Motivation as Basis for Building Infrastructure for Hardware MOOCs

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***Abstract*—With advancements in technological tools, e-learning/distance methods such as MOOCs are now mainstream and no longer just trends [1]. For a "hardware MOOC," i.e. a MOOC that requires hardware infrastructure apart from minimal tools required to access web technologies, various factors are key to participation in a MOOC. This work studies "marketing" factors in a hardware MOOC. Our work is for any agency attempting to engage with colleges in India and such developing countries, where it is needed to set up infrastructure for distance education. It is important for us to identify at the outset colleges likely and not so likely to setup infrastructure. This helps us maximize the return on our effort, in reaching out to colleges. e-Yantra is a robotics outreach project based out of Indian Institute of Technology Bombay and the e-Yantra Lab Setup Initiative builds the basis for imparting effective engineering education by creating standardized infrastructure and by training teachers in colleges. Principal Component Analysis and Logistic Regression are used to study success factors at the college and process levels in college participation in a hardware MOOC.**

Keywords— hardware MOOC, MOOC, motivation, PCA, logistic regression, e-learning

I. INTRODUCTION

The number of massive open online courses (MOOCs) have increased extensively in the recent years. In spite of benefits associated with these MOOCs, adoption rates are typically low [2]. Our work studies factors associated with the adoption of e-Yantra Lab Setup Initiative of e-Yantra. e-Yantra provides exclusive learning opportunities to students and teachers of colleges that have established Embedded Systems and Robotics Lab under this initiative. These learnings are provided in the form of Project Based Learning (PBL) material through competitions that require hardware for hands-on training along with necessary learning resources and tutorials provided online to participants.

e-Yantra Lab Setup Initiative is a holistic approach to:

(i) Impart theoretical and programming knowledge to teachers through workshops.

(ii) Provide hands on experience to teachers through online Task Based Training (TBT).

(iii) Help colleges set up a Robotics lab.

A college commits the following to participate:

(i) A team of 4 teachers to be trained by e-Yantra through an onsite 2 Day Workshop.

(ii) Funds to establish lab (approx. 2 lac INR) [3].

e-Yantra has 360+ colleges across India where a robotics lab has been established under this initiative [4].

Students and teachers of colleges that have established robotics labs through the e-Yantra Lab Setup Initiative (eLSI) get exclusive access to its various initiatives such as (i) special themes in e-Yantra Robotics Competition (eYRC) to bring the experience of Project Based Learning to engineering students. (ii) e-Yantra Ideas Competition (eYIC) that encourages students from robotics labs across the country to develop innovative projects. (iii) e-Yantra Resource Development Center (eYRDC) that provides resources for teachers to help them use their labs in an effective manner. (iv) e-Yantra Farm Setup Initiative (eFSI) that provides an opportunity to setup an agriculture based IoT-testbed and many other initiatives [4].

Typically, a college participates in the e-Yantra Lab Setup Initiative as follows:

(i) College requests information on initiative

(ii) College teachers attends Two day face-to-face workshop hosted by e-Yantra

(iii) College expresses intent to setup lab under the initiative

(iv) Teacher team participates in online Task Based Training (TBT) and college procures equipment required for lab setup

(v) College lab is inaugurated via online ceremony

e-Yantra began the e-Yantra Lab Setup Initiative (eLSI) in 2012 and since then has reached out to around **1400+** colleges that have participated in at least one step of this process and **360+** colleges have established labs. In recent years, MOOCs have attracted the attention of many stakeholders in education [5]. Our journey is of over 7 years - reaching out to 1400+ colleges. Inspite of reaching out to 1400+ colleges, the number of colleges that have completed the lab setup process is just 361 (approximately 25%). e-Yantra Lab Setup Initiative has

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reached out to almost all the 29 States and 7 Union Territories of India. 1400+ colleges reached out to come from a variety of Urban/Semi-urban/Rural regions of India. e-Yantra has at least one college that has established e-Yantra labs in each of 25 States and Union Territories in India.

We believe various factors affect the engagement of colleges with e-Yantra finally leading to lab setup lab under this initiative. It is important to study these factors to know their impact. This will help any agency such as ours and stakeholders in education systems engaging with colleges and efforts may be taken in accordance with these factors to maximise the outcome. In this study we relate various factors in the engagement of e-Yantra Lab Setup Initiative with colleges to understand the driving factors for final lab setup and the impact of these factors. The factors that affect the participation of colleges can be related to various stages of participation of colleges in this initiative.

In this study, we relate the following factors to successful lab setup in colleges:

(i) College requests information mail

(ii) College attends workshop in Mumbai district (or elsewhere)

(iii) Quarter of the year in which a college attends a workshop

(iv) Feedback of workshop

We try to identify the relationship of these factors towards successful lab setup through applied statistical techniques such as Principal Component Analysis to identify minimal factors required to explain maximum variation in the success. We then use these factors to form a logistic regression model to discover the weights of these associations and the statistical significance of the factors [6].

II. Understanding Chosen Factors

In this study, we relate the stated factors to successful lab setup in colleges. Each of these factors, is associated with motivation level of colleges to engage in this initiative or is an indicator of the success of the engagement as explained below.

The first factor, whether a college requests an information mail provides an insight that a college is proactive in looking for improvement in its infrastructure. Thus, colleges that request an information mail may be assumed to have an interest in creating (sustainable) eco systems for engineering education [3]. e-Yantra then provides all the necessary details regarding the e-Yantra Lab Setup Initiative and invites college to attend a Two Day Workshop at a mutually suitable location. Note: Colleges can directly register for workshop, without requesting information mail.

The second factor is whether a college has attended a Two Day Workshop in Mumbai district. e-Yantra organizes workshops across India in different regions so that colleges in a region can easily participate in this initiative. However, it is difficult to organise workshops at several places at the same time Hence, for colleges whose regions are far from a workshop locus, we organise periodic workshops at Indian Institute of Technology Bombay in Mumbai district. Thus, colleges that are interested in participating in our initiative but cannot attend workshops in other regions as well as colleges in Mumbai district region, attend a workshop at Indian Institute of Technology Bombay (Mumbai district). Thus, a college attending a workshop in Mumbai district typically comes from far away locations in India. As per our e-Yantra Lab Setup Initiative model, the college bears the cost of travel and stay of the team of teachers. This commitment shows that a college is motivated to better the lot of its teachers, students and education at their campus.

The third factor is the Quarter of the year. This factor determines whether a particular time of year affects the chances of colleges successfully completing the lab setup process. Since at a particular time teachers may have relatively less academic commitments and this may encourage them to complete their training with full dedication. Also, college management may show more interests to setup a lab during specific durations when funds are available or are required to spent in a fiscal year.

The fourth factor is Workshop Feedback. A Two Day Workshop is the first face to face interaction of participants with e-Yantra. e-Yantra provides a free-of-cost hands-on training on "Introduction to Robotics" to teachers through these workshops. It is through these workshops that a college understands the benefits to their teachers and students upon participating in this initiative We believe this first interaction with a college significantly impacts the final setup of labs.

Thus, the first two factors discussed are related to self motivation of colleges to setup e-Yantra lab. This includes the request for information mail that shows motivation of college to gather information about initiatives. The other factor of the location of attending Two Day Workshop shows motivation of college and its teachers to make efforts to participate in such an initiative by investing both time and money (for travel to Mumbai).

The third factor, Quarter of year when college attends workshop relates to most suitable time for colleges to successfully complete the lab setup process. The fourth factor is an indicator of successful first face to face interaction of the hardware MOOC with the college.

Studies have suggested that for MOOCs and e-learning methods, the instructor's attitude, student's motivation and technical competency are Critical Success Factors for MOOC's acceptance [7][8]. Studies have also shown that the perception of a MOOC by a participant plays a major role in adaptation of MOOC [9]. We study these four factors to explore how self-motivation among colleges and the first interaction of a hardware MOOC impacts successful participation of colleges in a hardware MOOC.

III. Exploratory Data Analysis

We consider the sample data of **468** colleges across India that participated in this initiative during May 2017 to March 2019. Of these, **101** colleges finally established a lab. In this section, we study descriptive statistics of various factors for the sample data.

A. *Information Mail Requests*

Fig. 2 below suggests that approximately 20% of colleges requested an information mail and 27% of such colleges successfully established lab (i.e. 5.4% of 101 applicants who set up labs also sent an initial request for information by mail).

This means that a college expressing interest for information about a MOOC only over email may not necessarily show motivation for participating in lab setup, i.e. take email enquiries with a pinch of salt.

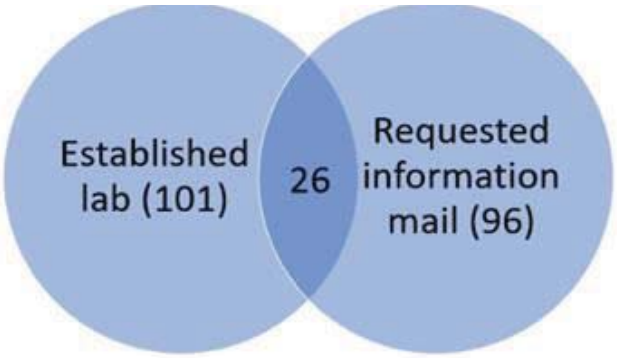

Fig. 1. Information mail requests statistics

B. *Workshop District*

e-Yantra conducted 40 workshops during May 2017 and March 2019. Out of these, 10 workshops were conducted in Mumbai District (at Indian Institute of Technology Bombay) and 30 at other Districts across India.

Fig. 2 suggests that approximately (89/468) 19% of colleges attended workshop in Mumbai district and (36/89) 40% of them successfully established lab. This means that if we motivate participants to come out of their comfort zone to engage with us - this is a good indicator of potential success.

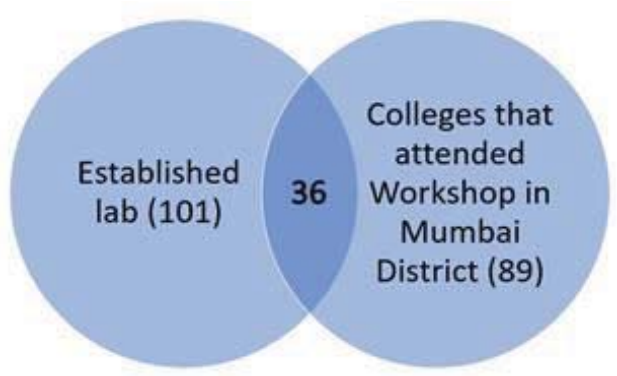

Fig. 2. Workshop District statistics

C. *Workshop Quarter Distribution*

Out of 40 workshops, 9 were conducted in Quarter 1 (Jan-Mar), 8 were conducted in Quarter 2 (April-June), 7 were conducted in Quarter 3 (July-Sep) and 16 were conducted in Quarter 4 (Oct-Dec).

Fig. 3 shows the trends of lab setup by colleges that attended workshop during each Quarter.

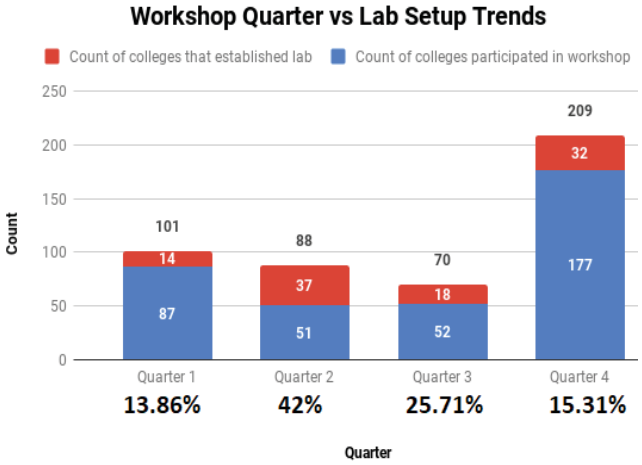

Fig. 3. Workshop Quarter vs Lab Setup Trends

As seen from Fig. 3, the percentage of lab setup of colleges attending workshop in Quarter 2 is the highest, followed by Quarter 3, Quarter 4, and lowest in Quarter 1. This indicates that teachers and college management are more motivated to participate in this initiative and complete the lab setup process in Quarter 2 and Quarter 3.

D. *Workshop Feedback Trends*

After each Two Day Workshop, anonymous feedback is taken from each participant. Out of various questions asked, we have considered responses to the following questions in this study:

(i) Was the content easy to understand?

(ii) Was the content relevant to academics?

(iii) Was the workshop interactive?

(iv) Were theory and practical sessions balanced?

(v) Would you recommend this workshop to others?

For each workshop, we created a workshop score of 15 with 3 points for each question.

Fig. 4. Workshop Score Trends

Fig. 4 is the graphical representation of workshop score for 40 workshops considered.

The trends of this score based on feedback from participants are:

Maximum: 13.732

Minimum: 11.735

Average: 12.829

IV. Principal Component Analysis

In this section we discuss the Principal Component Analysis carried for the various factors. Principal Component Analysis is a statistical technique to summarize data with a smaller number of variables and is useful in providing the information about the factors and variance in the data explained by them [10].

The Principal Component Analysis is carried out in "R Studio" software [11]. The data is first split into categorical and The square loadings for the factors are as shown in Table 1.

TABLE I. PCA Output

PCA Output	Squared loadings:				
	dim 1	***dim 2***	***dim 3***	***dim 4***	***dim 5***
Workshop Score	0.13	0.46	0	0.01	0.37
Workshop District	0.73	0.01	0	0	0
Workshop Quarter	0.58	0.65	0.91	0.26	0.4
Information mail request	0.12	0.06	0.09	0.68	0.02

For the Principal Component Analysis, maximum variance in the data is explained by the first dimension and factors with square loading of more than "0.5" can be considered as significant factors contributing to the dimension [10]. Thus, the results suggest that the major factors (or variables) that explain the maximum variance in the data are Workshop District and Workshop Quarter. Thus, whether a college attends a workshop in Mumbai district and the Quarter of the year when college attended the workshop is highly associated with the total variance in data, thus total variance in successfully establishing lab [12]. These factors are associated with motivation of the colleges to participate in this initiative by making extra efforts. Also the time of engagement with colleges during which teachers and management may be motivated to complete the lab setup process, as discussed in Section II.

V. Logistic Regression Model

The outcome of the process of e-Yantra Lab Setup Initiative is a binary, as a college can either successfully complete the process or not complete the process. Hence, to find the statistical significance of each of the factors discussed and to know their association with successful establishment of lab by a college, we use logistic regression. This develops a regression model to calculate how the factors are associated with "log odds" of the result [13].

In our study we develop a logistic regression model in "R Studio" with

(i) Request for Information Mail

(ii) Workshop District

(iii) Workshop Quarter

(iv) Workshop Score

as the input variables to know how they affect the final lab setup status.

The model result gives following estimates for coefficients for different factors:

TABLE II. Logistic Regression output

Coefficients:	**Estimate**
(Intercept)	-8.7683
Information mail requested (Yes)	0.415
Workshop District (non Mumbai district)	-1.4604
Workshop Score	0.5972
Quarter 2	1.4393
Quarter3	1.4586
Quarter **4**	0.5834

The statistical test of individual predictors results for statistical significance are shown in Table 3.

TABLE III. Z test for each predictor in logistic regression model

Coefficients:	**z value**	**p-value**
(Intercept)	-2.417	0.015645
Information mail requested (Yes)	1.269	0.204337
Workshop District (non Mumbai district)	-3.888	0.000101
Workshop Score	2.108	0.035033
Quarter 2	3.284	0.001023
Quarter3	2.937	0.003311
Quarter 4	1.361	0.173652

The results suggest that the most statistically significant factor is Workshop District and the negative sign with the estimate of coefficient with Workshop District (non Mumbai district) indicates that the log odds of a college establishing a lab decreases for colleges attending a workshop at other Districts (perhaps close to home) as compared to colleges that attend Workshop in Mumbai district. In other words, colleges attending workshops in Mumbai district have higher log odds of establishing lab as compared to colleges attending workshops at other Districts. The estimate of coefficient of Quarter suggests that the log odds also increase with a college that attends the workshop in Quarter 2 and Quarter 3. The log odds also increase with Workshop Score, that is, with positive feedback for workshop as indicated by the estimate of corresponding coefficient. As the p-value for the variable "Information mail requested (Yes)" (a college requested for information mail) does not appear to be statistically significant, it suggests that the data is insufficient to measure the impact of this factor or the factor does not have enough evidence statistically to prove impact.

The confusion matrix (classification table) for the developed model at cutoff point of 0.5 is as follows:

TABLE IV. OBSERVED AND PREDICTED LAB INAUGURATION STATUS BY LOGISTIC REGRESSION

Observation (Lab Inauguration)	**Prediction (Lab Inauguration)**		
		No	***Yes***
	No	257	55
	Yes	18	21

This gives an accuracy of 79.2%, Sensitivity of 93.45%, Specificity of 27.63% and precision of 92.44%. This validates good predictions by the model [14].

Fig. 5 below shows the ROC (Receiver Operating Characteristics) curve for the model.

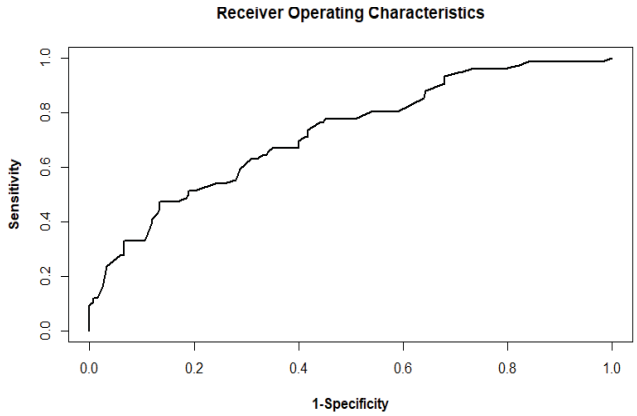

Fig. 5. ROC (Receiver Operating Characteristics) curve

Receiver Operating Characteristics (ROC) curves are typically used for visualizing the performance of classifiers. The Area Under ROC Curve (AUC) is a single scalar value representation of the performance. For the logistic regression model developed, the ROC curve has Area Under ROC Curve of 0.7255. The Area Under ROC Curve being greater than "0.5" confirms that the predictions have not been obtained as a random guess and that the predictions obtained are statistically significant [15].

VI. CONCLUSION

As observed from the Principal Component Analysis and Logistic Regression Model, the Workshop District, Workshop Quarter and Workshop Score are the statistically significant factors that are associated with the successful setup of lab at a college.

These factors indicate the willingness of making efforts to attend workshop, measure of feedback of a workshop and the time of the year when colleges are more likely to complete process. The study shows that self-motivated colleges and those willing to take more efforts to make a first face-to-face interaction are more likely to successfully participate in hardware based MOOCs. In our case, colleges from distant locations taking efforts to attend a workshop in Mumbai are more likely to successfully establish a lab as opposed to colleges that attend workshop at a local location.

The estimate of the coefficient of Workshop Feedback shows that the first face to face interaction (workshop in our case) plays a major role in successful participation of a college in the hardware MOOC. So, the MOOC should make this first interaction meaningful such that colleges find the MOOC beneficial and make the interaction most fruitful.

The estimate of the coefficient of Workshop Quarter shows that the time of first interaction of MOOC (2nd and 3rd quarter in our case) is associated with successful participation of a college. Thus, MOOCs should strategize to plan engagements with colleges at a period that is more suitable to colleges as colleges show more dedication in completing the MOOC establishment process in that period.

In summary, our study shows that it is important for a hardware MOOC to identify a group of motivated colleges, and make an effective first pitch to them at a suitable time (Quarter 2 and Quarter 3) to expect maximum motivation of colleges in the MOOC establishment process and maximize their participation in the hardware MOOC.

The study was carried out for 468 colleges spread across India. These colleges come from a diverse socio-economic and cultural backgrounds. Hence, the study should serve as a guide to any agency that is interested in setting up infrastructure for MOOCs and in general, engage with colleges and teachers.

Apart from the factors considered in this study, other factors such as academic rankings of institutions, age, location (urban/semi-urban/rural), academic reputation and other factors may be incorporated into future studies for a more detailed

analysis of participation of colleges in hardware MOOCs to build the required infrastructure.

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