Effectiveness of Computer Assisted Teaching of Geometrical Optics at Undergraduate Level

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ABSTRACT

Computer is an educational tool mostly used in designing and running experiments, exchange of information, visualization and so on. In class room the computers can be used to promote learning. This paper reports an effort of developing a computer base resource material using Microsoft Power Point named as PPRM. The PPRM contains sequences from everyday life, step by step diagram development; mathematical steps highlighted with different colour combinations, previous examination questions with solutions etc. This is expected to be an effective teaching aid. Primarily the development efforts are focused on Optics as a subject. Care has been taken to ensure all round development of students' visualization, understanding and retention. The paper describes the development aspects of the resource material and the educational research carried out to study its effectiveness in teaching.

Keywords: Optics teaching, Power Point, control group, experimental group, educational research

Introduction

'Optics' a branch of physics deals with abstract concepts and large number of ray diagrams. Lot of geometry and mathematics is required to support for understanding any optical concept or phenomena. Most of the teachers use 'chalk and talk' method to teach 'optics'. Students learn 'optics' by writing notes while teacher explains or writes on black board. Conventional method of teaching with the help of black board has some limitations to teach such abstract concepts. Students have to imagine more to grasp the concepts and dependent on rote learning. Especially in crowded classes with students strengths exceeds 50, such method poses several limitations. Teacher needs some teaching aid which helps in effective teaching of subject/ topic.

Goldberg and McDermott[1] study shows that students at university level do not understand basic issues with lenses. According to their observations, if a lens is positioned to create a real image of a bulb on screen students think in following ways:

- removing the lens will make the image right-side up
- the image does not lie on the screen
- covering half of a lens will block half of the image it creates.

Soloway[2] suggests the teacher has most important piece that makes learning occur. For better learning, it becomes necessary that the things should be clear at perception level and for better perception the object, things, events etc. should be sensed in as many ways as possible. Teaching aids help gaining information through multi sensory experiences. The perception is higher through seeing. Over the past few years there has been a strong world wide initiative to incorporate technology in delivery of instructions and to use it in teaching- learning process. The presence of computer offers a new opportunity to improve the quality of education. The paper reports the development aspects of the resource material and how effectively it used to teach 'Optics' in classroom. The effectiveness of developed resource material was tested by trying it out. The educational research carried out for this purpose is also described in the paper and findings are reported.

Content and Resource Material Development

The 'Geometrical Optics' and 'Optical Instruments' were the two topics from undergraduate physics curriculum were chosen to develop the resources.

Type of lenses, image formation by lens, aberration produced by lens and cardinal points are the main points covered in geometrical optics topic. While in optical Instruments eye pieces, microscope and telescopes are studied in details. Power point package is used to develop the two chapter's resource material. Sherry Turkle[3] asserts that, in hands of a master teacher, a power point presentation with few words and powerful images can serve as a jumping off point for a brilliant lecturer.

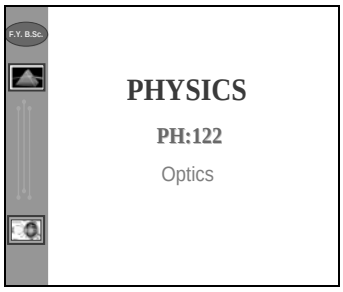
Procedure for Development the Resource

The development consist, collection of data, raw material and extra allied information which may be include in package. Step by step mechanism is used to develop the raw content. Power Point 2003 is used as base to develop the digital resource material. Power point features such as slide back ground colour, text selection, fonts with appropriate size, graphics, proper animation and transitions were consider to finalize the package. Maximum presentation golden rules were followed to increase the quality and usability of the package.

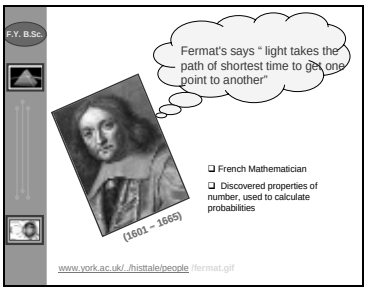
Total content were fixed into number of lectures. As per demand of content either textual or graphical, 40 to 50 slides were fixed per lecture. The slides can switch back and fourth with mouse click or touch arrow keys on the key board. As this is supporting resource package named as PPRM.

Figure 1 shows some developed slides.

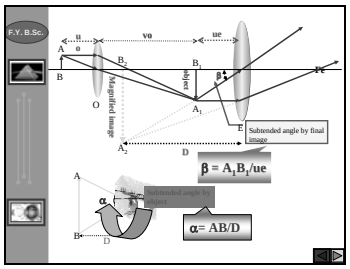
Title Screen



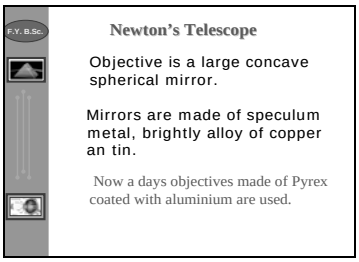
Scientist Photograph



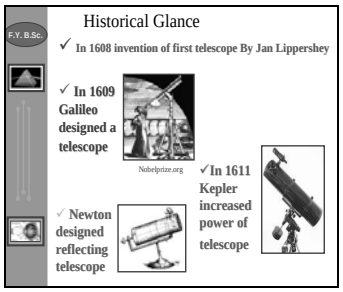
Ray Diagram



Text



Inventors and Innovations



Problems and Solutions

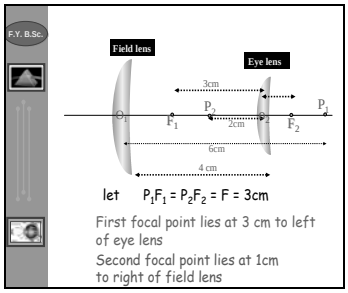


Figure 1. Summary of slide.

Educational Research

To test the effectiveness of PPRM, colleges were identified. These colleges were located in talukas places having rural background. These colleges were separated into two groups namely an experimental group and a control group. The developed package encompassed in compact disc (CD) which was handed over to experimental college subject teacher. With help of CD and computer assistance teacher cover the topics. The computer was attached to LCD projector and separate audio-visual hall was made available for this activity. The control group college students learned the same topics by conventional teaching method through their subject teacher.

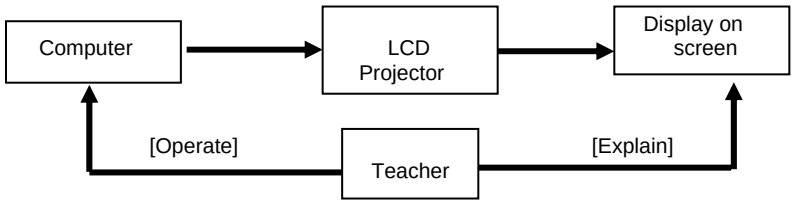


Figure 2. Mode of communication in computer assisted teaching.

Betterment in Understanding of Physics Concepts

This section gives a brief description of how experimental group gains over control group when sub topics 'aberration in images' and 'telescopes' from two chapters 'geometrical optics' and 'optical instruments' respectively taught with the help of the PPRM package.

1. "ABERRATIONS IN IMAGES" INCLUDES FOLLOWING POINTS

- Theoretical assumptions about the image formation by lens
- How these conditions are not satisfied practically in optical instruments such as telescope
- Defects in images discovered by Seidel
- Types of aberrations: spherical and chromatic, how to minimize these aberrations, circle of least confusion, lateral and longitudinal aberrations, achromatic doublet
- Other aberrations: Coma, astigmatism, curvature of field and distortion

The "aberration in images" is core topic of this chapter; conceptual clarity on this topic will defiantly students for better understanding of the remaining topics. Learner should get familiar with theoretical assumptions of image formation by lens or mirror, and practical difficulties. To minimize these aberrations different practical methods and theoretical methods (geometrical and mathematical treatment) are used. Students also get to know the dispersive power of material of lens and different equations used to calculate it. Students can solve the problems on design of aberration free instruments such as eyepieces or telescopes. Most of the textbooks cover this topic with only a few ray diagrams without use of colour which would have helped the students in the visualization, only text description is given along with mathematical derivations.

The PPRM covers the entire background of image formation and defects, using good visual images. The paraxial and marginal rays are shown in the ray diagram with different colours. With the help of animation, it is possible to show these rays focus on different places on axis and produce the images.

The spherical aberration takes place when the marginal and paraxial rays from object incident on converging lens get focus on different points on lens axis, produces a lateral spherical aberration in images. To observe this aberration if screen is placed on axis and moved towards the lens or vice versa the typical coloured circular rings are seen on it. Depending position of colour the various colour combination is observed on screen which is shown with the help of animation. The package covers different techniques used to minimize the spherical aberration. The photographs of aberration free lenses like crossed lens and Aplanatic lens are also included.

The chromatic aberration takes place when white light incident on a lens is dispersed in seven colours. The VIBGYOR pattern is observed on axis of lens. The dispersion of different colours can be seen with the help of animated ray diagram and their position on axis.

The other aberrations such coma, distortion etc. can be shown in animated form with their day to day examples with photographs .Thus the animated diagrams with different pleasant colour combinations and full with extra allied information which is not described in syllabus or text book is available to the students. Inclusion of Seidel's photograph with small biography may help student to get more information about his work they can get motivated. Problems and their solutions on dispersive power and previous examination question papers with solution and scheme of marking is also incorporated in this unit.

Compared to this teacher who uses conventional method has some limitations to cover and convey the same topic with help of black board. He can verbally tell the life history without a photo only if time permits. He may draw the marginal and paraxial rays and show the circle of least confusion at once. The ray diagrams to show coma, curvature of the field, distortion are so tedious and need high drawing skills that it is, not possible to draw these in regular classroom. It may consume more than 70% lecture time for this single activity. To clarify the chromatic aberration, if teacher takes extra effort for sketching the diagram using seven colour chalks on black board it may help student to understand the concept (normally such coloured chalks with true colours may not be available) , other wise students would have to just imagine the seven colours are dispersed through the lens and produced chromatic aberration.

2. TELESCOPE CONSISTS OF FOLLOWING POINTS:

- Historical development
- Astronomical Telescope
- Terrestrial Telescope

This topic covers the historical development of telescope and construction details of astronomical and terrestrial telescope.

PPRM covers the total historical development of telescope, showing inventors with their instruments and their period of development in details. It also shows marvelous photographs and brief information of today's worldwide telescopes and space telescope. Ray diagrams, working and mathematical analysis of astronomical, reflecting type telescope is included in detail. The problems on magnification and some previous questions with solutions are covered in a step by step method.

Traditional method has limitations; teacher verbally explains history and or shows some photos. This makes less impact as compared to the PPRM. Ray diagrams drawing on blackboard and making space available for analytical work is crucial job to teacher.

Computer assisted method helps the teachers to cover the topics in detail, as well as gives freedom to teacher to add extra information. Due to LCD facility last benchers can also view the details and teacher can repeat the content upto students' satisfaction.

Test Administration Procedure

To measure the performance of both groups achievement tests (pre, post and retention test) were conducted. These tests have multiple choice format and twenty-five questions were incorporated in each test. The pre test was conducted before teaching the syllabus. After completion of the syllabus, post and retention tests were conducted immediately and a gap of one month respectively. After more than one month gap same question papers were used for retention test. The marks obtained in all three tests by students were noted and used in further analysis.

Figure 3 is block diagram showing strategy of implementation.

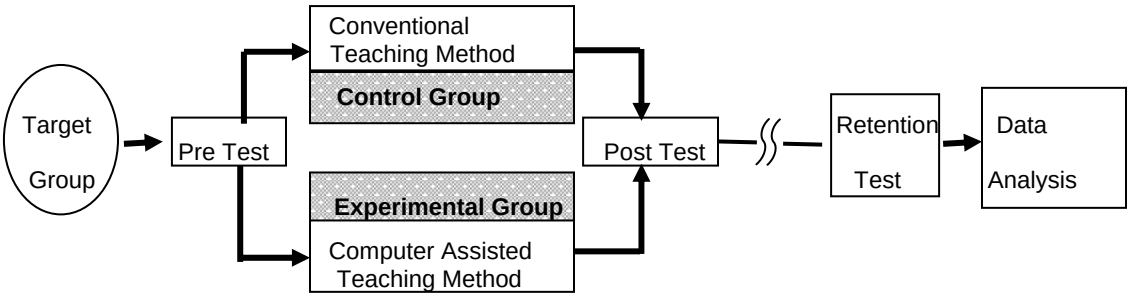


Figure 3. Mode of test administration.

In the present work extensive use of Power Point presentation is made. The effectiveness of this method is evident from the results presented in following section.

Results and Discussion

Both teachers were requested to keep the record of number of lectures required to cover these two topics. Following table shows the comparison of actual required lectures for both group teachers and allotted lectures by university.

Table 1. Time comparison of two groups.

Topic	Allotted	Required by	
		Control Group	Experimental Group
1. Geometrical Optics	10	12	08
2. Optical Instruments	06	07	04
Total	16	19	12

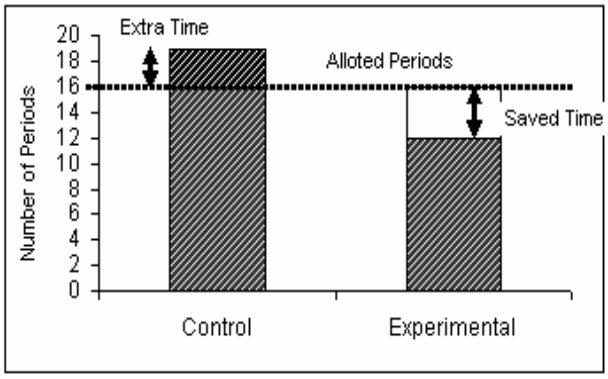


Figure 4. Graphical representation group wise period required to cover the chapters.

Table 1 gives comparison of lectures required to cover the given topics using the conventional and computer aided method. The control group teacher required 19 while experimental group teacher required 12 lectures to cover the same topics. This indicates that computer assistance helped in saving the time. It may be noted that, saved time was utilized to explain the topics with multiple revisions, problem solutions, university pattern Question Answering and repetitions up to student's satisfaction. This emphasizes effectiveness of the developed resource material as a teaching aid.

Further, in order to study the quality of learning ,the format of pre- post and retention test was adopted. The pre- test was conducted to ensure that the two groups were equivalent. Figure 5 shows the distribution of marks scored by the two groups. The equivalence of the groups is amply evident.

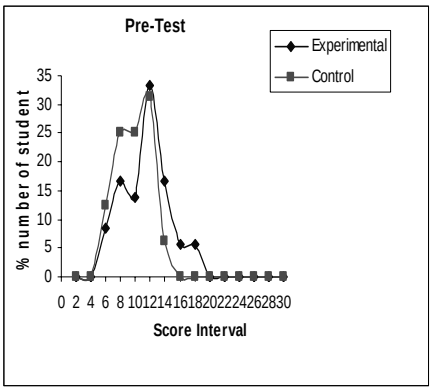


Figure 5. Experimental and control group pre test.

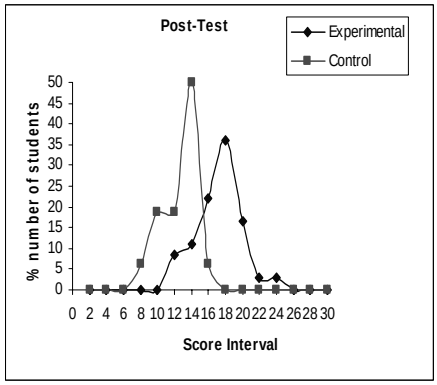


Figure 6. Experimental and control group post test.

A two-tailed *t* test for independent samples showed no statically significant difference (*t* observed = 1.80 < *t* table = 2.02, df = 50 at 5% level of significance) between experimental and control group at pre test level. This confirmed that both groups were equivalent before starting the experiment.

Table 2 shows mean values of the Pre Test, Post Test and Retention Test score for control and experimental groups.

Table 2. Mean score (*M*) obtained in achievement tests.

Group	No of Students	Pre Test *M*	Post Test *M*	Retention Test *M*
Control	16	9.43	12.43	11.62
Experimental	36	11	16.72	15.83

It may be noted that the study included data only from those students who attended all three tests. The table shows that increase in mean of experimental group was significantly greater than the mean of control group. Figure 6 shows clearly that the distribution of scores for experimental group is also shifted on the higher side.

A two-tailed t test for independent samples at post test indicates that the two distributions are significantly different(*t* observed = 5.95 > *t* table = 2.02, *df* = 50 at 5% level of significance). This confirmed that developed resource material helps to improve score. The average increase in score of the experimental group student was found to be 19% while the average increase in score of the control group student was found to be 10%. It can be noted that 35% students from experimental sample scored between 18 to 20 and 25 % students have scored more than 20. Performance of control sample also increased, but to somewhat lesser extent 50% students scored between 12 and 14 and just 5% scored 16.

A retention test was conducted on both groups to check the level of retention. As seen from Table 2 last column the mean score for experimental group is still higher than that of the control group. Mayer[4] finds that, when certain types of material are presented using multimedia methods, retention (defined as the ability to recall facts or steps in a process)

increases by an average of 23 percent; when text and graphics are combined, retention goes up an average of 42 percent; and if the text of a presentation is spoken rather than read if then retention goes up an average of 30 percent.

In both cases there is slight reduction of scores observed as compared to post-test. This indicates that the natural phenomenon of loss of retention is present in both groups. However the question of whether there is any significantly different behavior of the two groups, was analyzed by defining a loss factor as

$$\text{Loss factor} = \frac{(\text{Post test} - \text{Retention test score})}{\text{Pre test score}}$$

A two tailed *t* test for this data indicate that there is no significant difference between experimental and control group at retention. (*t* observed = 0.30 << *t* table = 2.02, *df* = 50 at 5% level of significance). This confirmed that both groups retain the content at similar level. The advantage gained by experimental group is long lasting.

Conclusion

Results from statistical computations show that developed resource material help the teaching and learning of the topics from 'Optics'.

Interviews with the teachers and students participating this experiment revealed that they were satisfied by the package and happy about the fact that it is time saving for both teacher and student community. The saved time may be utilized for other fruitful discussion or information about the course content. Such activity always creates subject interest, also improve teaching quality. Students watch their teacher clicking the mouse and verbally explain the things appear on screen. Students take the notes and drawn the figures too! Most of them fist time see such activity and enjoy the same.

Acknowledgment

One of the authors (S.G. Thube) wishes to acknowledge UGC New Delhi for awarding teacher fellowship, the authorities of Rayat Shikashan Sanstha, Satara, the Principal, Dada Patil College, Karjat (Ahmednagar) for granting study leave and the Head, Dept.of Electronic Science, University of Pune for permitting the study facility.

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