Solar Powered Digital Equipments for Distance Learning In Developing Countries

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ABSTRACT

Digital equipment and devices have become most essential tools for disseminating knowledge in educational institutions. The use of such equipment has now become more effective with the inclusion of contents available in the Internet. All of these tools and means have created a great opportunity for spreading teaching and learning in distance educational mode. But for a developing country, the main hindrances for spreading distance education are the cost of the equipment and availability of Internet access over all parts of the country. A research has been carried out on how the cost of useful digital gadgets and their accessories can be brought down to an affordable price and how the access to the Internet can be made easy for the students in general. This paper starts with the description of the challenges for reaching the objectives and then it explains how they are overcome by different indigenous technical solutions. Moreover, work on how the power requirement for the commonly used digital equipment has been minimized is reported in the paper. Finally it shows the techniques of applying solar power to supply the energy requirement for the gadgets to be used for distance learning. This has made a break through in education sector for a vast community in developing countries.

Keywords: *Multimedia classroom, hybrid projector, distance learning.*

INTRODUCTION

ICT refers to technologies that provide access to information through telecommunications (Selamat et. al., 2011). Uses of tools to integrate ICTs into everyday classroom learning provide students with increased exposure to technologies and e-content. The World Summit on the Information Society (WSIS) held in Geneva in 2003 identified two targets in its Plan of Action which are directly related to education (WSIS, 2003).

- to connect universities, colleges, secondary schools and primary schools with ICTs
- to adapt all primary and secondary school curricula to meet the challenges of the Information Society, taking into account national circumstances.

Although there has been quite a good penetration of cell phones and Internet access devices even in the rural areas in Bangladesh, there is almost no use of ICT and digital devices as a teaching and learning aid. Classrooms in Bangladesh usually use blackboards and text-books and very little has changed over the century in how the lecture is delivered. Teacher standing in front of the students delivers her lecture and use blackboards and chalk to explain the topic. The same is true for most of the developing countries in the world.

Multimedia projector projects documents and computer images onto a projection screen so that the image is displayed to an entire classroom. It can help teaching subjects, such as science or geography, easier by showing slides or video of actual hands-on experiments or maps. It allows the teacher to interact with the material along with the

students, or model her teaching in a way that effectively communicates the lesson to the students. The teaching materials can be developed by experts far away from the classroom and the teacher who is actually delivering the lesson can access it via Internet directly or download onto a USB device, which can then be inserted into the laptop and projected using the multimedia projector. But the lack of electricity in rural areas of developing countries has made its use expensive and difficult. Alternative sources of power are not feasible since digital projectors typically consume a lot of electricity.

This paper reports the design and development of a low cost, very low powered hybrid projector as a stand-alone or as a part to a laptop based teaching tool. The hybrid projector incorporates OHP technologies and is powered by solar PV panel so that it can be used at rural and remote locations having no electric power supply. Because of the low initial cost, long life, locally maintainability at low costs, ease of handling and the use of solar power to run the device, it would be very attractive for the developing countries as a classroom teaching tool.

Bangladesh Education Scenario

Bangladesh is the most densely populated country in the world with a population nearing 160 million. Demographically this is a young nation with population aged between 0-25 years covering almost 35% of the total population (Bangladesh Bureau of Statistics, 2012). This is reflected in the number of education institutions and the number of students and teachers. There are a total of 114,114 institutions with 30,752,756 students and 867,764 teachers in the country. Table 1(Bangladesh Bureau of Educational Information and Statistics, 2012) presents the details of the type of educational institution, number of students and number teacher along with the teacher-student ratio (TSR) in each category.

Table 1: Number of institution, student and teacher by type of education (2011)

Type of Education	No. of Institution	No. of Teacher	No. of Student	Teacher Student Ratio
Primary Education	78,685	395,281	16,957,894	43
School Education	19,070	223,555	7,510,218	34
College Education	3,475	95,620	2,915,851	30
Religious Education	9,330	107,177	2,197,877	21
Professional	282	4,752	70,998	15
Teacher Education	209	2,622	38,691	15
Technical-vocational	2,981	22,919	506,556	22
University	82	15,838	554,671	35

Being a developing country with a very low per capita income of 848 USD (Bangladesh Bureau of Statistics, 2012), Bangladesh is yet to provide quality education to all. Although the curriculum has been modified, particularly during the last decade, the classrooms are almost unchanged over the century. Students sit in benches facing the teacher while she delivers her lecture using chalk and blackboard and text books.

Recently, the government has taken up a project to establish multimedia classroom in schools (Minges et. al., 2011). Ministry of Education and Ministry of Primary and Mass Education are implementing the project under the Access to Information (A2I) Programme of Prime Minister's Office. Under the first phase of the project each of 23,000 primary and secondary schools will have a multimedia classroom at a cost of 1,800 USD within 2013. The classroom will have a laptop, a multimedia projector and Internet connection. A training program for teachers to develop content for the multimedia classroom is also part of the project. Considering the total number of primary and secondary school of 97,755 the first phase of the project covers about one third of the schools.

The biggest draw back of the project is that the multimedia classrooms depend on grid electricity to operate. The average power requirement for a multimedia classroom comprising of a computer and a projector is almost 300W. In Bangladesh, 28% of the population lives in urban areas (UNICEF, The State of the World's Children 2012: Children in an Urban World, 2012). All of the urban areas in Bangladesh have electricity supply. Till date, electricity has reached about 60% of the population of which 28% is represented by the urban population and 32% represented by rural population. That is, more than 55% of the rural population is without any electricity connection. Moreover, the

total generation is lacking behind the demand. The average load shedding in Bangladesh during the summer period is in excess of 10% of the demand. In 1 June 2012, the maximum generation was 5520 MW against a demand of 6500 MW (Bangladesh Power Development Board, 2012). The amount of load shed for the day was 980 MW, that is, 15% of the demand. The rural areas suffer the most due to load shed. Since the electricity demand in rural areas is far less than the urban areas, a 15% load shedding covers more than 30% of the rural area. As such, it is obvious that large number of rural schools that have electricity connection in fact do not have electricity due to load shedding. Without electricity multimedia classrooms will be useless. Also, the students in rural areas without electricity connection can never have access to the multimedia classroom.

The second draw back of the project is that the initial cost and maintenance of the system. As per costing of the project each set costs USD 1,800 per classroom which is quite high for Bangladesh. Without government help, very few schools can afford to have a multimedia classroom of their own. Maintenance of the projector is a big issue. Manufacturers provide a warranty of 1,000 hours for the projector bulb which is just about the average life of the bulb. Considering five lectures per day to be provided by the multimedia classroom in a secondary school (one for every class from class 6 to class 10), and 200 working days in a year, a projector will need to replace its bulb every year on an average. Replacing a bulb is very costly and so within one and half years schools having multimedia classroom will face financial burden.

Current Projector Technologies

Based on the mechanisms used to compose the image multimedia projectors can be broadly categorized into two technologies, digital light processing (DLP) or liquid crystal display (LCD). DLP technology uses an optical semiconductor, known as the digital micro-mirror device, or DMD chip to recreate source material. LCD projectors contain three separate LCD glass panels, one for red, green, and blue components of the image signal being transferred to the projector. As the light passes through the LCD panels, individual pixels can be opened to allow light to pass or closed to block the light. This activity modulates the light and produces the image that is projected onto the screen. Both of these technologies require complex driving circuits and their cost at this stage is prohibitive for the development of low cost multimedia projector.

The overhead projector (OHP) has been in use in classrooms across the world for almost half a century. The technology is simple, yet very effective. It has a light in the bottom with lenses and mirrors that project the image of a transparency placed on top of the projector box. The lamp is of high power and a cooling fan is necessary to prevent the lamp from melting from its own heat. Since the OHP cannot project image or video from a computer it fails to take the advantages of development and advancements of ICTs achieved during the last two decades.

In terms of power consumed, the DLP or three LCD based multimedia projector and the OHP are prohibitive for use in developing countries where access to electricity is yet to cross the halfway mark.

The Hybrid Projector

A. Initial design

The target was to develop a projector in such a way that the educational institutes both in urban and rural areas can use it. So, there are few points that we have to consider as design constraints. They are:

a) Low power consumption so that solar power can be used as source of energy.

b) The projector can be used both in overhead mode and multimedia mode so that if the laptop and/or Internet connection goes wrong it can be switched from multimedia mode to overhead mode.

c) The cost of the projector should be as low as possible so that an institution in rural areas can use it.

Based on the above assumptions, we took an overhead projector as a base of our development. First of all, we concentrated on the power consumption. We found that it uses two high power projection lamps which can be used alternately. The power consumption is 250W and it requires ac supply. Since our target was to use solar power as source of energy, we decided to replace with dc LED lamp having low power consumption. The only constraint in choosing LED lamp was the lumen equivalency. After many experiments, we decided for 12V, 32W conical type high durable LED lamp. After measuring the lumen output we found its equivalence with the original projection lamp. With the chosen lamp we run the OHP continuously for 12 hours and for several days, it did not caused any problem. Since we have to have provision for dual source, both ac and dc, we developed an adapter suitable for the lamp. There was a change over switch for making the source effective from ac to dc or vice versa.

The next step of the design was to convert the OHP into a multimedia projector. This portion was not as easy

as we thought. Our idea was to use an LCD screen on top of the overhead glass. But, finding a suitable LCD module was a difficult job for us. Since in Bangladesh stand alone LCD panel is not available, we started with removing screen from laptop and desktop monitors. We tried with panel from Lenovo and also from Dell pc/laptop. Initial experiments were failures because the LCD was not as transparent as expected. Finally we used LCD panel from Samsung desktop flat screen monitor. Its transparency level is much better than the previous ones.

With the LCD panel along with its control circuitry we fitted the assembly on top of the glass of the OHP. The video port is made exposed so that laptop can be connected. With the signals from the laptop the video output is transmitted to the LCD panel and since the panel is placed on top of the OHP, it is projected on the large screen. The content, whatever is displayed on the laptop screen, can now be projected in larger shape, fulfilling the requirement of multimedia projector.

B. Final design

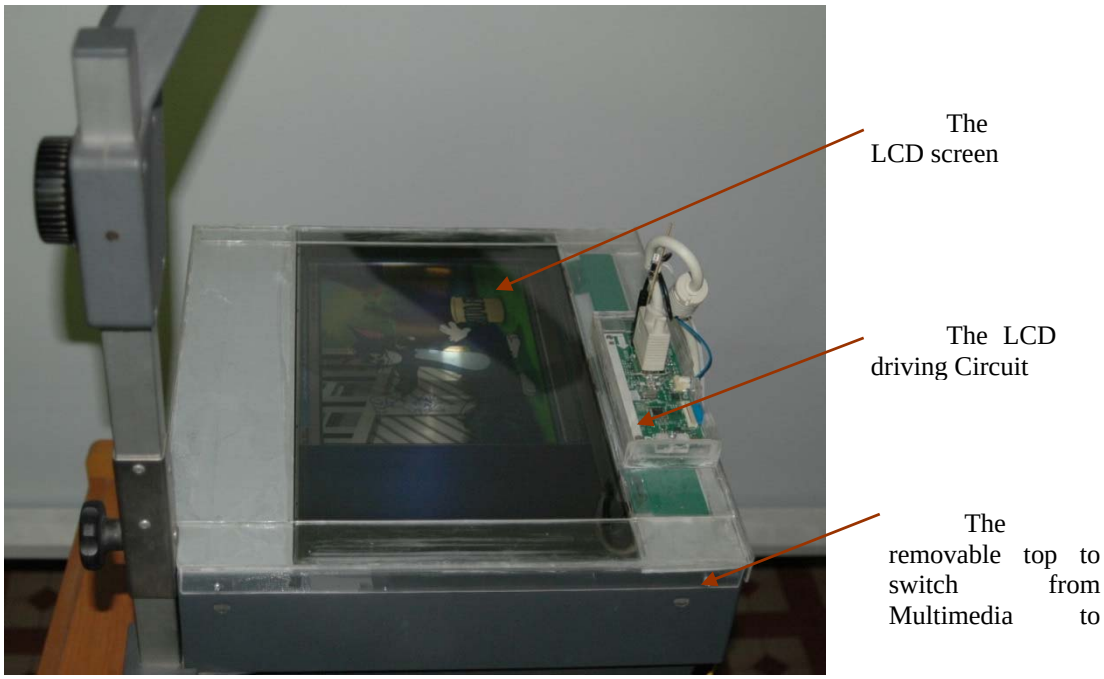

Figure 1: A prototype of the developed hybrid projector

The photograph of final prototype version of the hybrid projector is shown in Figure 1. As evident from the picture the projector is made by converting an Overhead Projector. A focused LED is used as the light source in the projector. Its consumption is measured to be 18W. The laptop used is a very tiny one having a power consumption of 44W only. In total the power requirement was 62W. The set was run using a 100W solar panel. The panel charges a battery under a charge controller and the battery supplies the requisite power for the laptop-projector set. The main modification is made by placing a LCD screen over the glass top of the OHP. The photograph shows also the placement of the video control circuit for the panel. For visibility, in prototype version, it is placed on top of the projector. But in commercial design it will be placed at one of its sides. The other important feature is visible from the photograph is that the top addition, i.e. the LCD panel assembly is detachable so that when it is removed the projector the unit can be used in its OHP mode. For example if the laptop is malfunctioning or the Internet connection can not be accessed, the multimedia mode of projection can not be used. As this hybrid projector can be used either of the modes, it can be switched from one to another.

C. Future developments

There are few issues that need to be addressed in future so as to convert the prototype version into commercial version. The total assembly of LCD panel and its controlling circuit should be manufactured by a LCD panel manufacturer suiting our requirement. First, the transparency level has to be high in comparison with that in the presently available LCD panel. Secondly the video control circuit should be robust and housed in a single assembly of the whole set up. Thirdly, the screen size should commensurate with the OHP's glass size. The other issues that need

to be addressed are: (a) Integration of solar charging system and battery within the OHP. (b) Choice of LED lamp and its changing provision and (c) robustness of the detachable part of the LCD assembly.

Cost Comparison

The development cost of the final design of hybrid projector system including the laptop, solar PV panel and battery with components procured from the local market is about 600 USD. Compared to the cost of the multimedia projector system currently being supplied to the schools under the aforementioned government project, excluding teacher's training, the cost of the developed system is less than 50% of that of the project. The battery may need to be replaced once in every three years. Almost no lamp replacement will be required for the developed system. Whereas, during the same period of time, the conventional multimedia projector will require 2 to 3 times lamp replacement costing on the average 125 USD per replacement. Considering all the facts stated, the "multimedia classroom project" cost, if our developed system was used, would be USD 13.8 million, whereas the present project cost is USD 28.4 million. It means that there would be a clear saving of USD 14.6 million.

CONCLUSIONS

A hybrid projector powered by solar PV panel is conceptualized and developed in the laboratory. A prototype version of the projection system has been experimented both in OHP and multimedia mode of projection. Starting from the concept up to its prototyping, step by step development process has been elaborated. The projection system has been proved to be satisfactory in either of the modes. The solar PV system is also tested in average condition of sunlight. Its use has proved to be satisfactory.

Finally, a cost comparison is made between the hybrid and conventional multimedia projector system for use in multimedia classrooms. It is shown that hybrid system will not only provide convenience to all kind of use but also it is cheaper than the conventional multimedia projector. Moreover, being solar powered, it saves energy and ensures availability of power to schools that do not have an electricity connection or suffers frequent load shedding.

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REFERENCES

Selamat, Z., Jaffar, N., & Kadir, H. A. (2011) ICT Adoption in Malaysian SMEs in *Proc. of International Conference on Management and Service Science* (vol.8, pp. 135-139), Singapore.

WSIS. (2003) World Summit on the Information Society Plan of Action.

Bangladesh Bureau of Statistics. (2012). available online at www.bbs.gov.bd.

Bangladesh Bureau of Educational Information and Statistics. (2012). available online at www.banbeis.gov.bd.

Minges, M., Raihan, A., & Raina R. (2011) *Bangladesh Access to Information Programme (A2I) Evaluation Report*.

UNICEF. (2012). The State of the World's Children 2012: Children in an Urban World.

Bangladesh Power Development Board. (2012). available online at www.bpdb.gov.bd.