pictures are invaluable as

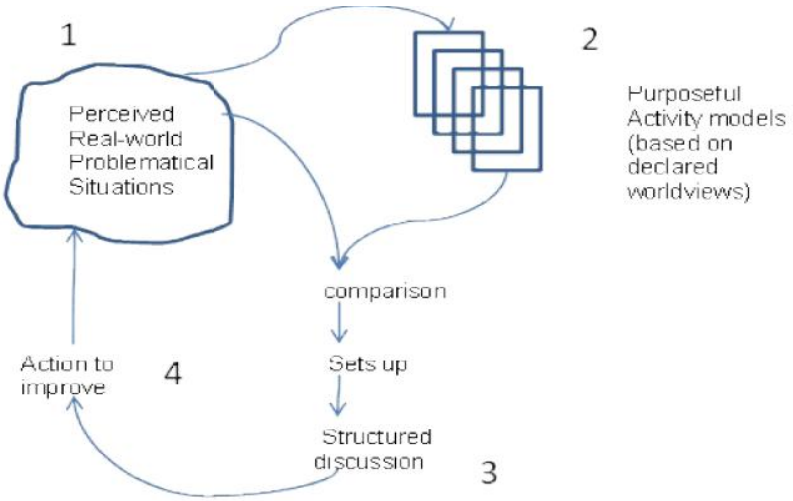

Fig. 2 SSM learning cycle [10]

basis for stating the discussion on the situation.

Analysis one consists of thinking about the different roles in the problematic situation, the roles of clients, practitioners and issue owners. The client role is represented by the person or persons who caused the intervention to happen, while the practitioner role is represented by the person or persons who conduct the investigation and the person or persons affected by the situation and outcome fulfill the role of owner.

Analysis two is a social analysis which takes culture seriously. Practical action to improve a situation through change must not only be arguably desirable, but also culturally feasible. SSM make use of a particular model to try and make practical sense of this social texture. This model states that the human social structure consists of roles, norms and values. Individuals in an organization could fulfill a formal or informal role. Formal roles are positions such as head of a department or a director, while an informal role could be somebody who is known for disturbing the peace. Norms refer to the expected behavior of an individual in a specific role, while values refer to the standards by which the behavior in a role gets judged. The three elements together, help to form the social texture of the situation.

Analysis three is referred to as a political analysis, focusing on the disposition of power. This power disposition is important, since it plays a role in deciding what gets done and what not.

B. Activity 2: Making Purposeful Activity Models

Activity models created for the different worldviews are used as the basis for debating and asking questions about real world problematic situations. Fig. 3 present guidelines, which could be followed, in order to build purposeful activity models. Before building an activity model, a Root Definition (RD), describing the activity system, must be created. The PQR formula is used to enrich the RD. It could be interpreted as do P, by Q, in order to achieve R. Another interpretation is P (What?), Q (How?) and R (Why?). The transformation process is described by Q.

By using the CATWOE mnemonic, shown in Fig. 4, the RD and transformation gets further enriched, resulting in improved questions to be asked about the real situation. T and W defines the transformation process and the worldview respectively, A refers to the actors who are the people doing the activity, C refers to the customers who are the affected people, E refers to environmental constraints, while O refers to the owners of the activity [10].

It is also necessary to determine the measures of performance namely efficacy, efficiency and effectiveness. Efficacy is the criteria to measure the success of the intended outcome, while efficiency is the criteria by which the minimum use of resources in the transformation process is measured and effectiveness is the criteria to measure the fulfillment of a long term aim with the transformation process.

When building the activity model, aim to use 7 +/- 2 activities, divided into three groups of activities. The first group is those activities that are concerned with the object which gets transformed, the second group is those activities that do the transformation and the last group will be those activities that are concerned with the transformed entity. Use arrows to connect the activities and to show their dependency on one another. Lastly add the three monitoring and control activities to the activity model.

C. Activity 3: Using Models to Structure Discussions

Purposeful activity models are used to structure questions as to facilitate an orderly discussion about the real situation, as well as discussions about change to improve the situation. Typical questions that could be asked about an activity are: Who does it? When? How? How else could it be done? [10].

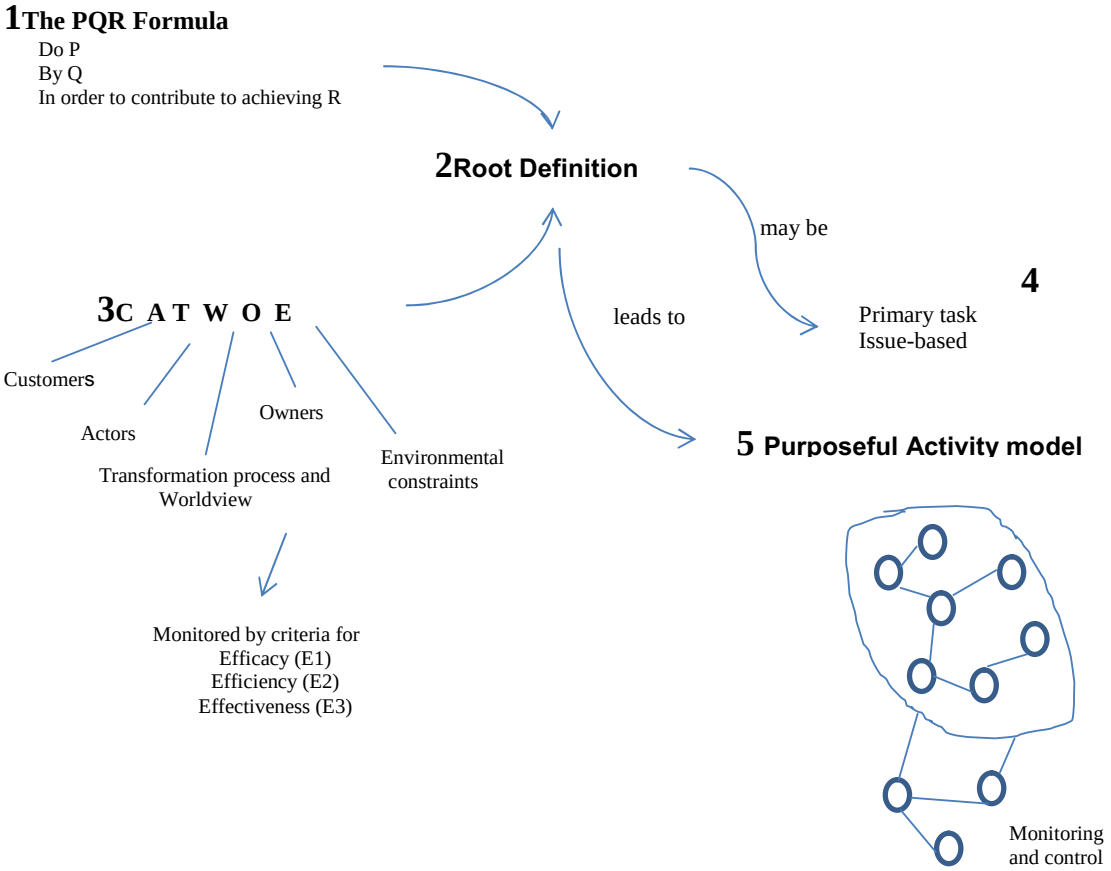

Fig. 3 Guidelines which help building models of purposeful activity [10]

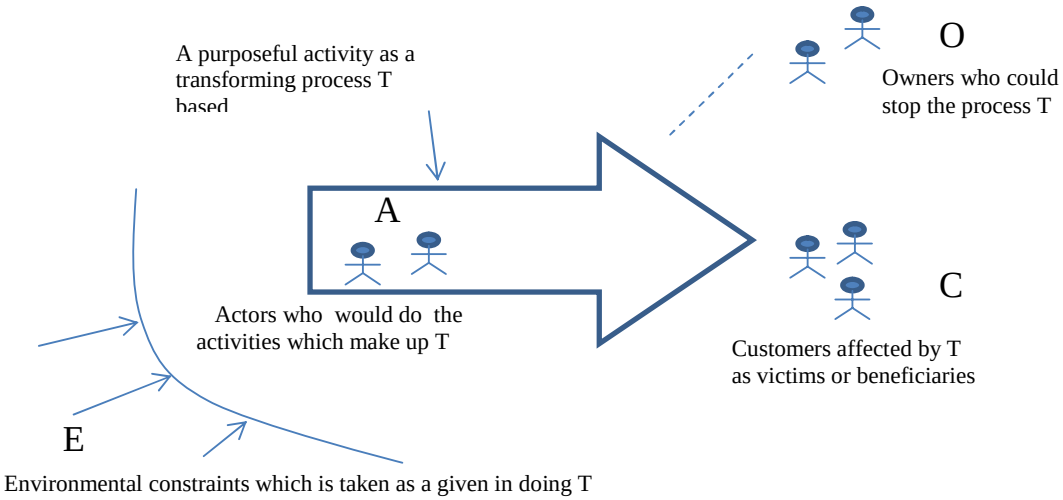

Fig. 4 CATWOE model of purposeful activity [10]

D.Activity 4: Defining Action to Improve

Defining action is not about consensus, but about accommodating people with common concerns. To accommodate different people mean that deep-rooted positions may shift and worldviews may be appeared [10]. Accommodations must focus on changes that are arguably desirable and culturally feasible.

V. Teaching Students Towards a Holistic Systems Approach

Currently, the networking module in question, mainly consist of technical knowledge on designing, building and maintaining networks. The strategic operation of SSM inside the organization is at this point outside the scope of the curriculum. But we need to give the students a theoretical understanding of systems thinking and SSM, thus supplying them with a tool to approach networking design more holistically in terms of the organization and its goals. We belief that the application of these ideas are the best way to internalize the concepts, therefore the students will be presented with case material to improve their modeling skills.

Formative evaluation will be used to guide the students during their modeling of example problems. Peer evaluation, in the form of class presentations, will be used to ensure that students get the opportunity to learn from one another. In terms of summative evaluation a small project will be given to individual students, in order for them to demonstrate their ability to apply the methodological principles.

VI. SSM Case

This example will illustrate how SSM will be demonstrated to the students using a case inside the students' frame of reference. The problematic situation and worldviews would be observed only from the students' point of view. This will also serve as an example of the summative evaluation of the SSM application.

Engineering students at a University of Technology (UoT), must as part of their qualification, do at least one year work integrated learning (WIL). This training must be done at an accredit company in their field of study. Companies that are prepared to offer training to this students, have to be accredited by the university. Students are monitored by the university through on site visits by lecturers. Each student must be assigned a mentor at the company, as well as a mentor from the university. The company mentor is, in collaboration with the university mentor, responsible for mentoring the student, completing reports and evaluating the student. Students and company mentors must hand documentation to the university on a regular basis. The university assists the students in finding WIL placements, but it is ultimately the students' responsibility to find WIL placement.

The problematic situation as seen from the student perspective is the identification of such companies who offer WIL and the process of getting employed as a trainee at these companies.

A. Activity1: Finding Out

The motive for using rich pictures in Fig. 5 is the difficulty to express the complex human situations with all its interrelations. As information is gathered the picture will become richer, but it will never be finished.

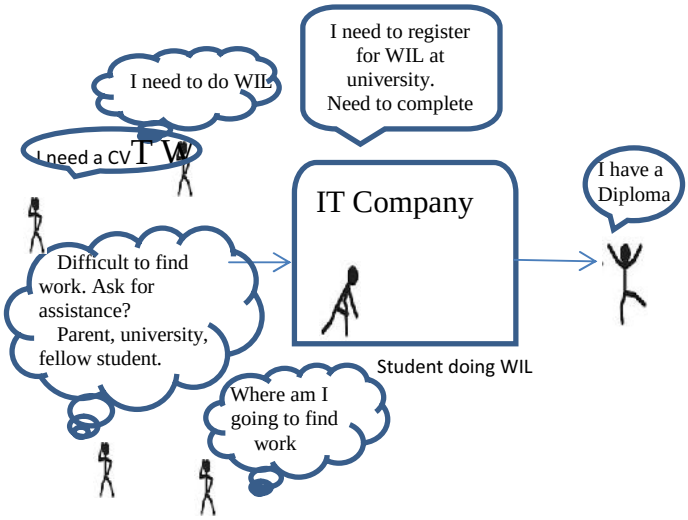

Fig. 5 Rich Picture

Client role (person or persons who caused the intervention to happen) - Students

Practitioner role (person or persons who conduct the investigation) - Lecturer at UoT

Owner role (person or persons affected by the situation)- Students, parents, UoT, companies.

B. Activity2: Model Building

1. This is an activity across departments, therefore it is issue-based, rather than a primary task. Before the actual building of the activity model the following definitions: PQR, Root definition, CATWOE and E1, E2, E3, which are relevant to the situation, must be carried out.

1. PQR

P (What) Students must get WIL opportunities at companies.

Q (How) Students must apply and do WIL

R (Why) To gain practical experience, pass WIL and obtain a diploma

2. Root Definition

A system, to assist students at a UoT, to be placed at companies who offer WIL opportunities, in order to gain practical experience, which is compulsory to complete their training, as to obtain a formal qualification.

3. CATWOE

C (Customers) Students, UoT, companies, parents

A (Actors) Student

T (Transformation) Student without WIL and diploma - Student with diploma and experience

W(Worldview) I, as students need to find a WIL opportunity

O (Owner) UoT, companies, students, parents

E (Environment) WIL guide lines of the university

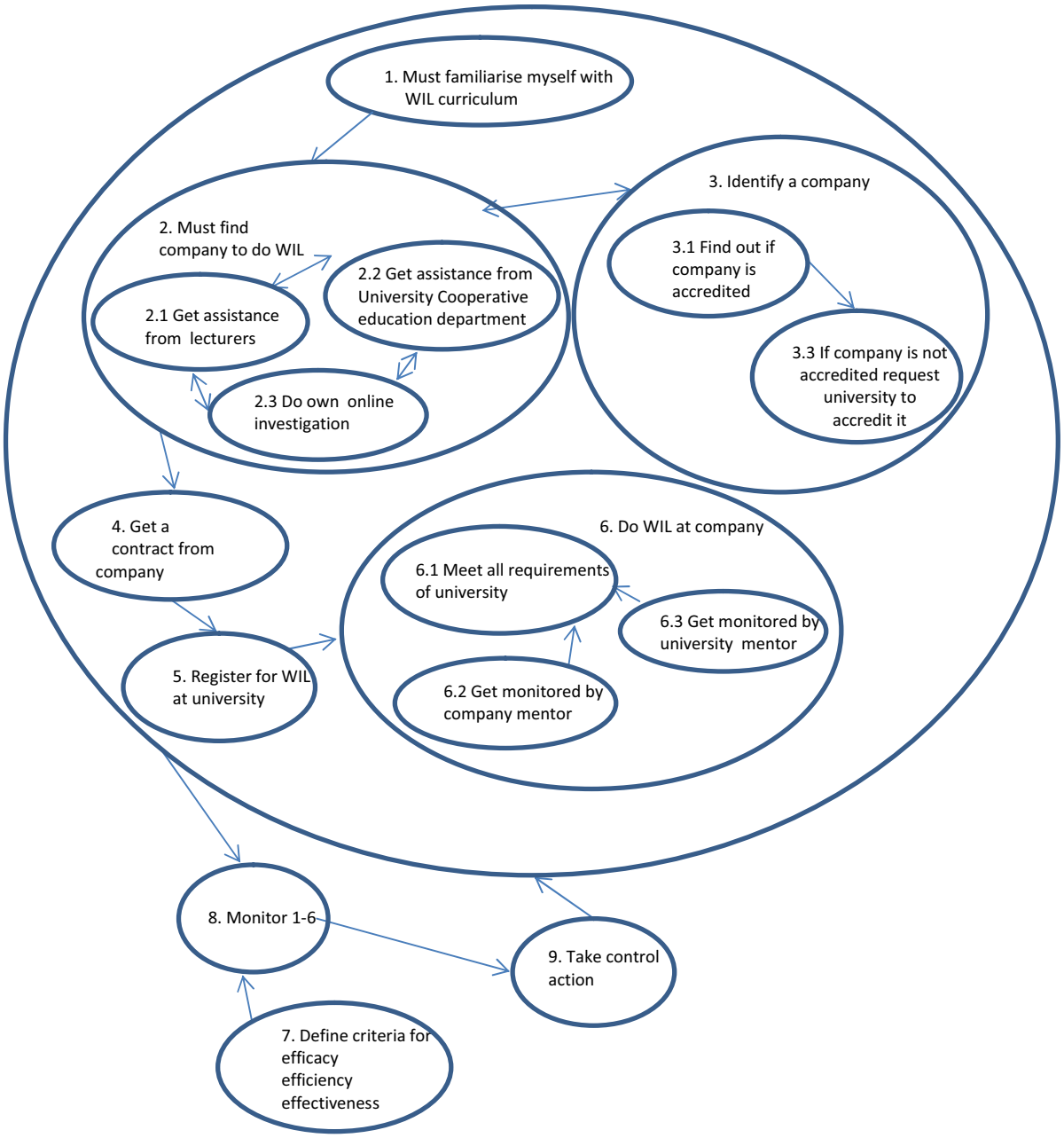

Fig. 6 Activity Diagram

4. E1, E2, E3

E1 Did I get a WIL opportunity?
E2 Did I complete my WIL successfully?
E3 Do my opportunity lead to other students getting opportunities at the same company?

The purposeful activity model as in Fig. 6, would lead to structured questions, which could facilitate discussion about the real problematic situation. Actions to cause change in the problematic situation could also now be defined.

VII. Short Description of the Course

Week 1: Introduction to Soft Systems Methodology (SSM)
Week 2: SSM application and assignment
Week 3: The Internet and Its Uses
Week 4: Help Desk
Week5: Planning a Network Upgrade
Week 6, 7: Planning the Address Structure
Week 8, 9: Configuring Network Devices;
Week 10, 11: Routing ISP Services;
Week 12: ISP Responsibilities;
Week 13: Troubleshooting and SSM assignment due date

VIII. Conclusions and Future Research

The summative assessment could be used to determine the

extent to which students internalize the concepts of the SSM, but it is very difficult to establish whether such an endeavor is successful, as the stated goal is to widen the perspective of the students in their work-life. Feedback obtained from mentors and students during site visits should also give some indication of the success.

Future research should consider viewpoints of the companies, as well as the university. Each of these viewpoints could lead to their own activity diagrams, which would enrich the discussion and ultimately lead to better action to improvement. Research on the enrichment of SSM using critical systems heuristics could lead to further widening of student perspective regarding stakeholder involvement.

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