Flipped Labs as a Smart ICT Innovation: Modeling Its Diffusion among Interinfluencing Potential Adopters

Raghu Raman

Abstract. Smart ICT innovation like flipped classroom pedagogy is freeing up face-to-face in-class teaching system for additional problem based learning activities in the class. But the focus of flipped classrooms is more on the theory side with related lab work in science subjects further getting marginalized. In this paper we are proposing Flipped Labs - a method of pedagogy premeditated as a comprehensive online lab learning environment outside the class room by means of tutorials, theory, procedure, animations and videos. Flipped labs have the potential to transform the traditional methods of lab teaching by providing more lab time to students. An ICT educational innovation like flipped labs will not occur in isolation in an environment where two interrelated potential adopters namely teachers and students influence each other and both have to adopt for the innovation to be successful. In this paper we provide the theoretical framework for the diffusion and the adoption patterns for flipped labs using theory of perceived attributes and take into account the important intergroup influence between teachers and students. The results of this analysis indicated that Relative Advantage, Compatibility, Ease of Use, Teacher Influence and Student Influence were found to be positively related to acceptance of flipped labs.

Keywords: Flipped classroom, Online Labs, Simulations, chemistry, ICT, innovation.

1 Introduction

Smart ICT innovation like flipped classroom method of teaching is freeing up face-to-face class oriented teaching system for additional problem based learning

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activities. Also known as ‘inverted classroom’, or ‘reverse instruction method’, the flipped classroom method is one in which what is traditionally done in class is switched for what is traditionally done for homework [1]. This means, that rather than listening to lectures in school and doing their homework at home, students watch lecture videos at home and do their “homework” in the school, under the guidance of the teacher. therefore, rather than the teacher giving synchronous in-class group teaching, students are looked forward to make use of the video materials offered, by the side of additional resources to gain knowledge of concepts and finish assignments on their own at their own speed and at place fitting to the student [2]. In flipped classroom method of teaching, if any student is trailing, the teacher has additional time to endow with personalized facilitation when class time is on, even as other classmates are engaged in their problem based learning activity

The National Focus Group on “Teaching of Science”, suggested prevention of marginalization of lab work in school science curriculum. Investment in this regard is required for improving school labs to promote experimental culture. But there seem to be two principal difficulties. Firstly, experiments require a certain minimum infrastructure – a lab with some basic equipment and consumables on a recurring basis. Learners get access to the physical lab for only a short period of time, which is often not sufficient to allow them to try different scenarios and hence limits the learning cycle. Secondly, assessment of practical skills in science in a sound and objective manner is by no means an easy task. The difficulty multiplies manifold if assessment is to be carried out for a class of 50 students which is very common in schools in India.

The traditional method of conducting classes using information from textbooks and lecture notes gives very little motivation or incentive to students to attend classes [3]. In fact, most of the times student only attend lectures to pass time and do not actually learn anything through them [4]. On the other hand flipped classrooms were found to promote higher levels of inventiveness and coordination among the students, thereby indicating the need to introduce flipped classroom practices for the future generations [5]. The need of the hour is to achieve maximum output from the students. For this, several studies have been conducted to determine how flipped classrooms are more advantageous than traditional classrooms. A study conducted by [6] shows that flipped classrooms helped students get higher grades and better achievements as compared to traditional classrooms. Another advantage with flipped classroom is the increase in the time available for problem solving and hands-on activities [7]. Flipped classrooms are noted for their use of modern technology as part of their teaching methods. Many studies have found that the use of technology in teaching “helps in reduction of attrition, increasing the outcomes and improving student satisfaction.” [8]. This modern method of teaching has been found to be especially useful to students pursuing higher studies as the use of technology helps them to review their notes anytime they need to, even when they are not sitting in a classroom [9]. Perhaps the biggest advantage of a flipped classroom system is that it gives the teachers more time in getting the students to master a particular topic which is otherwise difficult to achieve in the limited time available during classroom teaching [10].

Educational innovations generally have two major groups of potential adopters – teachers and students (Fig. 1), whose ultimate benefit stems from interacting with each other. Since the two potential-adopter groups are interdependent, one group of potential-adopter decision to adopt the innovation could have a positive/negative effect on the other group. For the educational innovation to succeed both kinds of potential adopters must adopt it. Lack of feedback and interaction can lead to equilibrium where cost-savings are not realized, since no-one adopts to a critical mass point. In this paper, we consider instead interinfluence effects in the context of two groups of heterogeneous potential adopters where the users may realize gains by interacting with one another (Fig. 2)

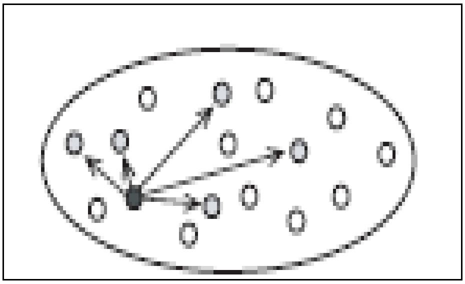

Fig. 1 Single group of potential-adopters – teachers or students

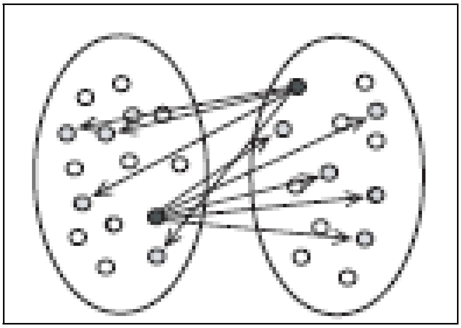

Fig. 2 Two groups of potential-adopters – teachers and students and their interinfluence

The adoption decision in an interrelated system of potential-adopters is a choice affected by three factors

1. diffusion rate of first group (teachers)
2. diffusion rate of second group (students)
3. interdependent influence diffusion rate (teachers-students-teachers)

2 Flipped Labs

Online Labs (OLabs) for science experiments is an ICT innovation based on the idea that lab experiments can be taught using the internet, more efficiently, less expensively, and offered to students who do not have access to physical labs [11, 12. 13]. It was developed to supplement the traditional physical labs. OLabs as flipped classroom method of pedagogy is premeditated as a comprehensive learning environment by means of tutorials, theory, procedure, animations and videos outside the classroom whereas the assessments takes the form of theoretical, experimental, practical and reporting skills. We call this approach of using OLabs in a flipped mode as flipped labs (Fig. 3).

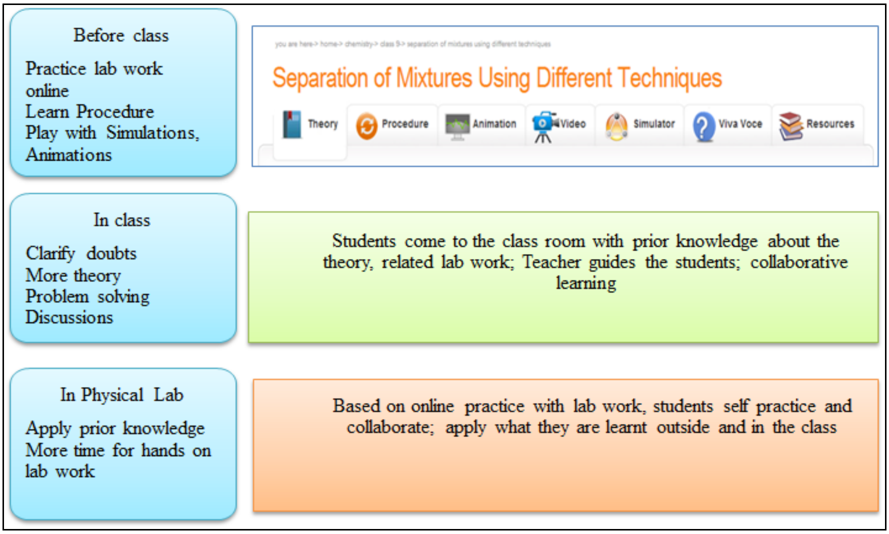

Fig. 3 Model of Flipped Labs

Flipped labs have the potential to transform the traditional methods of lab teaching by upturning long-established teaching methods to involve students in the practical and problem based learning methods. Utilizing flipped labs, teachers move out of the classroom and deliver online as a way to free up precious lab time for students to practice lab work outside the physical labs (Fig. 4). Flipped labs are not a substitute to traditional physical labs but it helps students familiarize with new concepts and acquire some pre knowledge before coming to the classroom. Today flipped classrooms are mostly focusing on the theory side and giving lecture notes to students via video, audio etc. However both theory and lab work are very important for conceptual understanding. But the real problem is that the lab time is limited. Sometimes the teacher will demonstrate the experiment or students will do the experiment in a group. Then there is this issue of lag between the time theory is taught in the classroom and the time student actually gets to perform the related lab work.

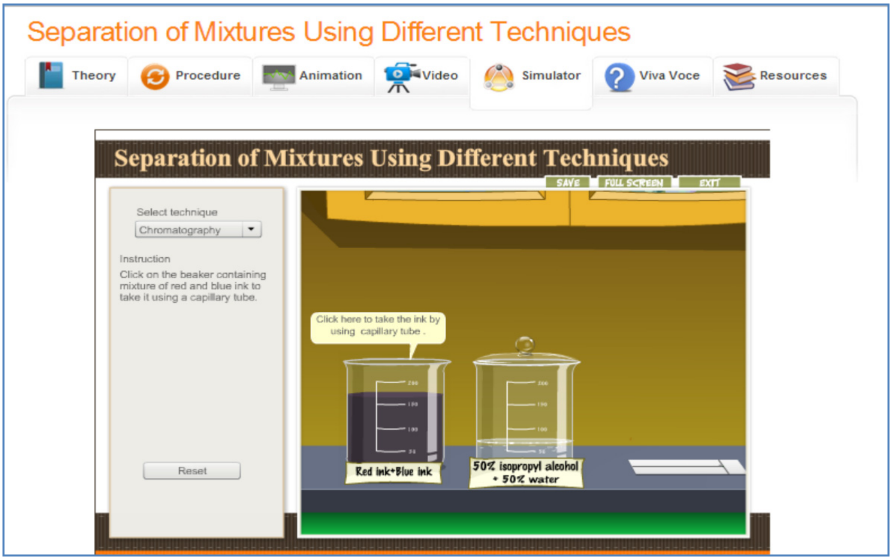

Fig. 4 Sample Flipped Labs showing simulation for students to practice outside class

3 Research Model

Flipped Labs is an innovation if it is 'perceived as new by an individual or other unit of adoption'. An ICT educational innovation like Flipped Labs will not occur in isolation in an environment where two interrelated potential adopters namely teachers and students influence each other and both have to adopt for the innovation to be successful. More importantly this paper provides the theoretical framework for the diffusion and the adoption patterns for Flipped labs using [14] theory of perceived attributes and takes into account the important intergroup influence between teachers and students. The Flipped Labs rate of adoption was investigated by assessing two groups of characteristics, which were the independent variables - innovation characteristics and environment characteristics (Fig. 5). We also considered the interinfluence between teachers and students.

Employing [14] framework, [15] proposed mathematical model as a nonlinear differential equation for diffusion of an innovation in a group of size M. In such a scenario [16] adoption of innovation is due to two influences viz. external influence (mass media) which is a linear mechanism and internal influence (word-of-mouth) which is a non-linear mechanism. The differential equation giving the diffusion is

$$\frac{dN(t)}{dt} = \left(p + qN(t)\right)\left(M - N(t)\right) \quad (1)$$

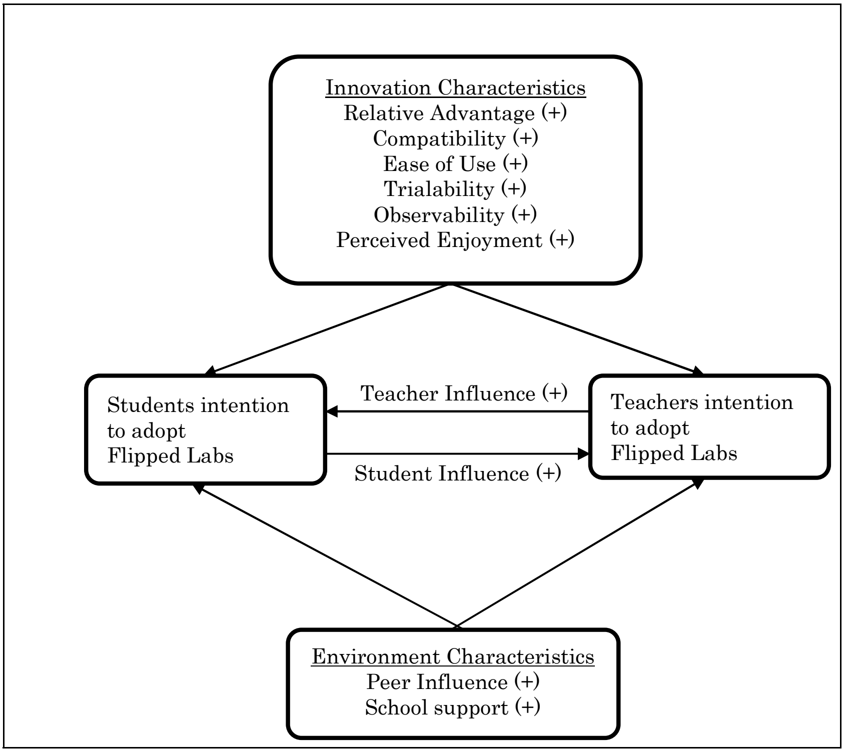

Fig. 5 Research model for diffusion of Flipped labs among students and teachers

Where N(t) is the cumulative number of adopter-students who have already adopted by time t, M is total number of adopter-students who will eventually use the innovation, p is the coefficient of external influence and q is the coefficient of internal influence

In terms of the fraction F(t) of potential adopter-students

$$F(t) = \frac{N(t)}{M} \quad (2)$$

the Bass model can be rewritten as

$$\frac{dN(t)}{dt} = (p + qMF(t))(1 - F(t)), \; F(t = 0) = F_0 \tag{3}$$

Equation (3) yields the S-shaped diffusion curve. It is assumed that the carrying capacity M of the adopter-students remains constant.

Now we extend the Bass model to account for the interinfluence between teachers and students. We define the following terms.

- p_1 external influence for the adopter-teachers
- q_1 internal influence for the adopter-teachers
- F total number of adopter-teachers who will eventually adopt the innovation
- f cumulative number of adopter-teachers who have already adopted by time t
- p_2 external influence for the adopter-students
- q_2 internal influence for the adopter-students
- S total number of adopter-students who will eventually adopt the innovation
- s cumulative number of adopter-students who have already adopted by time t
- m total number of adopters who will eventually adopt the innovation
- c_1 teacher influence on students ($c_1 > 0$, $c_1 < 0$, $c_1 = 0$)
- c_2 student influence on teachers ($c_2 > 0$, $c_2 < 0$, $c_2 = 0$)
- α proportion of teachers in the total population of potential adopters ($0 \leq \alpha \leq 1$)

The differential equation giving the diffusion for teachers (f) is

$$\frac{df}{dt} = f(t) = (p_1 + q_1 f + c_1 s)(F - f) \tag{4}$$

The differential equation giving the diffusion for students (s) is

$$\frac{ds}{dt} = s(t) = (p_2 + q_2 s + c_2 f)(S - s) \tag{5}$$

The equation (4), (5) takes into account the interinfluence of teachers and students

The differential equation giving the diffusion for the combined population of potential adopters (m) (students and teachers) is

$$\frac{dm}{dt} = m(t) = \alpha f(t) + (1 - \alpha)s(t) \tag{6}$$

4 Innovation Characteristics

Relative Advantage: [14] defines relative advantage as — 'the degree to which an innovation is perceived as being better than the idea that it supersedes'. We hypothesize that Relative advantage of Flipped Labs positively affects intention to adopt it.

Compatibility: [14] defines compatibility as — 'the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters'. We hypothesize that Compatibility of Flipped Labs positively affects intention to adopt it.

Complexity/Ease of Use: Any innovation quickly gains a reputation as to its ease or difficulty of use [14]. We hypothesize that Complexity of Flipped Labs negatively affects intention to adopt it.

Trialability: Trialability is "the degree to which an innovation may be experimented with on a limited basis" [14]. Innovations that potential adopter can play with on a trial basis are more easily adopted as it presents less risk to the potential adopter. We hypothesize that Trialability of Flipped Labs positively affects intention to adopt it.

Observability: Another aspect of [14] is the degree to which the results of an innovation are visible to others. If potential adopters can see the benefits of an innovation, they will easily adopt it. We hypothesize that Observability of Flipped Labs positively affects intention to adopt it.

Perceived Enjoyment: According to [14] Perceived enjoyment is the 'degree to which using an innovation is perceived to be enjoyable in its own right and is considered to be an intrinsic source of motivation'. We hypothesize that Perceived Enjoyment of Flipped Labs positively affects intention to adopt it.

School Support: More often teachers and students are motivated to consider technology decisions that are sanctioned by the school management since those will have adequate support resources including the necessary IT infrastructure. We hypothesize that School support for Flipped Labs positively affects intention to adopt it.

Peer influence: Interpersonal influence appears to be extremely important in influencing potential adopters, as is demonstrated by the fact that the opinions of peers significantly affect the way in which an individual feels pressures associated with adoption of the innovation. We hypothesize that Peer influence for Flipped Labs positively affects intention to adopt it.

Teacher Influence: Since teachers play a pivotal role in implementing innovations, their perception of the innovation will strongly influence their students thinking. We hypothesize that Teacher support for Flipped Labs positively affects student's intention to adopt it.

Student Influence: Students perception of the innovation will strongly influence their teacher's thinking. We hypothesize that student support for Flipped Labs positively affects teacher's intention to adopt it.

5 Research Methodology

In our study, 81 students and 32 teachers participated. A five point Likert scale based questionnaire was administered to understand students' and teachers' perceptions on the factors that influence the adoption of flipped labs pedagogy. The survey consisted of nine independent research variables hypothesized to be a factor affecting the adoption. The independent research variables used in the study were Relative Advantage, Compatibility, Ease of Use, Observability, Trialability, Teacher Influence, Student Influence, Peer Influence and School Support.

In our study reliability of the attributes had values ranging from 0.72 to 0.86 for students and 0.69 to 0.89 for teachers which is in the acceptable range. Regression analysis was conducted for all nine adoption variables on the dependent variable and hypothesis results calculated (Table 1). There is strong support for attributes like Relative Advantage, Compatibility, Ease of Use and Teacher Influence. The regression equation for students was statistically significant ($p < .0001$) and explained approximately 78% of the variation ($R^2 = .78$).

Table 1 Summary of Hypothesis results (students)

Attributes	Mean	SD	t test	p-value	Result
Compatibility*	24.91	4.55	7.318	0.003451	Accepted
Ease Of Use*	10.03	1.94	-1.9245	0.00272	Accepted
Observability	6.63	1.79	-0.2441	0.4036	Rejected
Perceived Enjoyment	11.42	2.40	-1.0942	0.1372	Rejected
Peer Influence	9.26	2.65	-1.1231	0.1308	Rejected
Relative Advantage*	22.30	3.80	1.438	0.007534	Accepted
School Support	14.53	3.25	2.4526	0.2932	Rejected
Trialability	7.47	1.69	-0.9276	0.3769	Rejected
Teacher Influence*	14.36	3.06	3.6516	0.00287	Accepted

*$p < 0.01$

Interestingly for teachers also there is strong support for attributes like Relative Advantage, Compatibility, Ease of Use and student influence along with an additional attribute School support (Table 2). The regression equation for teachers was statistically significant ($p < .0001$) and explained approximately 76% of the variation ($R^2 = .76$).

Table 2 Summary of Hypothesis results (teachers)

Attributes	Mean	SD	t test	p value	Result
Compatibility*	32.72	4.76	-1.3302	0.009835	Accepted
Ease Of Use*	7.62	1.85	-2.1597	0.002084	Accepted
Observability	6.93	1.51	0.1642	0.4357	Rejected
Perceived Enjoyment	12.52	2.54	0.7958	0.2159	Rejected
Peer Influence	10.70	2.30	-1.5723	0.06491	Rejected
Relative Advantage*	20.48	3.69	-1.6358	0.00575	Accepted
Student Influence*	11.74	2.19	0.1567	0.00187	Accepted
School Support*	16.72	2.86	-1.6641	0.00158	Accepted
Trialability	7.50	1.83	-0.7514	0.2296	Rejected

*$p < 0.01$

6 Conclusions

This research has provided a deeper investigation into adoption of smart ICT innovation like flipped labs guided by the framework of Rogers' theory of perceived attributes. In this study we had proposed that certain characteristics of flipped labs as a smart ICT innovation could account for the degree of acceptance of innovation by teachers and students. The results of this analysis indicated that Relative Advantage, Compatibility, Ease of Use, Teacher Influence and Student Influence were found to be positively related to acceptance of innovation. For the first time we have empirical evidence to show that the adoption of an ICT innovation is directly impacted by the interinfluence between teachers and students. When interinfluence plays a key role in the diffusion of innovation, the adoption decisions of a teacher/student often goes beyond their own decisions. We posit that a teacher's adoption decision comes not only from her own experiences but also from student's influence. Likewise the students' adoption decisions are influenced by the teachers' perceptions. The results revealed that for innovation attributes like Relative Advantage, Ease of use, Compatibility and Interinfluence student and teacher perceptions were similar.

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