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A Graphic Science Education as a Training of Communication

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Abstract. Until now, graphic science education was mostly taken as the entrance of design and drawing education in the areas of architecture and machinery engineering. However in a highly advanced information society like ours, there are increasing demands for skills to graphically express complicated information in an easy-to-understand manner, and graphic science education needs to play this role in the future. Technical education to heighten such skills must be positioned as literacy education in the same way as language education and information processing education, and though students need to understand what is being taught and master the skills, what is more important would be to use those skills, and be aware of actually using them for other studies, research, and self-expression.
At Osaka City University, based on these needs, we offer a lecture "Graphic Science" as a public lecture, particularly studies using computer graphics. This paper discusses the aim of this class and details of the curriculum, and then analyzes how goals are achieved based on student's works, to show the direction of future graphic science education.

Key Words: Graphic Science, Graphic Science education, Computer Graphics
MSC 2000: 51N05

1. Introduction

With the progress of computer graphics (hereafter referred to as CG), it is often the topic of a debate how should CG technical skills be introduced into graphic science education. Broadly speaking, some attempt to actively incorporate CG technology as a excellent simple way of high quality drawings expressing brightness and color, while others believe that the principle of graphic science education lies in understanding and mastering projection methods and it does not matter if the method of expression is by hand or CG (or it should be mainly by hand, which is a more basic method of expression). We believe that apart from these disputes over hand CGs, there exists valid reasons for actively incorporating CG in graphic science

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education. This stems from our strong belief of the need for graphic science education as design language education.

The Keio University Shonan Fujisawa Campus in Japan established in 1990 is known for its various innovative attempts. One such is its curriculum which organically merges liberal arts education and specialized subject education. As described in [1], they particularly focus on literacy education required for learning and emphasize significance of the two education pillars of natural language (so called linguistics) and artificial language (information processing), and are producing considerable results. We are profoundly aware of the importance of these two educational pillars, but believe that in addition to these, design language education should be added as the third pillar (see Fig. 1).

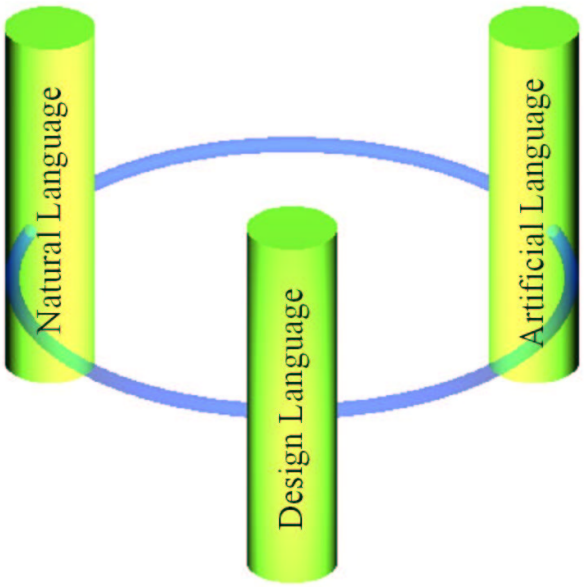

Figure 1: Three pillars of literacy education

In the advanced information-oriented society we live in today, we are required the capacity to reorganize complicated information appropriately and express it in a clear manner. Essential for this is the skill to express clearly using appropriate drawings or pictures, in addition to information analysis skills. Presentation tools as represented by the application software "Microsoft Power Point" provide a lot of templates on drawings and various expressions and allows the user to choose from these, thus enabling expression above a particular quality regardless of the user's expression ability and drawing skills. However considering the ever-increasing progress of information processing, and future circumstances of our society shifting to a competitive one where choices are made based on the results of various presentations, there are limits to presentation tools based on selection from templates. The skills to draw appropriate figures as desired considering color scheme and tone, etc. will become important. At the same time, without the ability to read information correctly from given expressions, objectives may not be read correctly in the flood of information available. We call the skills of communicating through expression using such drawings and understanding them as design language, and believe that needs for this design language will become very high in the future.

So what are the classes which meet to such needs? We believe that graphic science should indeed answer to such needs, where graphic science is defined as the fundamentals of

industrial drawing and space design with a curriculum centering around understanding and leaning projection methods, and is mostly taken up as a liberal arts class or public lecture historically.

Based on this idea, the Osaka City University provides a graphic science class as a public lecture open to all departments, and promotes the use of CG in these classes. Though we are still in the process of completing it as a curriculum for realizing design language education, this paper attempts to report the curriculum based on this principle and analysis of works by students, to show the direction of graphic science education of the future.

2. Detail of curriculum

At Osaka City University, freshmen (some sophomores) are offered *Graphic Science I* class in the first term where students are taught to understand the projection methods and learn actual technique by hand. And they are also offered *Graphic Science II* in the latter to learn the fundamentals of CG and related information. Though graphic science education by hand still remains because we believe understanding projection methods serves as the basis of design language even in future advanced information society. In addition, the basic hand method is more suited for training for conceiving three-dimensional figures in minds. This paper discusses our *Graphic Science II* class.

2.1. Objectives of the Graphic Science II class

The aim of this subject lies in understanding CG technology and related information. From the perspective of design language education, we especially stress that knowledge and skill mastered in this class is helpful not only in the duration of the lectures but also after the course. In our lectures, we repeatedly explain possible application of CG in the future such as drawings in reports of other lectures, perspective and isometric drawings in design subjects, graduation papers, etc. Like linguistics and information processing education, we stress that it is something which will serve useful throughout a person's life, and we set continued use by the student a major goal in the lectures.

2.2. Students

This subject is intended for freshmen of the Department of Architecture, Faculty of Engineering (compulsory), freshmen in the Department of Environmental Urban Engineering, Faculty of Engineering (compulsory), Department of Environmental Design, Faculty of Human Life Science (compulsory), Department of Civil Engineering, Faculty of Engineering (optional), Department of Applied Physics, Faculty of Engineering (optional), and sophomores of the Department of Information and Communication Engineering, Faculty of Engineering (optional). But it is open to all departments, and there are some students — though few — from the Faculty of Science and Faculty of Literature taking the class. Lectures are held three times a week (twice only for 2001 and 2002) for about 160 students (including repeaters).

2.3. Details of lecture and assignments

Table 1 shows the lecture schedule of our *Graphic Science II* class. We hold eleven lectures in half a term (of which one is a review) and two tests. Assignments include three small assignments;

Table 1: Schedule of *Graphic Science II* lectures

	Content	*Assignment*
1st	Introduction	impression for the submitted works by past students, and comments and suggestions for the lecture
2nd	the basis of POV-Ray	
3rd	the description method of primitive figures	giving small assignment 1 (Scarecrow)
4th	rotation, magnification – reduction, translation and repeat	giving small assignment 2 (Stairs)
5th	conditional branch, defined colors, block pattern	
6th	CSG model	giving small assignment 3 (CSG)
7th	behavior of light flow (light source, reflection, transmission)	
8th	giving final assignment and having questions regarding lectures until then	giving final assignment
9th	midterm examination	
10th	texture, group, prism, solid of revolution	
11th	the others	
12th	review of the final assignment	
13th	the final examination	

- *"Scarecrow"* for mastering the combination of primitive figures,
- "Stairs" targeting the comprehension of repeat procedure, and
- *"CSG"* aiming at the understanding of the concept of Constructive Solid Geometry (CSG), and
- the *"Final Assignment"* for applying all that what was learnt to tackle a high level task.

Though the lectures do not differ greatly in content from general CG education, we particularly focus on several topics considering the perspective of design language education. The topics are

- *"the behavior of light and effects"* (specular reflection and diffuse reflection, optical characteristics of general materials, types of lighting methods, adaptation brightness, and psychological effects),
- *"color and its effects"* (color expression method, psychological effects),
- *"visual point and visual field"* (using the analogy of camera lens), etc. Particularly for the visual field, we also demonstrate by examples that a totally different impression can be given according to the visual point and visual field for the same three-dimensional figure.

2.4. The application used

We use the CG application POV-Ray (Persistence of Vision Ray Tracer). This application is continuously being developed by users all over the world based on the application software for ray tracing called DKBTrace which was developed by David K. Buck. The detail of POV-Ray can be seen at the POV-Ray official web page[1].

We selected POV-Ray due to such reasons as

- it is a freeware,
- it does not restrict the platform of computer, and is able to run on Microsoft, MacOS and Linux,
- it produces high quality CG images,
- it is easy to visualize numerically calculated results with flexible data interface, etc.

All of these reasons take into account the aim of "continued use" described in 2.1. We spend about 40 minutes to explain the installation of POV-Ray in a detailed way which may be even considered redundant, but this is done so that any student can build an environment for using POV-Ray themselves in the future when required.

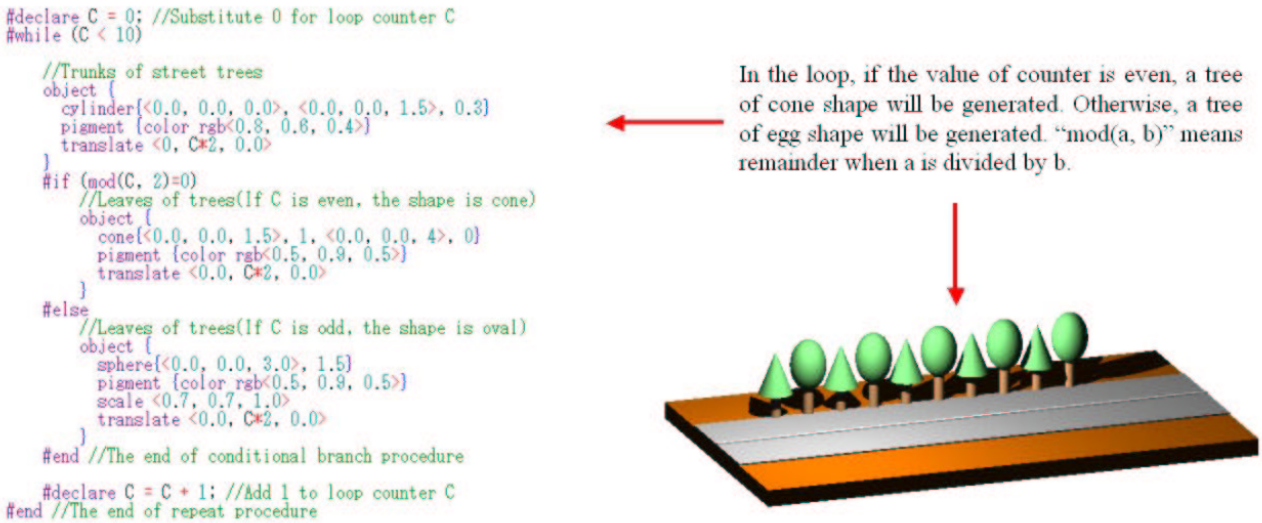

Figure 2: The figure which explains conditional branch procedure described in the textbook [2] used in the lecture

2.5. How lectures are given

Due to campus facilities, this class is held in a room which does not allow practice on computers. Only lectures are given in a normal classroom[2] according to the contents of Table 1 using the textbook [2]. Practice is done by the students themselves outside class hours by

1) lending them the CD-ROM for them to install in their personal computers,
2) distribution services of images of rendering results using WWW CGI function (*scene files*, i.e., information describing the figures, are entered in forms).

[1] See http://www.povray.org/.

[2] As mentioned in the paper, POV-Ray is compatible with multi-platform and the computer center machine in our university should be used, however because the OS of the general terminal in the computer center is NeXTSTEP which is not compatible with POV-Ray, we had to use this method.

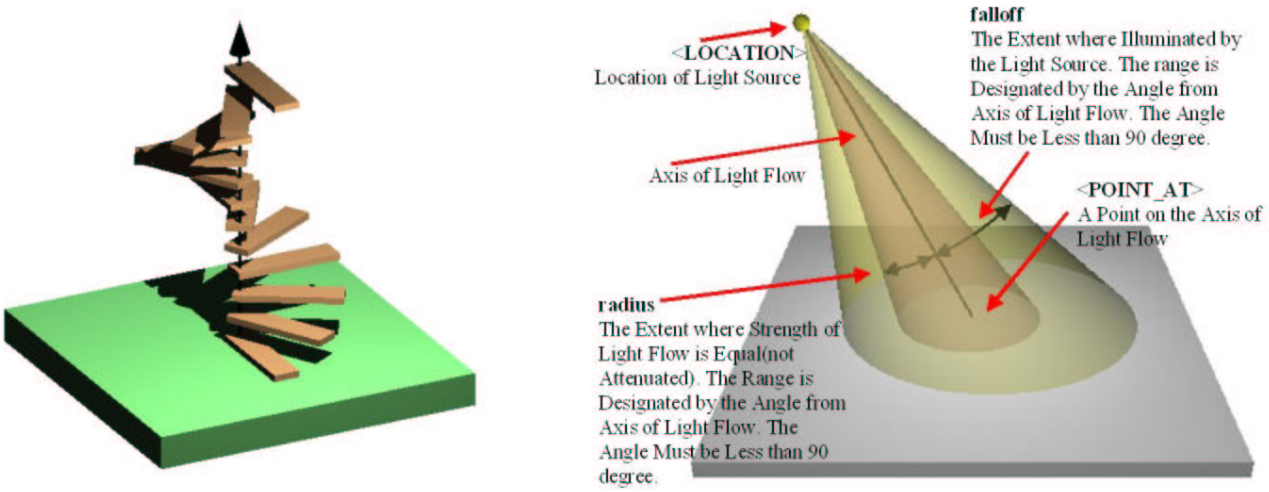

Figure 3: The figures which explain the repeat procedure (left) and the arrangement of a light source with directional characteristics (right) as described in the textbook [2] used in the lecture

Since this class is open to all faculties, the information processing skills of the students vary considerably. So we have made an attempt to avoid the use of technical terms in the textbook as much as possible, and use graphical drawings instead for a more intuitive understanding. For these drawings (see Figures 2 and 3), we try to rouse the interest of the students and enhance their learning desire using POV-Ray as a practice use of design language.

2.6. Final assignment

We only give the students *"Unique Shape"* as the main theme of the final assignment and do not set down any other restrictions in particular. However, because some students have a hard time selecting their themes without a single clue, we give them the following seven categories:

1) Surrounding small objects,
2) interior perspective drawings,
3) landscape,
4) two-dimensional architectural drawings,
5) whatever you wish you had (imaginary objects),
6) Origami (folded papers) architectures, or
7) others.

Since we have incorporated "Others", the theme is practically free. However to make sure the students address their assignment enthusiastically, we ask them to take account of the following two aspects as much as possible:

- *Ardent attachment* for the theme, and
- *benefit for actual life* given by the theme.

For both the small assignments and final assignment, we ask the students to send scene files describing figure information by e-mail. After checking the scene file grammar, we render the CG image with the file and open it through our web page[3]. We allow resubmissions of

[3]See http://graphics.arch.eng.osaka-cu.ac.jp/zukeikagaku/.

the final assignment before the deadline. Many students often resubmit improved versions of their work two or three times after being enormously influenced by the work of others on the web.

3. Submitted works

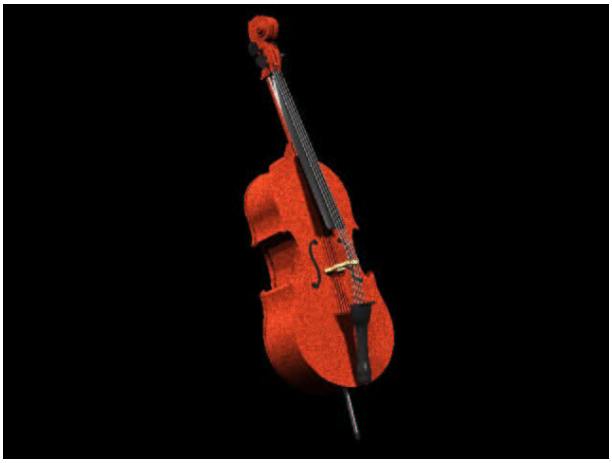

Figure 4: Submitted work — Cello

Figure 5: Submitted work — A new plan of the own room

Figure 6: Submitted work — Akashi Kaikyo Bridge, Kobe

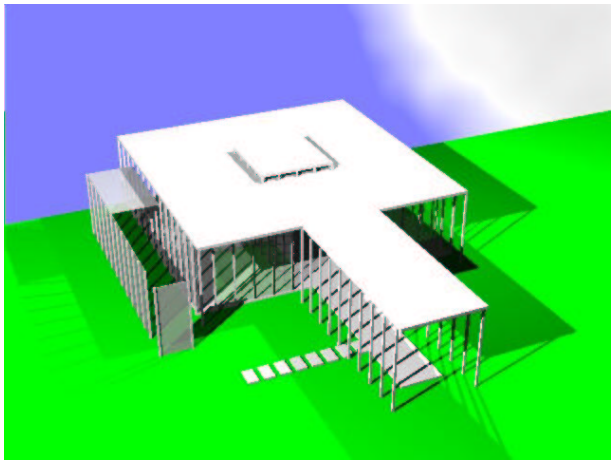

Figure 7: Submitted work — A study house

The students have about one month including their winter holidays to work on their final assignment. Though the quality of most works is very high, here we will just introduce four pieces due to limitation of paper space in Figures 4 to 7, to indicate the trends of submitted works.

Fig. 4 shows a submitted work *"Cello"* by a freshman of the Department Architecture, Faculty of Engineering. According to above-mentioned categorization, this would belong to *"surrounding small objects"* and *"ardent attachment"*. Like this example, many students select musical instruments as theme, such as an electric guitar, mandolin, trumpet, piano,

drums, etc. The shape of instruments is composed of complicated curves and surfaces, and CSG modeling takes considerable time and efforts to construct them. But this is compensated by the "affection" the students feel towards their theme and the quality of works regarding instruments is therefore very high. This work is composed of basic figures only and described by a scene file consisting of about 450 lines including visual points and light source settings.

Fig. 5 shows the work *"A new plan of the own room"* by a freshman of the Department of Architecture, Faculty of Engineering. This work examines the harmony of the own room by arranging lightings and furniture selected from magazines. It is described by a scene file composed of about 600 lines. This work would belong under the category of *"interior perspective drawings"* and *"benefit for actual life"*. Examples of indoor perspective often submitted include the student's room, kitchen, toilet, Japanese tatami mat room, inside of a famous architecture, etc. As the actual size can be used for these works, they are very real. In addition, as most parts are composed of straight lines and planes, modeling itself is quite easy. In the case of interior perspective drawings, as the position of the visual point is restricted, the more the visual field is broadened, the more will distortion of the perspective increase, resulting in something which is quite different from the actual impression. To prevent the distortion from increasing while keeping a sufficient visual field, most work place considerable study on visual point position and visual field. Regarding *"benefit for actual life"*, we showed more socially significant theme such as "study of landscape ordinance", "enhancement of appearance of region", "revitalization of local shopping streets", etc., but it seems that the theme was too early for a freshman.

Fig. 6 is the work *"Akashi Kaikyo Bridge"* by a freshman of the Department of Architecture, Faculty of Engineering. It is described by a scene file consisting of about 400 lines. This work would belong to *"landscape"* and *"ardent attachment"*. Bridges are often selected as a theme of landscapes. In particular, due to the location of the Osaka City University, the Akashi Kaikyo Bridge is often picked as a theme. In addition to the beautiful form of the bridge, the different expressions it carries between day and night, are also very interesting. So students put in a lot of effort in studying the position of sunlight, and position and color of the light source used to light up the bridge.

Fig. 7 is shows *"A Study House"* by a freshman of the Department of Environmental Design, Faculty of Human Life Science, which the student actually designed for another class. This would come under *"surrounding small objects"* and *"benefit for actual life"*. This work is described by a scene file consisting of about 100 lines. Attempts to express works designed by themselves by CG are common among students who belong to the departments which offer design classes. CG enables students to study something which cannot be easily done using models, for example, understanding of changes in impression when materials of the object change, or comparison of sunlight conditions in summer and winter. Themes like these would be expected the largest contribution to the education system in university.

We introduced just four typical works among a lot of high quality unique works submitted by students.

4. Summary

This paper discussed the need for design language education. It introduced the *"Graphic Science II"* class given at the Osaka City University (open to all departments) as an example of design language education class, and it presented works submitted by students. Considering that no practice is done using computers in this class, the level of the final work submitted

is considerably high. Though the students do not yet have a complete understanding of the need for design language, the explanations based on the concept of design language serve for heightening the incentive of students at least. And since many of the students say that they would like to continue using POV-Ray in various ways, this shows that our goal of directing the course of design language has been achieved to a certain extent. We will continue these efforts and make further improvements, review our curriculum, and strive to establish it as a design language education.

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