# Low Cost Tablets as disruptive educational innovation: Modeling its diffusion within Indian K12 system

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*Abstract*-The world of today is not looking for innovations that are mere incremental but those that are disruptive. Aakash, the Low Cost Tablet (LCT) initiative by Indian govt. was launched in 2011 amidst dominance by the likes of Apple, Amazon, and Samsung etc. Single most objective of this initiative was affordable ICT learning tool for the 220+ million students. LCT like Aakash can be seen as a disruptive innovation from the as they are simple to use, cheap, low performing, targeted at low portion of mainstream market and focused on social sectors like education, health to increase access and equity. Within Rogers theory of Diffusion of Innovation, we propose a framework for innovation attributes that can significantly predict student and teacher behavior intentions and motivations towards LCT for use in classrooms. Authors investigate the innovation attributes for adoption of LCT in a social group comprising of (N=121) potential-adopter students and teachers from India. The results revealed that motivations for adopting LCT are strongly associated with innovation attributes like relative advantage, compatibility, ease of use, peer influence, perceived enjoyment and perceived usefulness. Overall, both teachers and students expressed positive attitude towards using LCT as it enhanced their digital literacy skills. Bigger question is to identify what kind of new teacher training program, models and approaches and learning environment are required for successful adoption of educational innovation like LCT. Findings contribute to the design of new pedagogical models that maximizes learning potential of LCTs for K12 education.

*Keywords—Innovation; Diffusion; Tablet; K12; Disruptive; ICT*

## I. INTRODUCTION

The world of today is not looking for innovations that are mere incremental but those that are disruptive. Innovating with limited resources is spreading across the business world [1]. The dynamics of disruption are recurrent in computing industry. The evolution of computing platform paradigms is a textbook example of disruptive technologies taking over established technologies [2]. Disruptive innovation challenges those very elements that are usually stable during a simple optimization process. Elements include business models, values, functions, user patterns, competencies and skills, product and service architecture etc. [3].

Low Cost Tablets (LCTs) can be seen as a disruptive innovation from the context of both [4] and [5] as they are simple to use, cheap, low performing, targeted at low portion of mainstream market and focused on social sectors like education, health to increase access and equity. [2] Say that LCTs display two key characteristics which fit them in Christensen's disruptive framework. First, tablets are cheaper than portable computers and second, tablets are underperforming relative to portable computers in the two key productivity-related performance dimensions: computing power and storage space. [6] Suggest that tablets with its advanced attributes would disrupt current learning environment resulting in higher learning outcomes. LCTs are looked as possible frugal solution, and they can help in democratization of technology and help in state-building [7].

LCTs have gained more importance in education and more so in the developing part of the world where affordability is key determinant in technology adoption. There are number of studies which empirically prove benefits of LCTs. [8] in their study show that the use of tablet PCs in e-learning 1) enables concentration on the content, 2) reduces the extraneous cognitive load imposed by making annotations, 3) increases learners' comprehension and memory retention, and 4) enables efficient note-taking, thus increasing the accuracy of notes as learning aids. [9] Work on impact of LCTs on English comprehension has mixed experiences. It suggests that introduction of Android tablets in the classroom did not have a significant negative impact on sixth-graders' reading comprehension. While [10] in their work suggest that iPad (a high end table) was successfully integrated into students' life as an assistive technology. Interesting thing to note about the research was it was conducted on students with reading difficulties. This clearly means that tablets and LCTs in particular have positive effect on learning outcomes.

Table computers are – a lightweight, highly portable device with an unmistakable architecture: a single panel covered by a touch screen which serves as its main input device. Although similar to smart phones in concept and design, tablets are

substantially larger, with screen sizes varying from 5 to 10.1 inches and weighing from 0.18 to 1.0 kilograms. Moreover, tablets pack more computing power and storage capacity than smart phones but still lag behind full-fledged notebooks [2].

The tablet computer and the associated special operating software is an example of pen computing technology, and thus the development of tablets has deep historical roots. The first patent for a system that recognized handwritten characters by analyzing the handwriting motion was granted in 1915. The first publicly demonstrated system using a tablet and handwriting text recognition instead of a keyboard for working with a modern digital computer dates to 1956. Since then there have been numerous attempts at making various kind of devises which can be today categorized as table. The tablet computer market was reinvigorated by Apple through the introduction of the iPad device in 2010. Since then table market has seen rapid growth and expansion. The Ministry of Education in South Korea planned to introduce tablet PC in primary schools by 2014 and expand it to secondary and high schools by 2015 [11].

The importance of using portable and table devises started in developed countries and has rapidly reached developing countries. Governments in developing countries have understood the power of these devises and have started working on ways in which how it can be made accessible to large audiences. Indian government through its launch of 'Aakash' table has led the way. Aakash is the name given to the LCT being procured by the Indian government to help enhance the quality of education. It is envisioned that computing and internet access used in a blended learning environment will empower both students and teachers. The Indian government has laid out a vision to equip all 220 million students across the country over the next few years with such products. First launched in 2011, it's 'jaw dropping' price garnered global attention and helped spur the low cost tablet computer industry. For supply to students, the government not only waives duties and taxes, but also further subsidizes the cost by 50%. Since then Aakash has at least undergone three revisions. Aakash not only came as a frugal innovation, it gave aspiration to the nation to lead in low cost frugal innovation. [12] argue that Aakash has gone beyond being a technology artifact to a device that represents Indian aspirations at several levels -- as a forward thinking state, an ingenious entrepreneurial class, and an energetic population that needs nothing but access to technology to succeed. A research was conducted in the area of Den Bosch, Netherlands to understand the adoption and acceptance of tablet PCs of primary schools. Six schools were selected in the area. The size of the schools varied from 195 students to 700 students per school. It was found that the students have a positive attitude towards using tablet PC for education. In addition it was also found that perceived usefulness; perceived ease of use, and independency influenced the students' attitude [12]. In a separate study in an Austrian university, it was found that

98% of 98% of the students and 64% of the faculty respondents felt that the tablet devices helped the students improve the quality of their work significantly [13].

According to [14] modeling the diffusion of disruptive innovation is a difficult thing since they serve multiple existing and new market segments. If we were to model the performance trajectories of different type of computers, we might get a graph as shown in Fig. 1. Even today the speed of desktops, laptops, tablet pc is far higher than LCT satisfying the performance needs of high end customers.
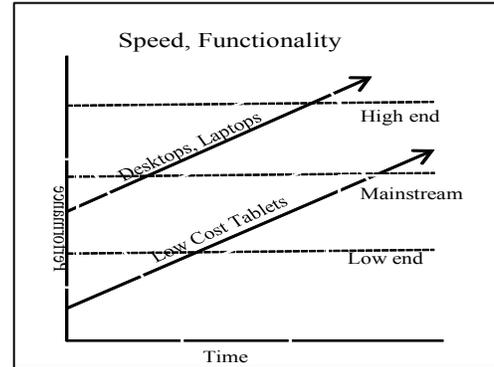


Fig. 1. Performance Trajectories

But the substantial low cost of ownership and ease of use of LCT is allowing them to establish their own market linkages with the low end customers and even becoming attractive to main stream and high end customers. (Fig. 2.)
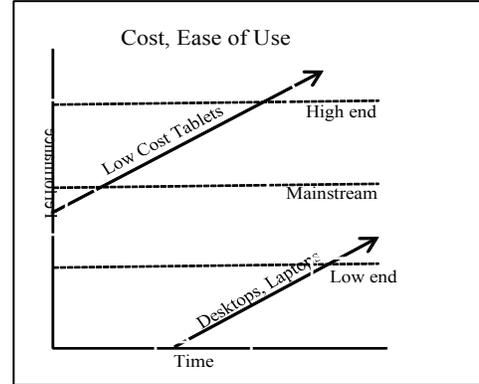


Fig. 2. Performance Trajectories

II. DIFFUSION OF EDUCATIONAL INNOVATION

[15] Defines innovation as a 'new product, a new production technology, a new material, or a new organization structure'. A number of educational researchers have argued that [16] Theory of Diffusion of Innovations is an effective way to examine the adoption of innovations by schools and teachers [17, 18]. According to [16] Innovation is 'an idea, practice, or object that is perceived as new by an individual or other unit of adoption'. According to [19] the rate of diffusion of

innovations forms an S-curve which represents cumulative distribution of potential adopters. During the initial stages when there are few adopters, the distribution rises slowly but then accelerates to a peak value until half of the potential adopters in the system have adopted. Thereafter the rate of adoption increases at a slower pace until the remaining potential adopters have adopted.

Regarding diffusion of technology in education and how teachers and students have been impacted a large body of research has been published. According to [20] promoting adoption of technology in classrooms by school leadership has tremendous positive influence on the teachers to adopt. Using technology in classroom is directly affected by teachers own beliefs and attitude towards computers [21]. In a study by [22] it was found that male students were comfortable and confident in using technology than female students but both had positive beliefs about the value of technology in classrooms. The ease of use of technology innovation is a very important factor for teachers to integrate technology into classrooms according to [23].

### III. CASE STUDY: FACTORS AFFECTING DIFFUSION OF LCT

Using seven innovation attributes, we modeled the rate of adoption of LCT. (Fig. 3). The characteristics of innovations and their influences that affect the rate of adoption include relative advantage (how an innovation is perceived to be greater than its predecessor); compatibility (the degree to which the innovation is compatible with existing values, the horizon of experiences and the needs of the adopters); complexity (the degree to which the innovation is easy to use or considered useful); trial-ability (how much the innovation can be experimented with); observability (the level of an innovation's results that are observable to others)



**Innovation Characteristics**

Relative Advantage (+)
Compatibility (+)
Ease of Use (+)
Trialability (+)
Observability (+)
Peer Influence (+)
Perceived Enjoyment (+)
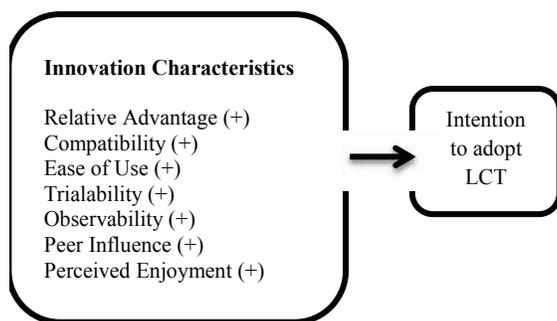
Intention to adopt LCT

Fig. 3. Research model for diffusion of LCT among students and teachers

We hypothesize that Relative advantage, Compatibility, Ease of Use, Trial-ability, Observability, Perceived Enjoyment, Peer influence positively affects teachers and student intention to adopt LCT. Perceived relative advantage of the LCT were validated by asking such as "If the LCT

made them more efficient", "Did it make it easier for the teacher and students to interact?". The compatibility of LCT with related items like Desktops and Laptops is evaluated by considering both teachers' and students' existing values, past experiences, and needs. Teachers and students who perceive LCT to be a useful item in classrooms will find it compatible and be more eager to adopt it. Complexity questions were phrased as, "Will LCT require more time to learn and use? If there ways, teachers and students can try and play with the LCT, then to that extent trial-ability aspect of LCT becomes attractive which will more often lead to higher adoption rates. One way the potential adopter teachers and students will be positively influenced is when they are able to observe their peers using LCT.

We discuss the use of Amrita's STEM learning materials to study the pedagogical effectiveness of tablet enhanced learning, attitudes and preferences using different LCT. The findings from two major workshops and a teacher training camp using tablets for STEM learning are included in this section. The first study was held as part of Inspire Science held at Amrita University and high school students in grades XI and XII using tablets as part of a 5 day Inspire Camp.

In Inspire Science camp, a total of 90 students out of the 185 attending the camp were randomly selected for the studies. A short introduction to the study was given, followed by a hands-on session where each student had the opportunity to test and explore the system themselves on LCT. They were first administered the pre-lab questionnaire online. All students worked with STEM learning modules based on android tablets. They then answered the post lab questionnaire and the survey, both online. The study identifies various factors such as learning effectiveness, ease of use; scrolling through the screen, amount of information displayed and so on. A 5 point Likert-scaled questionnaire to gauge student perceptions of the ease-of-use and preferences for OLabs on LCT was conducted after the post-assessment. Similarly we also conducted a teacher workshop with 31 teachers in using LCT as a teaching tool in the classroom which included exploring OLabs on LCT.

### IV. RESULT ANALYSIS

In our study reliability of the attributes had values ranging from 0.69 to 0.82 for students and 0.68 to 0.84 for teachers which is in the acceptable range according to Tavakol. Regression analysis was conducted for all seven adoption variables on the dependent variable and hypothesis results calculated. (Table 1, 2). There is strong support for innovation attributes of LCT like relative advantage, compatibility, ease of use, peer influence and perceived enjoyment confirmed by both teachers and students. The regression equation for both teachers and students was statistically significant ($p < .0001$) and explained approximately 74% of the variation for students and 77% of the variation for teachers.

Table 1 Summary of Hypothesis results (teachers)

| Attributes | | t-value | Result |
|---|---|---|---|
| Relative Advantage* | H1 | 1.34 | Accepted |
| Compatibility* | H2 | 1.52 | Accepted |
| Ease of Use* | H3 | 1.54 | Accepted |
| Trial-ability | H4 | -0.94 | Rejected |
| Observability | H5 | -1.02 | Rejected |
| Peer Influence* | H6 | 2.19 | Accepted |
| Perceived Enjoyment* | H7 | 1.97 | Accepted |

Table 2 Summary of Hypothesis results (students)

| Attributes | | t-value | Result |
|---|---|---|---|
| Relative Advantage* | H1 | 3.26 | Accepted |
| Compatibility* | H2 | 2.89 | Accepted |
| Ease of Use* | H3 | 3.05 | Accepted |
| Trial-ability | H4 | 0.67 | Rejected |
| Observability | H5 | 0.76 | Rejected |
| Peer Influence* | H6 | 3.43 | Accepted |
| Perceived Enjoyment* | H7 | 2.06 | Accepted |

*$p < 0.0001$

### A. Ease of Use (students)

61% agreed that the LCT was easy to use, 85% said that they enjoyed the challenge of figuring out high-tech gadgets, 23% felt that using a tablet will require a lot of training and 53% said that they can figure out new high-tech products and services without help from others. (Fig. 4.)
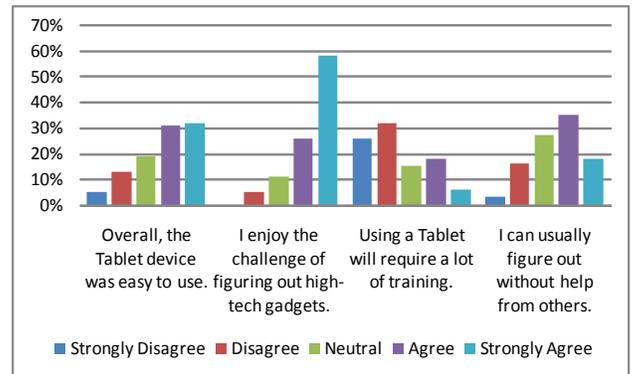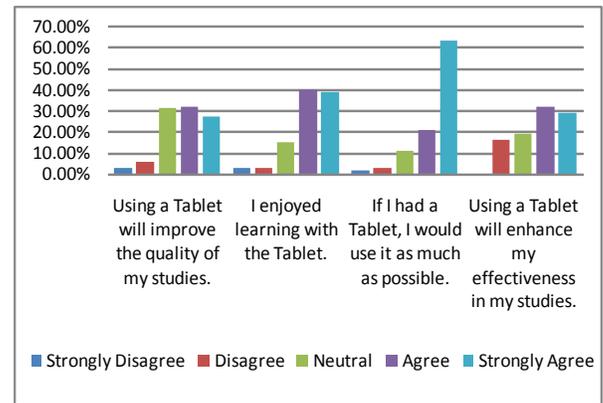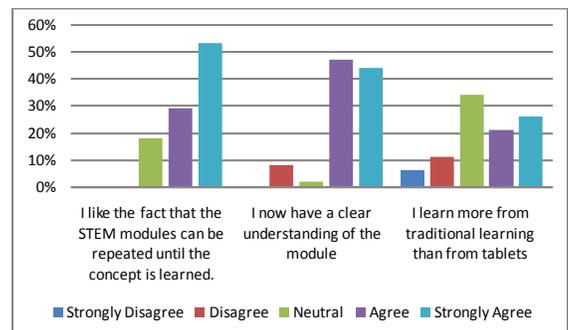
### B. Perceived Enjoyment & Value (Students)

79% agreed or strongly agreed that they enjoyed learning with the use of LCT, 60% that using a LCT will improve the quality of studies, 61% that using a LCT will enhance effectiveness in studies and 83% said that if they had a LCT they would use it as much as possible. (Fig. 5.)

### C. Pedagogical Value (teachers)

87% of the teachers agreed that STEM modules can be repeated until the concept is learned, 90% said that they have a clear understanding of the module and 45% felt that they learn more from traditional learning than from LCT.



**Fig. 4. Ease of Use (students)**



**Fig. 5. Perceived Enjoyment & Value (Students)**



**Fig. 6. Pedagogical Value (teachers)**

## V. CONCLUSION AND FUTURE WORK

The traditional class room educational system is unable to draw students to the classrooms; the drop-outs from rural schools are increasing. In such an environment the best possible option to attract students is to amalgamate education and technology to make it more personalized and engaging [24]. The induction of LCT into the field of education is one such disruptive innovation that has successfully attempted to increase the motivation levels of students towards learning. Researchers [25, 26, 27, 28] have found that tablet PCs are

very instrumental in increasing students' motivation to learn. Certain researchers [26, 29] have also highlighted few negative experiences related to features of the tablet PCs like short battery life and lack of screen brightness.

Vast research has been conducted to understand the impact of tablet PC on the students / teachers in the educational sector, but research on understanding the factors the influence the intent of adoption of LCT is limited. The present study has identified five innovation characteristics that influence the intent of adoption of LCT by students/ teachers. The implications from the study could assist technocrats in developing LCT that would satisfy the specified characteristics, thereby increasing the adoption of LCT. The present study is limited to the Indian sub-continent only. To increase the robustness of the results as well as to increase the generalizability of the findings further research needs to be conducted in other developing nations. A comparative study of a similar kind between the developed and developing nations could lead to deeper insights in terms of the intent of adoption. Further research can be undertaken to understand how students' societal background would impact the rate of diffusion of LCT.

### ACKNOWLEDGMENT

### REFERENCES

1. Rao, B C.(2013). " How disruptive is frugal". Technology in society. Vol 35. pp 65-73

2. Cortimiglia, M.N., et al. "Tablets: The Next Disruptive Computing Technology?," *IT Professional* , vol.15, no.3, pp.18,25, May-June 2013

3. Agogué, M., et al. (2014). An introduction to innovative design-Elements and applications of CK theory.

4. Adner R. (2002). When are technologies disruptive? A demand-based view of the emergence of competition. Strategic Management Journal 23(8): 667–688.

5. Christensen CM. (1997). The Innovator's Dilemma. Harvard Business School Press: Boston, MA.

6. Thinley, P. (2013). Tablets as Disruptive Interactive Learning Innovation in Teaching and Learning Environment. In . Jan Herrington et al. (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2013* (pp. 2315-2319).

7. Hanna Nari Kahle, et al. (2013) "The democratizing effects of frugal innovation: Implications for inclusive growth and state-building", Journal of Indian Business Research, Vol. 5 Iss: 4, pp.220 – 234

8. Ando, M.; Ueno, M., "Analysis of the Advantages of Using Tablet PC in e-Learning," *Advanced Learning Technologies (ICALT), 2010 IEEE 10th International Conference on* , vol., no., pp.122,124, 5-7 July 2010.

9. El-Mouelhy, I., et al.. (2013). Does a Creative Learning Medium Matter? Impact of Low Cost Android Tablets on Elementary Students' English Comprehension, Perceived Performance and Memory Retention. *Creative Education, 4,* 42-50

10. Gasparini, A. A., & Culén, A. L. (2012). Tablet PCs–An assistive technology for students with reading difficulties? The Fifth International Conference on Advances in Computer-Human Interactions (ACHI 2012), Valencia.

11. Ruyter, L.(2014). Using tablet PC for education? The adoption process of primary schools and children's acceptance.University of Twente, Netherlands

12. Mudliar P., and Pal J., (2013) ICTD in the popular press: media discourse around Aakash, the 'world's cheapest tablet'. In *Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers - Volume 1* (ICTD '13), Vol. 1. ACM, New York, NY, USA, 43-54.

*13.* Oberer, B., et al. (2014). Tablets as Primary Educational Computing Devices. An Impact Analysis on the Educational Landscape in an Austrian University. *Procedia - Social and Behavioral Sciences,* 116, 477-480

14. Linton, J. D. 2002. Forecasting the market diffusion of disruptive and discontinuous innovation. *Engineering Management, IEEE Transactions on,* 49**,** 365-374

15. Ozok, A. A., et al. (2008). A comparative study between tablet and laptop PCs: User satisfaction and preferences. International Journal of Human-Computer Interaction, 24, 329-352.

16. Schumpeter, J. A. 1934. *The Theory of Economic Development* Cambridge, Harvard University Press.

17. Rogers, E.M. 2003. Diffusion of Innovations (5th Ed) . New York. The Free Press (2003)

18. Sahin, I., & Thompson, A. (2006). Using Rogers' s theory to interpret instructional computer use by COE faculty. Journal of Research on Technology in Education, 39(1), 81-104

19. Yates, B. L. (2001). Applying diffusion theory: Adoption of media literacy programs in schools. Washington, DC Abayomi, B. and Jaspar, R. (2011). "Disruptive Innovations at the Bottom of the Pyramid".

20. Bass, F. M. 2004. A New Product Growth for Model Consumer Durables. *Management Science,* 50**,** 1825-1832.

21. Baylor, A., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology using classrooms? *Computers and Education*, *39*, 395-414.

22. Hsu, Y., et al. (2007). Factors influencing junior high school teachers' computer based instructional practices regarding their instructional evolution stages. *EducationalTechnology and Society, 10*(4), 118-130.

23. Pierce, R., et al. (2007). A scale for monitoring students' attitudes to learning mathematics with technology. Computers & Education, 48(2), 285–300.

24. Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. Journal of Information Technology for Teacher Education, 9(3), 319–342

25. Karmeshu., Raman, R. & Nedungadi, P. (2012). Modelling Diffusion of a Personalized Learning Framework. Educational Technology Research and Development, 60(4), 585-600.

26. Li, S., et al. (2010). Empowering student learning through tablet PCs: A case study. Education and Information Technologies, 15(3), 171-180.

27. Twining, P., et al (2005). Tablet PCs in schools: Case study report. Becta Research.

28. Nedungadi, P., et al. Enhanced STEM learning with Online Labs: Empirical study comparing physical labs, tablets and desktops, Frontiers in Education Conference, 2013 IEEE, pp.1585,1590, 23-26 Oct. 2013

29. Raman, R.; et al. The VLAB OER Experience: Modeling Potential-Adopter Student Acceptance, Education, IEEE Transactions on , vol.PP, no.99, pp.1,1

30. Ifenthaler, D., & Schweinbenz, V. (2013). The acceptance of tablet-PCs in classroom instruction: The teachers' perspectives. Computers in Human Behavior, 29(3), 525-534.