Development of Optics Kit for Schools in Developing Countries – International School of Photonics Model

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ABSTRACT

In India, the pedagogy of science education is "believe what text book says". Providing schools with appropriate teaching materials to enhance teaching has always been a challenge in a developing country like India. Generally it is not possible for a normal school in India to afford the expensive teaching materials to teach through demonstrations and experiments. Thus students are forced to believe what text book says rather than learning concepts through experiments. The International School of Photonics SPIE (International Society for Optical Engineering) student chapter came up with 'Optics kit' to supplement the teaching of optics in school level. 'Optics kit', developed with indigenously procured components, could be sold at an affordable prize for an average Indian School. The chapter is currently selling the kit for less than $20. The content of the kit is at par with many kits already available commercially in developed countries, and the price is just 10% compared to those kits.

The kit is aimed to higher secondary level students in India, where students are taught Ray optics and basics of Wave Optics. The content of the kit is developed based on this syllabus. The Optics Kit contains simple optical elements like lens, grating, polarizer, mirror, diode laser etc. The kit can be used to demonstrate optics phenomena like interference, diffraction, polarization etc.

The kit was developed based on the feedback gathered by the chapter through its outreach activities. The syllabus for the kit was developed through thorough discussion with educational experts in the field of Physics. The student community welcomed the optics kit with overwhelming enthusiasm and hence the project proved to be successful in giving an opportunity for students to "See and Believe" what they are learning.

KEY WORDS

Optics Education, Optics kit, Hand on Optics

INTRODUCTION

Education plays an important factor in the economic development of a country[1]. On the other hand it is difficult for economically backward country to provide sufficient infrastructure to improve the quality of education. Effect of this contradiction is evident in the quality of education that can be offered by developing countries through its government aided school, especially in the case of science education. Science education demands proper laboratory facilities for the students to perform experiments and develop analytical thinking rather than learning abstract ideas given in text books.

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Last two decades witnessed tremendous growth in the field of Optical and Photonics and its application to various fields like communication, healthcare, environmental studies, astronomy, energy harvesting etc. In India, the physics syllabus in schools follows traditional contents. The traditional content does not emphasize the import of optics in today's technology arena. Students are not aware of the development of science and technology in various fields and corresponding state of the art. Considering the economic situation of the state, it will take long time to bridge this gap and bring the education into right track.

A quick and partial solution is to seek a parallel approach. This is the reason why various organizations like International Society of Optical Engineers (SPIE)[2], Optical Society of America (OSA), United Nations Educational, Scientific and Cultural Organization (UNESCO)[3] encourages optics outreach activities in developing countries.

International School of Photonics SPIE (ISP-SPIE) student chapter in collaboration with OSA student chapter ventured the development of a simple, cost effective optics kit in order to develop interest in optics to school students. The idea is still in a developing stage. The first version of the prototype was launched in February 2008 and the second version with many modifications was launched in November 2008. This paper mainly focuses on the approach we adopted for developing this Optics Kit.

1. BACKGROUND

ISP-SPIE student chapter has been involved in optics outreach activities since the year 2005. The student chapter organized events like "Optics to School", "Optics Fair" etc. which all aimed to address a large group of students in a couple of days. The one day "Optics to School" program caters on an average 200 students. The massive optics outreach program which is being conducted once in a year caters more than 1400 students every year. These programs mainly involved hands on experience with simple optics experiments. The responses to these events were overwhelming and the feedback showed that students had a different learning experience, which was different from their regular learning experience in schools.

In high school[1], students learn only classical ray optics. Concepts of reflection, refraction on convex and concave mirror and lenses are taught. The laboratory experiments involve experiments with lenses and mirrors since these experiments are cost effective for schools to afford. In higher secondary level students learn the basic concept of Wave optics. Phenomena like interference, diffraction, polarization are introduced to students at this level. Traditionally it is difficult to set up classical experiments like Young's double slit experiment with broad band sources. Because of these, such experiments are performed only at college levels. In higher secondary level, students are forced to learn these phenomena as abstract ideas rather than performing experiments and getting convinced themselves.

The availability of cheap laser sources opens new opportunities to set up many optics experiments in a simple and cost effective way. Experiments to demonstrate interference, diffraction etc. can be set up easily using a cheap laser pointer which is available for less than half dollar in India. We tried to harness this opportunity to bridge the lack of experimental facilities to demonstrate concepts of wave optics in higher secondary school level by developing this optics kit which will act as a supplement to the current syllabus. The causes that lead to the beginning of this project is shown in figure 1.

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[1] In Indian educational system, school education is for 12 years. 8^{th} standard to 10^{th} standard is referred as High school and 11^{th} and 12^{th} standard are referred as Higher secondary

2. DESIGN CONSIDERATIONS

At present there are similar optics kits available commercially in developed countries. But the costs of these kits are very high to be afforded by schools in India. Hence the main design consideration was to make the final product as much cost effective as possible without compromising much on the content of the kit. The feedback from the outreach activities gave a right solution for this challenge. It is not the number of components or number of experiments which is included in the kit that matters but it is the knowledge content of the kit that matters. Hence we adopted our basic approach as to choose the right set of experiments which can give maximum concept to students.

The cost of the kit had to be kept around 800 Indian Rupees (<20$) so that it will be easily affordable for schools. This price is affordable for individual students as well who are interested to explore the beauty of optics by themselves. Since this kit is also intended to be used by teachers for classroom demonstrations, we choose to include the conventional experiments in the kit. This gives the advantage that teachers can use this kit as a teaching aid without any special training.

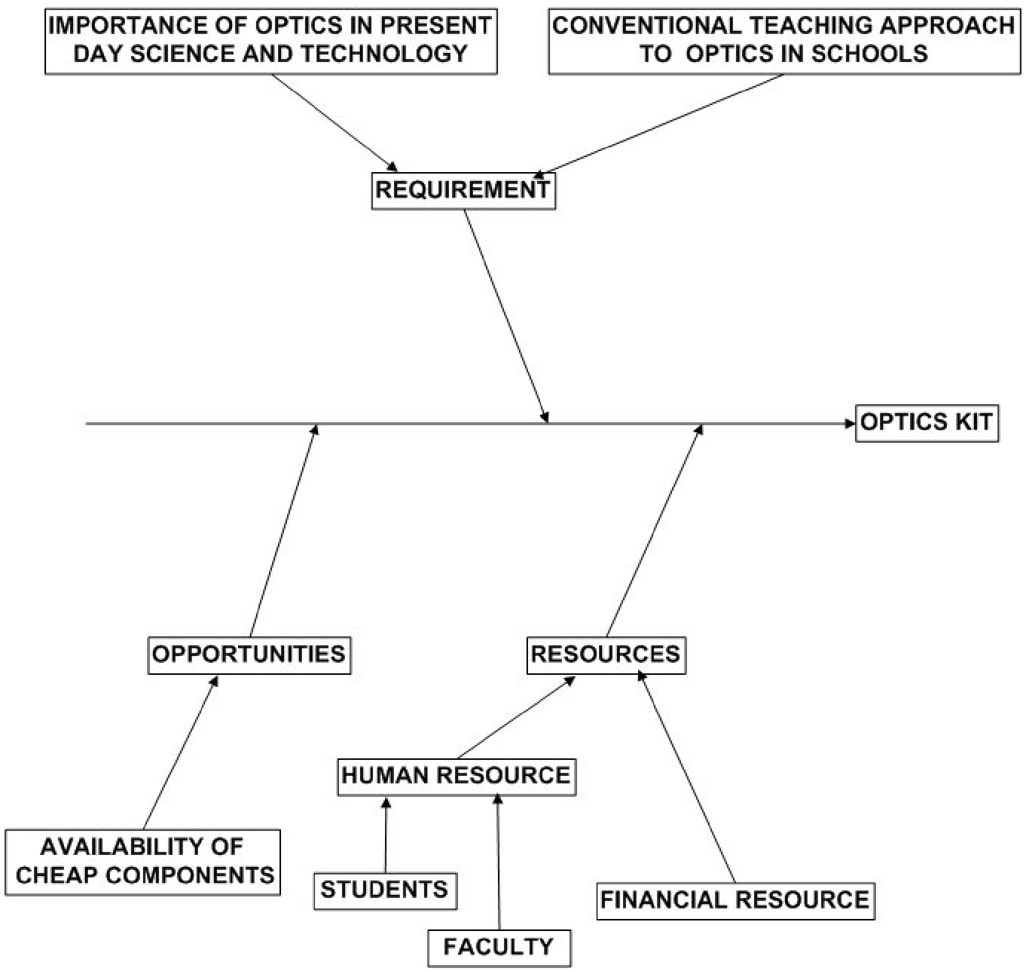

Figure 1: Cause effect diagram showing the background of optics kit development project

3. RESOURCES

ISP – SPIE student chapter comprises of 50 student members. The group comprises of research scholars, undergraduate students who are studying course in Photonics and faculty members. This provided sufficient human resource to take this project forward. The financial needs were met by the 1300$ provided by SPIE as an outreach grant for the development of optics kit. This grant was obtained for the developing a cost effective optics kit and publicizing it.

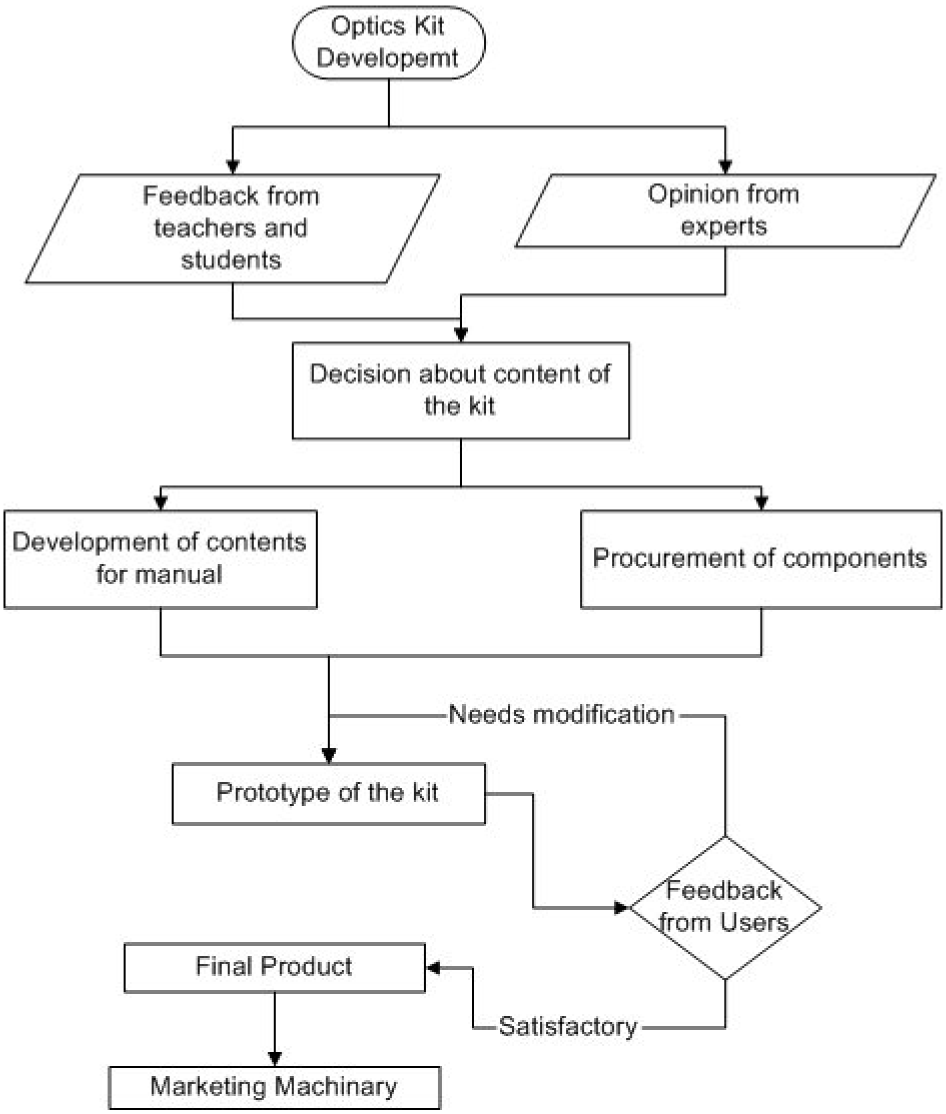

Figure 2: Implementation of Optics kit project

4. IMPLEMENTATION

The route map for the project was made based on the feedback received from teachers and students during the optics outreach activities. Second stage involved discussion with experts to decide about the content to be included in the kit. Discussions with experts in the field of education and optics gave clear guidance regarding the goal to be achieved by such a project.

From these feedbacks and discussions it was decided that as a starting, it is better to include classical experiments in the kit which explains concepts of interference, diffraction and polarization. Along with that

The most challenging part in this project was developing a manual for the kit and procuring components indigenously. The idea was to develop the kit in such a way that the components should readily be available so that the student member of the chapter themselves can assemble the kit and sell it to schools and individuals. The components were procured from local distributors and it was packaged in a compact manner. The students and faculty were involved in the development of the manual for this kit. On the second beta version the content of this manual is complete but it needs refinement to ensure that students get maximum out of this kit. The implementation pathway is shown in figure 2. As of now there is no proper machinery for marketing the product. This will be implemented once the product is ready for commercial marketing.

5. CONTENTS

The contents of the optics kit are listed below

- Laser pointer
- Single Slit
- Double slit
- A pair of Polaroids
- Mirror
- Lenses
- Rope and slits to explain polarization
- Microscopic slide with cello tape to demonstrate photoelasticity
- Diffraction Grating
- Diffractive optics Element
- Manual
- SPIE DVD – “Light at work”
- SPIE CD – “Careers in Optics”

All the components except diffractive optics elements were procured from local suppliers. The diffractive optics element was provided by SPIE. Figure 3 shows the photo of the final packaging of the second beta version of the kit. The SPIE DVD and CD included in the kit gives students a feel about the state of the art in the field at present, which is essential to attract the interest of students to the field of Optics and Photonics.

5.1 Manual

The content of the manual was compiled by a group of students in the chapter with the guidance of faculty advisor. The content was carefully designed to make it interesting for students who are using the kit. The introductory part of the manual has three sections. Manual starts with an introduction about Optics and Photonics, followed by a brief timeline about the development of the field of Optics. This section is followed by a brief note about how one can create interest in a field through anecdotes. This introductory part can create an interest for the user to go forward and try out the experiments involved in the kit.

Figure 3: (on left) Packaging of beta version 2.0 of the optics kit (on right) Optics Manual

Later part of the manual contains explanation of experiments. Each experiment aims at introducing the concept of a new phenomenon to student. The section starts with an introduction and background of the phenomena, followed by experiments that can be performed by students. The experiments are not meant to be for taking any quantitative analysis. Instead students can observe the phenomena and get a feel of it. At the same time the components are sufficient to extend the experiment that can be done with quantitative measurements.

6. Experiments

The experiments are designed to provide three types of learning experience to students. It invokes curiosity in students, it helps student to learn a new concept and some fun. Students are not meant to understand some involved concepts like photo-elasticity, diffractive optic elements etc. but it serves as a way to invoke curiosity in students.

6.1 Interference

This section aims at explaining the concept of wave nature of light through Young's double slit experiment. Interference fringes can be made using the double slit and laser pointer provided with the kit. The formation of the fringes will be counter intuitive for a student who has been learned only ray optics. This can be a nice way introduce wave nature of light to students.

Figure 4: Inside view of Optics kit

6.2 Diffraction

As an extension to the Young's double slit experiment single slit diffraction patter can be produced using the laser and the single slit provided with the kit. Also diffraction pattern from a diffraction grating can be demonstrated using the diffraction grating provided. The diffractive optics element can be used to make different patterns just to invoke more curiosity in students.

6.3 Polarization

The transverse nature of light can be shown using experiments related to Polarization. There is a pair of slits and rope to demonstrate the mechanical analogy of polarization. This concept can be extended and demonstrated using the Polaroid sheets provided with the kit. By keeping the microscopic slide, stuck with cello tape between the Polaroid sheets, demonstration of photo-elasticity can be performed to give more opportunity for fun for students.

Figure 5: Various components in Optics kit

6.4 Dispersion

This is a more involved experiment to create a prism using water and mirror in order to create rainbow. This experiment can be used to explain concept of dispersion, refractive index etc. to students.

7. CONCLUSION

The second beta version of the kit was launched in November 2008 during the Optics Fair conducted by the student chapter. The response from students and teachers towards the kit was positive. Hence the idea of developing a cost effective optics kit with simple components and simple experiments proved to be a big success. The authors could successfully demonstrate the feasibility of this model within the given financial and practical constraints. This is a generic model which can be applied for developing low cost study aids to supplement school education in developing countries.

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