Invited Paper

Education in Optics in CANON

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Abstract

The HRD philosophy in R&D in Canon is based on the three-self spirit (self-motivation, self-awareness and self-management). The Canon's R&D engineers are required a positive attitude, creativity and courage to research and to develop new products.

Educational measures in optics being in effect in Canon consist of the in-house training courses, studying abroad, publication and others.

Several matters which should be noted in education in optics are also discussed; for example, the relationship among geometrical, physical and quantum optics.

key words ; education in optics, R&D human resource development, HRD

I. INTRODUCTION

Canon is a creative manufacturer which researches, develops and manufactures new products. R&D technologies and development management have diversified along with the business diversification of the company.

Education and training are essential to all Canon and they are vital for nurturing of the talents necessary to manage innovation and to change. Continuing diversification of produciton requires continued education and training. The entire process of bringing new products needs education and training.

In this very real sense, people are the company's most valued asset; education and training are the most effective means of developing those assets.

In Canon, various education and training programs are provided to acquire not only basic but also new technologies that are directly connected to the business.

In this paper, we will discuss the education in Canon; especially the education in optics in Canon.

II. The COMPENDIUM of CANON[1)]

Canon's corporate philosophy is "To be a global corporation providing kyosei (living and working together for the common good) in all countries where we operate.

Canon's corporate mission is to make a positive contribution through continued growth and reinvestment in the world's communities.

Our objectives consist of three statements:
- We are responsible global citizens.
- We will create unique products of the highest quality based upon leading-edge technologies.
- We will build an ideal company for continuing prosperity.

Our values are characterized by the following five statements;
- We respect cultural differences among ourselves, our customers and our communities.
- We believe that self-motivation, self-awareness and self-management are the three keys to good results.

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- We respect the dignity, value the initiative and recognize the merit of each individual.
- As members of the Canon family of companies, we trust and respect each other and work together harmoniously.
- Above all, we sustain our physical and emotional health in order to lead full and happy lives.

Canon has, since its foundation, emphazised technology and been a company which contributes to society through technology. Here we enumerate Canon's products;

- Copiers;
  office-use copiers*, personal-use copiers*, color copiers*,
- Computer peripherals;
  laser beam printers*, bubble jet printers, image scanners*, still video cameras*,
- Information and communication systems;
  facsimiles*, computers, word processors, desk-top publising systems, micrographic systems*, magneto-optical disc systems*,
- Cameras;
  SLR cameras*, lens shutter cameras*, video cameras, lenses*,
- Optical products;
  semiconductor production equipments*, broadcast equipments*, medical equipments*,
- Others;
  audio & visual aids*, displays(FLCDs*), clean energy(solar cell panels*), calculators, electronic typewriters and others.

The product placing an asterisk means the application of optics. This list shows that the optical engineering is one of the most important and indispensable technologies in Canon to pursuit its business strategies.

III. The BASIC THINKING of CANON R&D ENGINEERS DEVELOPMENT

The philosophy to nurture engineers in Canon is summarized as follows:

- Self-development is a basis of human resource development
  Education cannot help a person if one has no motivation for learning and developing. In other words, the three-self(*) spirit is the starting point of education in Canon. (*Self-motivation, Self-awareness, Self-management)

- Workplace is the most important training room
  Only able people are qualified as professionals. The workplace where such professionals exhibit their abilities is the most important training room.

- Training opportunities must be planned and used by engineers themselves
  Training opportunities planned by engineers who know the best are the key to good results.

- Every R&D manager is responsible for development of subordinates
  R&D managers training efforts reflect on their subordinates.

- We develop corporate culture to encourage everyone to show one's ability
  Talented human resources are nurtured in energetic culture and environment.

IV. CANON R&D ENGINEERS

We desire our engineers to have courage to challenge unknown subjects, and passion and vitality to overcome failures. At the same time, we want them to have balanced human nature - being strict to themselves, modest and sincere to accept other's opinions.

The foundation of original R&D is developed from good nature.

The requirements for engineers in Canon are described as follows;

- Always maintain a positive attitude
  R&D engineers create new things. Their sources of energy are passion and vitality.

- Set own goal and challenge it with creativity and courage
  R&D engineers, whether working for technology development or product development, must set own goal. It is even more so if the development is original and state-of-art.

- Have deep professional technologies and wide field of vision
  Now that technologies are further diversified, it is becoming more difficult to develop superior products with technologies of one field alone.

- Inter"feel" products and technologies
  The strength of a manufacturer's technologies is measured by its products released on the market.

- Be highly sensitive to and have insight into information
  We live in the information age. Our daily life is flooded with various information. R&D engineers must be sensitive to information and find out useful ones for their research work.

- Have a profit mind
  Canon's pursuit of profit is justified when the earned profit is reinvested in its R&D activities, because by offering superior products, Canon is contributing to the societies, to the countries and in large to the world.

- Innovate not only technologies but also management
  R&D engineers, who are in the forefront of the rapid technological innovation, must be able to change the system of their R&D acivities to cope with new technologies.

. Choose the present actions toward the future
  There are two types of conception to envision the future. One is IN-OUT type. The other type is called OUT-IN in which the present is viewed from the future as a starting point. The OUT-IN conception is said to be effective for dealing with human beings or management.

- Have professional skills for management
  R&D engineers must have professional skills for management in order to effectively carry out duties. They should know "QC" for the quality, reliability and safety and other commonly used skills such as "Design Review". These skills are equally effective as long-term experience.

- Have good communicatons about own work
  R&D engineers are required to work with other engineers. Thus, engineers must be able to explain their thinking and work to other team members. Good communication skill is one of the important qualifications for R&D engineers.

V. EDUCATION PROGRAMS

V.1. Technology training

The objective of this program is to learn technologies at all levels, from fundamental to frontier technologies, through lectures, exercises and experiments. It covers various fields, such as electrical engineering, software engineering, matrials engineering, and it, as a matter of course, contains optical engineering.

The followings are the optical engineering training courses.

- General optis [25 days]
  paraxial theory, ray tracing, aberration, OTF, tolerance, optical instruments (lenses, camera, LBP and others), interference,

diffraction, polarization, radiometry and photometry, light source, detector, optical materials, optical fabrication, automatic lens design and lens design work-shop.

- Introduction to imaging optics [3 days]
  paraxial theory, ray tracing, aberration, optical instruments.
- Introduction to electoroptics [2 days]
  wave theory, interference, applications of LASER.
- Introduction to optical measurements [2 days]
  interferometer, measurement by light.
- Digital imaging technology [7 days]
  digital image processing, thoery of color, image evaluation, standards of imaging (JPEG, MPEG et al).

V.2. Engineer study abroad scheme

This scheme sends Canon's engineers to graduate schools in Europe and the U.S. for two years with the objective of acquiring cutting-edge technology, preparing engineers for internationalization and constructing an international human network.

Up to the present, two engineers studied optics at the California Inistitute of Technology, five engineers researched into imaging science at the University College London, McGill University, Stanford University, the University of Sydney and Carnegie Mellon University, and two engineers were engaged with the research of optical materials at Princeton University and the University of Rochester. Among them, two engineers have received Ph.D. degrees and several have earned M.S. degrees.

V.3. Canon research report

Among research results accomplished at Canon, those which were highly evaluated by in-house personnel and outside people are summarised, and distributed to experts in and outside the company.

Up to the present, nine papers have been published and the followings deal with themes related to optics:

No.1 : "Study of erosion of polished surface of optical glasses" (in Japanese) by Dr.Mitsui
No.2 : "Estalishment of the 5-th order aberration theory for practical use and its application in the optical design" (in Japanese) by Dr.Matsui
No.3 : "Theory of zoom lens" (in Japanese) by Dr.Yamaji
No.4 : "High-sensitivity interferometory" (in Japanese) by Dr.Matsumoto
No.5 ; "Helmholtz-Kirchhoff integral theorem in electromagnetic diffraction and propagation phenomena" by Dr.Suzuki
No.6 ; "Paraxial theory of mechanically compensated zoom lenses by means of Gaussian brackets" by Dr.Tanaka
No.8 ; "The spectral sensitization of photoconductivity for dye-sensitized CdS" (in Japanese) by Dr.Nakatsui
No.9 : "A new bipolar imaging device" (in Japanese) by Dr.Tanaka

V.4. Thesis announcement meeting

The objective of this program is to introduce the latest research activities at universities to the company. New employees who have finished a master's course or doctor's course report their theses.

VI. SOME "NOTA BENE"s in EDUCATION in OPTICS

Here we discuss several points which should be noted in education in optics.

VI.1. Relationship among geometrical, physical and quantum optics

Optics can be classified into several categories; they are geometrical optics (paraxial optics, real ray optics, wave-front optics), physical

optics (scalar wave optics, vector wave optics) and quantum optics; LASER optics, nonlinear optics and statistical optics strech over plural optics'.

One must keep in mind which optics should be adopted to analyze or to synthesize an optical instrument.

Now we take "a lens" as an example. Paraxial theory is sufficient to understand a magnifier, ray optics is used at the beginning of camera-lens design, wave-front optics is employed at the final design stage of a camera lens and partially coherent theory and scalar/vector wave optics must be used in the design of semiconductor production purpose lenses.

VI.2. Understanding of geometrical optics

In the field of physics, geometical optics is the approximated theory of Maxwell's electromagnetic wave theory with assumptions that densities of electric current and electric charge are both zero and wave-number tends to infinity. And the paraxial theory is the extremum in which ray height and ray inclination angle become zero.

In the realm of mathematics, geometrical optics is constructed with the Fermat's principle which can be considered an axiom. And paraxial values are formulated with the projection transformation.

Therefore, geometrical optics is the approximation of wave theory in physics, on the other hand, geometrical optics gives the perfect imaging in mathematics. We must understand both aspects of geometical optics.

VI.3. Sign convention and notation in geometrical optics

As with sign convention and notation in geometrical optics, there is little standardization in textbooks. Here we show some examples.

	Focal points	Principal points	Nodal points
Berek [2]	F, F'	H, H'	K, K'
MIL-HNDBK 141 [3]	F, F'	P, P'	N, N'
Marechal [4]	F, F'	H, H'	N, N'

VI.4. Distinction of radiometry and photometry

Radiometry is the measurement of quantities associated with radiant energy. On the other hand, photometry is the measurement of quantities associated with visually evaluated radiant energy. We distinguish them clealy one another.

VII. CONCLUDING NOTES

The importance of optics in Canon was first presented.

Next, it was presented the fundamental philosophy of R&D human resource development in Canon and was discussed the Canon's R&D engineers.

Then, it was enumerated several educational measures in optics being done in Canon. They are various training courses, engineer study abroad scheme, Canon research report and others.

It was lastly discussed several points which should be noted in education in optics.

References

1. The CANON HANDBOOK 5th Ed. (Canon, 1994, Tokyo).
2. M. Berek "Grundlagen der praktischen Optik" (Walter, 1930, Berlin).
3. MIL-Handbook 141 Lens Design (Defense Supply Agency, Washington DC, 1962).
4. A. Marechal "Imagerie geometrique, Aberrations" (Rev. Opt., Paris, 1962).