CONCLUSION

Simulation models have been in use in various fields for quite some time but their use in supporting the e-learning in higher education has not been much explored by the researchers. The focus of this thesis is on emphasizing on the use of simulation-based e-learning and on measuring its effectiveness so that students in higher education (i.e. in universities and/or colleges) can explore various aspects of new age Software Engineering practices.

8.1 RESULTS

The main achievement of the thesis work lies in the validation of simulation based e-learning in software engineering with the help of a Software Engineering Simulation Based e-Learning Environment (SESeLE). The SESeLE tool we used was based on the concept of integrating System Dynamic Modelling with established methods, i.e. Goal-Oriented Measurement (GOM) and Descriptive Process Modelling. The results of the work carried out by us have been summarized below:

1. The basic objective of any VLE is to create an adaptive learning environment and necessary learning models that integrates individual learner’s learning styles into the learning environment. The majority of the adaptive systems till date have used the traditional collaborative student modeling approach of questionnaires to detect their learning styles. Various theorists and practitioners have developed positions about simulation based designs by applying the characteristics of System Dynamics (SD).

There is abundance of literature available on the experiential learning approach, incorporating scenario-based learning, case studies, role-play and authentic activities all of which have characteristics commonly used in simulations. The fundamental idea behind it is that the learners should educate themselves individually by incorporating their own learning styles into the VLEs rather than be educated conventionally in these environments. Simulation is a powerful tool for learning that can further enhance educational
goals by boosting motivation levels of various learners with its novel ways of interactive processes. This active learning approach is more likely to provide learners with deeper learning experiences and help them to acquire more usable as well as transferable knowledge.

Collaboration of learning measures with explicit learning goals is very significant in this process. For the learners in VLE, after the design phase, the task as the role players is to learn concepts from the simulation presented in the lectures. The understanding of the concepts is much more effective and deep when playing roles in those scenarios, while the control group participants learn less about concepts than designers in the same scenarios.

In order to support simulated learning and to overcome MOODLE’s other limitations highlighted earlier in the chapter 2, the authors have proposed a Software Engineering Simulation based e-Learning Environment (SESeLE) and developed a software tool called SESeLE tool. While creating SESeLE tool software, the mode of online pedagogy and some learning styles have been closely studied and followed. This tool provides an online e-learning platform for simulated class room teaching/learning environment and includes online courses, assignments, evaluations and result displays. SESeLE encourages learners to become connected participants (by facilitating them to identify their learning styles and integrating those into their individual learnings) and provides a productive environment conducive to learning where they are able to explore their full potential.

2. In chapter 3, we have first presented an approach to integrate System Dynamics Modeling with Goal Oriented Measurement and Descriptive Process Modeling in order to provide software developers with a comprehensive approach to simulation based e-learning. System Dynamics Model can be used for learning about a) the dynamic complexity of systems, b) for the identification of optimal policies in existing systems, and c) for improvement of system behaviour through structural changes in the system under development. Next, we have introduced the GOM process briefly followed by the description about the five dimensions of GOM goal definition as available in the literature. Based upon these inputs we have defined five
dimensions for the SESeLE tool on the similar lines and introduced the SESeLE goal definition taxonomy in brief.

3. In chapter 4, we investigated the effect of using the model in software project management education on the behaviour of Computer Science and Software Engineering learners. The ‘BEHAVIOUR’ focused on the problems of project planning and control. The performance of the learners was analyzed with regard to four dimensions, i.e., interest in the topic of project management (DV1), knowledge of typical project behaviour patterns (DV2), understanding of simple project dynamics (DV3), and understanding of complex project dynamics (DV4). The learners were made to go through a training session on SESeLE, their responses on these dimensions were gathered before and after the training and then both sets of responses of individual learners were compared. Even though the findings of the analyses show several interesting trends, but there is a statutory caution that should be kept in mind that the statistical results must be interpreted with caution due to a) small number of learners involved as the sample group; and b) several threats to internal validity.

A positive impact was found with respect to the change of scores from pre-training test to post-training test for all four dependent variables. There was significant effect observed for DV1 to DV3. For DV4, the power of the test seemed to be too low that no measurable effect could be detected. The experimental design, and the BEHAVIOURs involved in the experiment need further improvement in order to avoid speculations about the positive or negative effects of the threats to internal validity.

We proposed two null hypotheses and three alternative hypotheses in all in this Chapter. On the basis of the acceptance of the 1st Null Hypothesis $H_{0,4,1}$, we can say that there is no difference between the scores in pre-training test and post-training test. On 2nd Null Hypothesis $H_{0,4,2}$, we found that there is significant difference in effectiveness of the experimental group (using the SDM) and the control group. In reference to the 1st Alternative Hypothesis $H_1$, we observed that the average performance of all learners during the post-training test is better than that in the pre-training test. With regard to the 2nd
Alternative Hypothesis $H_2$, we found that the average performance improvement of the experimental group is better than the average performance improvement of the control group. In reference to the $3^{rd}$ Alternative Hypothesis $H_3$, we found that the average post-training test scores of the experimental group (using the SDM) are better than the average post-training test scores of the control group.

Therefore, we should keep in mind two important factors. First, more time has to be allowed particularly for executing scenario blocks, and for the familiarization with the simulation tool. Second, the experimental BEHAVIOUR, as it is, does not yet fully exploit all potentially available features of a learning tool that can be offered to the learners with the help of SDM.

4. In chapter 5, a total of 392 students of technical courses (belonging to IT and Computer Science only) were involved in this task and they were asked to respond to the issues like their practical knowledge of software handling, interest and knowledge of software project management and the impact of e-learning on their knowledge in software project management.

The most preferred mode among female students was Web based learning style while it was found to be the second most preferred style of learning among male students. Reading textbooks was not significantly popular among female students as compared to male students. Nearly half of the students showed their interest in participating in any kind of seminar or workshop related to software project management. The post-training test score was also found to be significantly increased from pre-training test scores with regard to their knowledge about typical patterns observed in software project management issues.

ANOVA test was performed to observe the significant differences in various learning styles on post-training test scores overall and in both male and female students. Five null hypotheses were proposed in this chapter. On the basis of the acceptance of the $1^{st}$ Null Hypothesis $H_{0,1}$, we can conclude that there is no significant difference between the average response of the male and female
students with regard to the issues related to their Interest in Software Project Management. The results of the $2^{nd}$ Null Hypothesis $H_{0.5.2}$ showed that the pre-training test scores of the male and female students on both the problems are significantly different from the post-training test scores. As the $3^{rd}$, $4^{th}$ and $5^{th}$ Null Hypotheses i.e. $H_{0.5.3}$, $H_{0.5.4}$ and $H_{0.5.5}$ have found to be negated, we can conclude that the post-training test scores of male and female students on both the issues of simple and difficult software project management were significantly different. The pre and post-training test scores of the students on both the issues were also significantly different. There was also a considerable difference between the post-training test scores on both the issues among students categorized according to their preferred choice of learning.

5. Chapter 6, in all 315 students (of general courses) were included in this section of our work and they were made to respond to the issues regarding their ability to use ready-made computer based application programs, use e-learning features of SESeLE, preferences on using ICT in learning and greater opportunities provided by ICT. We noticed that word processor based documentation and e-mail were the two most common abilities of these students (male and females). Female students gave lesser preference to Powerpoint presentation and online searches as compared to male students. The similar results were found among the rural and urban students.

The perception of students was measured on their preferences of using ICT in learning with VARIMAX rotations for the investigation of general factors which can be extracted from the subsection 5.3 (containing 24 questions) of questionnaire tool Q5. The overall six factors were found during the course of action: a) Computer liking, b) Interacting with Foreign Teachers, c) Traditional Study Methods, d) Learning in Small Groups, e) Sharing Ideas, and f) e-Learning. The same technique was applied to find out the assessment of greater opportunities provided by the ICT based on the subsection 5.4 (containing 17 questions) of questionnaire tool Q5. Thus the overall five factors were found during the course of action: a) Applied approach, b) Foreign knowledge, c) No boundary learning, c) Mass knowledge distribution, and d) Quota system. In all, four null hypotheses were proposed in this
chapter. On the basis of the acceptance of the 1st Null Hypothesis $H_{0.6.1}$, we can say that the male and female students do not significantly differ on all the factors related to their perception about ICT. With the help of the 2nd Null Hypothesis $H_{0.6.2}$, we found that there is no significant difference among rural and urban students with regard to the factors related to their perception about ICT. In reference to the 3rd and 4th Null Hypotheses i.e. $H_{0.6.3}$ and $H_{0.6.4}$ the same can be said to be true as far as perception of male & female students as well as rural and urban students towards ICT programs is concerned. Hence, we can conclude that the students, irrespective of their gender and rural or urban background, shared the same perception on the factors like traditional study, e-Learning methods, sharing ideas, learning in small groups etc.

6. Chapter 7, in all 410 students (of technical as well as non-technical courses) were included in this section of our work and they are made to respond on the issues like a) usage of off-line digital technology in gathering and sharing information, b) usage of on-line communication tools in gathering and sharing information, c) usage of on-line learning facilities in gathering and sharing information, and d) role of e-learning concept in the studies as perceived by the students. We found that the average response of the students is significantly higher who use e-learning as an additional learning technique along with the average response of those students who are using traditional learning techniques only.

On the basis of the acceptance of the 1st Null Hypothesis, we can say that there is no significant difference between the average response of the male and female students all the issues related to the usage of digital technologies. On 2nd Null Hypothesis, we found that the there is no significant difference between the average response of the male and female students on all the issues related to the usage of online communication tool. On 2nd Null Hypothesis, we found that the there is no significant difference between the average response of the male and female students on all the issues related to the usage of online learning facilities. On 4th Null Hypothesis, we found that the there is no significant difference between the average response of the male and
female students on all the issues related to the role of e-learning concept in the studies. We conclude that the average response score of the former on the concept of doing learning task collaboratively or individually, Gathering Information and Managing information is significantly higher than the score of the latter. We also present the average response of the students who use e-learning as an additional learning technique along with the average response of those students who are using traditional learning techniques only.

8.2 Limitations and Future Work

The results presented in this thesis can only mark a milestone within a work in progress. Now we are presenting a point-wise summary of the potentialities of System Dynamics in the field of software engineering, and a brief discussion of the limitations of the conducted research work. By reflecting the limitations, an outline for the future work will be given.

1. SDMs are both a formal and informal statement of knowledge about the modelled reality and a source for generating new knowledge by conducting virtual experiments. Systematic experimentation with SDMs can be helpful in the area of theory-building in software engineering.

2. An SDM can be used as an electronic laboratory where hypotheses about observed problems can be tested. It can be achieved in software engineering by integrating the System Dynamics method into accepted state-of-the-art approaches, and the introduction of simulation based e-learning as a standard technique for visualisation and decision support into training. The scope for future research can be identified by discussing the extent of the achievements gained with SESeLE support.

This thesis is an attempt to integrate SDM development with process modeling and goal-oriented measurement; and a step forward towards developing support for decision-making, learning from past learnings, and support for planning/control.

Much work, however, has still to be done with regard to modularization and reuse of SDMs. The size of the students sample can be enhanced and be made broad based covering more students in the verticals as well as the horizontals of academics of higher education. SESeLE tool also falls short in many areas like in defining the
design principles for developing elementary base models and easily adaptability to different virtual learning environments. In the absence of any national or international standards for VLEs, the validity of outcomes of using the SESeLE tool for learning purposes can always be questioned.

Another methodological limitation of SESeLE is the insufficient guidance about the combining of empirical learning with simulation-based learning from the perspective of cost-effectiveness. This issue should be addressed in a follow-up with higher education research that should be specifically dedicated to cost-benefit analysis of simulation-based e-learning.

In addition to methodological enhancements of SESeLE, there is also a need to continue with empirical validation of such VLE tools. Even though first empirical evidence supports the effectiveness and efficiency of the SESeLE, there is still a scope to carry out more experiments and industrial case studies in order to support findings of this thesis. A very promising new area of research is currently emerging in the field of higher education and training. The integration of simulation technology into web-based learning environments could lead to path-breaking innovations in order to achieve increased effectiveness of individual and collaborative learning in technical and non-technical courses in universities/colleges.