Virtual Labs in Engineering Education: Modeling Perceived Critical Mass of Potential Adopter Teachers

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Abstract. Virtual labs for science experiments are a multimedia technology innovation. A possible growth pattern of the perceived critical mass for virtual labs adoption is modeled using (N=240) potential-adopter teachers based on Roger's theory of diffusion and of perceived attributes. Results indicate that perceived critical mass influences behavior intention to adopt a technology innovation like Virtual Labs and is affected by innovation characteristics like relative advantage, ease of use and compatibility. The work presented here models the potential-adopter teacher's perceptions and identifies the relative importance of specific factors that influence critical mass attainment for an innovation such as Virtual Labs.

Keywords: virtual labs, innovation diffusion, critical mass, simulation, lab experiments.

1 Introduction

Virtual learning environments like Virtual Labs have played a catalytic role in improving conceptual learning across the higher education landscape. The trends and challenges elicited in Mueller's work [1] highlighted an important factor affecting its implementation i.e. the perception of such an environment by the users and therefore its rigorous usage.

The dominant focus of the content coverage of virtual learning environments has been on theory concepts. While this is important, practical knowledge on usage and applications of theory is equally critical in science and engineering curriculum [2], [8]. Cognizance of fundamentals, conceptual understanding of its applications in the field of study, sensory attentiveness, psychomotor skills development etc. forms the gamut of objectives for laboratory exercises. The limited experimental infrastructure and restricted time in most institutions make it challenging to ensure all students attain these learning outcomes in a satisfactory fashion.

Recent years have seen creation of a new dimension to virtual learning with the introduction of virtual labs. Virtual labs have been augmenting the hands-on physical laboratories in several ways by allowing students to learn most elements of the experiments prior to physically seeing or experimenting with the instrumentation [9], [14]. Physical laboratories group students to perform activities while virtual labs

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provide individualized training. Virtual labs are in fact preferred in many educational scenarios for scalability and tacitly addressing fundamental issues such as the inability to visualize complex phenomena, compromise in topical coverage of the content due to variations in teaching styles etc. In spite of its advantages of the academic community hasn't integrated virtual labs in a global way as is the case with physical labs. Unless there is massive adoption of virtual laboratories, its large-scale impact will remain a distant reality.

Many technological innovations have required espousal by a threshold 'critical mass' for their main-stream usage and sustenance [10]. Some examples include: E-platforms used for online businesses [12] showed success when factors such as user's decision and user network surpassed the critical mass. Grajek [11] developed empirical models in global cellular telephony that predicted the critical mass based on heterogeneous factors and showed how the timing of technology introduction is critical. Grewal [13] emphasized that the depth of usage of an innovation apart from the critical mass should also be considered in ascertaining the level of adoption.

The phenomenon of critical mass is important in the context of virtual labs due to the interdependent and collaborative aspect of technology adoption in teaching processes. Rogers [10] defines critical mass as 'the point after which further diffusion becomes self sustaining.' Loch and Huberman [19] concluded that critical mass can be attained if users have a high rate of trialability. The threshold level for critical mass varies anywhere between 10% [20] and 25% [21]. Our work analyzes the potential adopter teacher's intention to adopt virtual labs using their perception of critical mass. Thus it becomes important to consider 'how many' should adopt virtual labs for it to become a conventional technology.

Starting with a research model we develop various hypotheses and describe the research methodology followed to empirically validate the hypothesis with conclusions and recommendations.

2 Literature Survey

2.1 Virtual Labs for Engineering Education

Review of the literature on physical and virtual labs by Ma et. al [5] showed lack of foundation to evaluate effectiveness of laboratories and the need to consider learning outcomes and student preferences more closely in an isolated fashion. Corter et al [4] compared the effectiveness of physical laboratories with remotely controlled and simulation based virtual laboratories and showed that all three were effective in terms of conceptual understanding they imparted to the students. Today virtual laboratories that are simulation-based or remotely triggerable have been developed for physical & chemical sciences, engineering, biotechnology and medical sciences. The VALUE labs (Virtual Amrita Laboratories Universalizing Education) [14] has built over 400 experiments that are interactive animations, mathematical simulations of physical phenomena and interfaced a variety of equipments as part of its virtual laboratory development program. This was developed as part of larger consortia of 12 institutes whose mission was to develop over 1500 experiments in nine disciplines of engineering and