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Present Status of Graphics Science and Graphics Representation Education in Japan

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Abstract. The Japan Society for Graphics Science undertook a survey on the education of Graphic Science and related subjects at Japanese universities and colleges from 2002 to 2003. The items surveyed included subject name, implementation details, ability being trained, subject contents, etc. The principal results of the survey are as follows.
1) With regard to the ability being trained, the importance is placed on the drawing ability and the information transmission ability by the use of drawings, while less importance is placed on the abilities to generate and analyze three-dimensional shapes, i.e., geometrical abilities.
2) A lot of importance is still placed on hand drawing (Descriptive Geometry), though the introduction of CG/CAD is progressing rapidly in Graphic Science and related subjects.

Key Words: Graphic Science, Graphic Representation, Computergraphics, Graphics education

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1. Introduction

Descriptive Geometry is the research and technology of producing graphic representations of three-dimensional objects and solving three-dimensional geometric problems using the graphic representation, and has been considered to be the basic knowledge required by people who handle three-dimensional shapes such as mechanical engineers, architects and figurative artists. In Japan, it has been taught at universities, junior colleges and technical colleges in Mechanical Engineering, Architecture and Civil Engineering, and Arts and Design departments under the subject name of "Graphic Science".

However, in recent years, with the increase in the use of Computergraphics (CG) where computer technology can be used to make graphic representation and geometric processing, and the development and spread of the technology to apply CG to design and drawing (computer aided design, CAD), the practicality of Descriptive Geometry is dropping, and along with that, traditional Graphic Science education is being abolished or reduced at most of the universities and colleges, and there is a trend to introduce CG/CAD for Graphic Science education. By using CG for graphic representation, the results of numerical calculations and various simulations can be visually displayed, and this is being used in various fields of science and engineering. Moreover, CG is now being widely used for games and movies. There is now a new trend for education centered on CG for graphic representation in Information and Media-related departments. With the wide spread of CG/CAD, the education of Graphic Science has entered a period of revolution.

In order to grasp the present status of Graphic Science education in this period of revolution, and to understand how Graphic Science education is being carried out, the *Japan Society for Graphics Science* undertook 2002–2003 a survey on the education of Graphic Science [1]. The results of the survey were compiled and studied by the *Survey Committee* of the Japan Society for Graphic Science. This paper summarizes the results of the survey.

2. Content and method of the survey

2.1. Survey contents

This survey was intended to cover not just the subjects named as "Graphic Science", but also other subjects related to "graphic representation". The items surveyed are listed in Table 1.

Table 1: Survey contents

(1)	Subject name
(2)	Implementation details: compulsory/ elective, the number of contact hours, lectures/ laboratory exercises, and the number of lecturers and students
(3)	Ability being trained
(4)	Lecture content
(5)	Educational materials being used
(6)	Graphic Science peripheral subjects

2.2. Survey contents

Centered on members of the Japan Society for Graphics Science, surveys were sent to the instructors responsible for Graphic Science-related subjects at universities, junior colleges and technical colleges, including the instructors responsible for subjects covering Graphic Representation such as design and drawing. They were asked to respond to the questionnaires about their relevant subjects in their educational institutions. If they were responsible for more than one subject, they were asked to submit multiple replies. Responses were received from 173 institutions covering 278 subjects. There were responses from institutions nationwide.

According to the department names, the responses were sorted into mechanical engineering, architecture and civil engineering, arts and design, information and media, and general. The departments that were put into the "Information and Media" area included electric and electronic engineering, information technology, and media departments. The subjects and departments that were put into the "General area" included subjects offered by universities without specifying departments, home economics departments, and pedagogy-related departments. The various areas numbered 57 institutions with 98 subjects, 49 institutions with 79 subjects, 23 institutions with 38 subjects, 15 institutions with 20 subjects and 29 institutions with 43 subjects, respectively. Only a small number of responses were received for the Information and Media area, and as a result the related departments have not been fully covered.

3. Results and discussion

3.1. Subject names

Because of the wide range of subject names, they were sorted into

"Graphic Science", "Drawing", "Design and Drawing" and "CG/CAD".

The results are listed in Fig. 1. Overall, "Graphic Science" occupy 38%, "Drawing" 21%, "Design and Drawing" 21%, and "CG/CAD" 15%. It can be seen that Graphic Science and Graphic Representation education is currently undertaken in various subjects. The following shows the results by area.

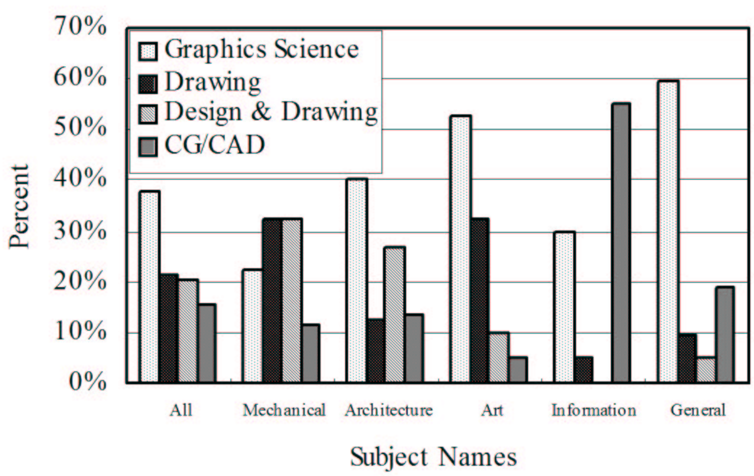

Figure 1: Subject name of graphics education

Mechanical Engineering-related: "Graphic Science" was low at 22%, but "Drawing" and "Design and Drawing" were both high at 32%. Graphic Representation education in the Mechanical Engineering-related area is centered on "Drawing" and "Design and Drawing".

Architecture and Civil Engineering-related: "Graphic Science" was higher than in the Engineering-related area at 40%, but "Drawing" was low. "Design and Drawing" was 27%.

Art and Design-related: "Graphic Science" was 53% and "Drawing" was 33%. "Design and Drawing" was low.

Information-related: "CG/CAD (Computergraphics)" was more than half at 55%. "Graphic Science" was also 30%, but this was restricted to the classical electrical and electronic engineering departments, and could not be seen for information technology and media departments.

General: "Graphic Science" was the highest at 60%. Next to the Information-related area, this area was the second highest for "CG/CAD" at 19%.

As can be seen, depending on the area, the subject names are different.

3.2. Implementation details

a. *Liberal arts, common specialized and specialized subjects:*
The results are shown in Fig. 2(a). There are many cases where the subjects are taught as specialized or common specialized subjects. In the "General" area, the ratio of the subjects being taught as liberal arts subjects is rather high at 30%, but in other fields there is not much difference according to the area.

b. *Elective, compulsory or elective compulsory subjects:*
The results are shown in Fig. 2(b). Almost half the subjects are elective. As they are elective, they are considered to be not absolutely necessary for the curricula. It could be said that there is a need for clarifying the position of Graphic Science education in the curricula.

c. *Lecture, lecture with laboratory exercises or laboratory exercises:*
The results are shown in Fig. 2(c). There are not many subjects which are just lectures

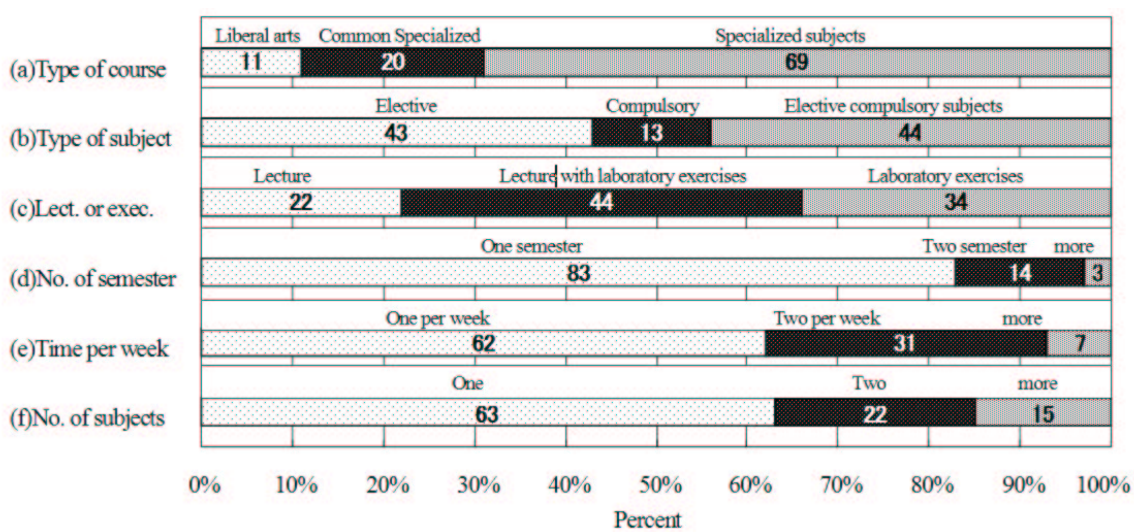

Figure 2: Implementation details

(22%), and most are lectures with laboratory exercises, or laboratory excercise subjects. It can be seen that for Graphic Science-related subjects the importance is being placed on laboratory exercises.

d. *Lecture duration:*

The results are shown in Fig. 2(d). Most subjects are for half the year, in one semester (83%). In the past many lectures were for one full year, but now it seems they are only given for one semester.

e. *Number of contact hours per week:*

The results are shown in Fig. 2(e). The number of contact hours is one per week (62%). Looking at the results by the type of subject, most of those that are only lectures, and those which are lectures with laboratory exercises are given for one contact hour per week, and most of those which are laboratory exercises are given for two contact hours per week. One contact hour is 90 minutes for most universities, and 60 minutes for most technical colleges.

f. *Number of subjects:*

The numbers of subjects reported by the various institutions are shown in Fig. 2(f). A little over half of the departments only had one subject, but almost 40% offered over two subjects. Depending on the institution, we can see that there is a great discrepancy in the number of hours of the Graphic Science-related subjects. The average number of subjects per department or course is 1.61 .

3.3. Ability being trained

With regard to the ability being trained, the respondents were asked to complete the survey from the five items shown in Table 2 so that the total would be 100%.

These results are shown in Fig. 3. According to this, overall, “1. Drawing ability” accounts for 25%, and is the single highest item. “2. Graphic Representation ability” accounts for 21%, and “3. Drawing communication ability” accounts for 16%, and together these are 37%. The total of items 1.–3. gets almost 65%, so we can see that importance is placed on the Drawing ability and Information Transmission ability. “4. Three-dimensional shape generation ability” accounts for 16%, and “5. Three-dimensional shape analysis ability” accounts for 13%, and

Table 2: Ability being trained

1	Drawing ability	the ability to accurately make drawings
2	Graphic Representation ability	the ability to represent graphically the information you want to transmit so that it is easily understood
3	Graphic communication ability	the ability to receive and transmit information using graphics
4	Three-dimensional shape generation ability	the ability to process and produce two-dimensional and three-dimensional shapes using graphics
5	Three-dimensional shape analysis ability	the ability to analyze three dimensional shapes using graphics

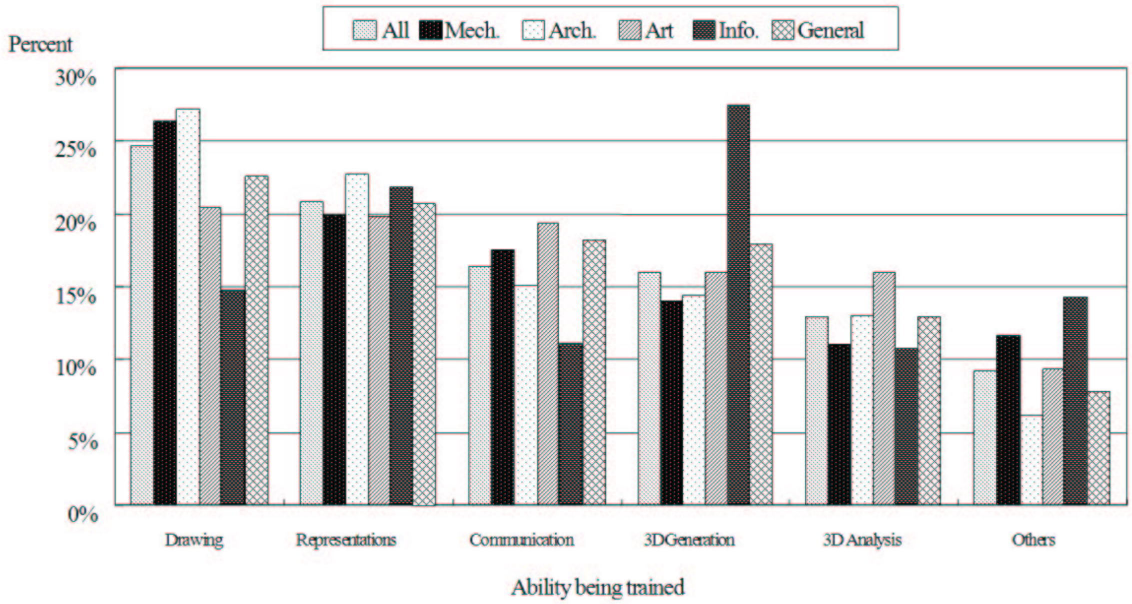

Figure 3: Ratios of ability being trained

together these are 29%. It can be said that less importance is placed on these abilities, i.e., on geometrical abilities.

Looking at the different areas, in the “Engineering-related area” and the “Architecture and Civil Engineering-related area”, compared to the overall total results, slightly more importance is placed on the “Drawing ability”, and in the “Art and Design-related area” slightly more importance is placed on the “Drawing communication ability”, although these differences are not significant.

3.4. Subject contents

3.4.1. Subject content items

As shown in Table 3, with regard to the subject contents, the respondents were asked to choose from 15 Descriptive Geometry-related items, and 17 Computergraphics-related items, depending on which items were covered in the subjects.

The breakdown of the response to the “Descriptive Geometry-related items” and the “Computergraphics-related items” for the subjects is shown in Fig. 4. The following breakdowns are shown for the subjects: the gray bar shows the “Descriptive Geometry-related items” only, the black bar shows both the “Descriptive Geometry-related items” and the “Computergraphics-related items”, and the white bar shows the “Computergraphics-related items” only. From the syllabi attached to the survey responses, for the subjects that had responses for both Descriptive Geometry-related items and Computergraphics-related items, many institutions taught Descriptive Geometry (hand drawing) topics in the first part of the semester, and CG/CAD topics in the last part.

3.4.2. Descriptive Geometry-related items

As shown in Fig. 4, an overall 86% of subjects responded to either “Descriptive Geometry-related items” only, or both “Descriptive Geometry-related items” and “Computergraphics-related items”, meaning some sort of Descriptive Geometry-related content was taught in the

Table 3: Subject contents

Descriptive Geometry-related items	
1) Graphic Science history	9) polyhedra
2) perception of graphics	10) curved lines and curved surfaces
3) two-dimensional graphics	11) cuttings and intersections
4) orthogonal projection	12) developments
5) axonometric projection	13) shades and shadows
6) oblique projection	14) fundamentals of engineering drawing
7) perspective projection	15) other
8) points, lines and planes	
Computergraphics-related items	
1) CG history	10) curved surfaces
2) geometric transformation	11) generation of artistic forms on mathematical relations
3) projective transformation	
4) two-dimensional CG processing	12) animation
5) hidden surface elimination	13) image processing
6) shadings	14) colors
7) realistic representation (rendering)	15) CG system
8) geometric modeling	16) programming
9) curved lines	17) other

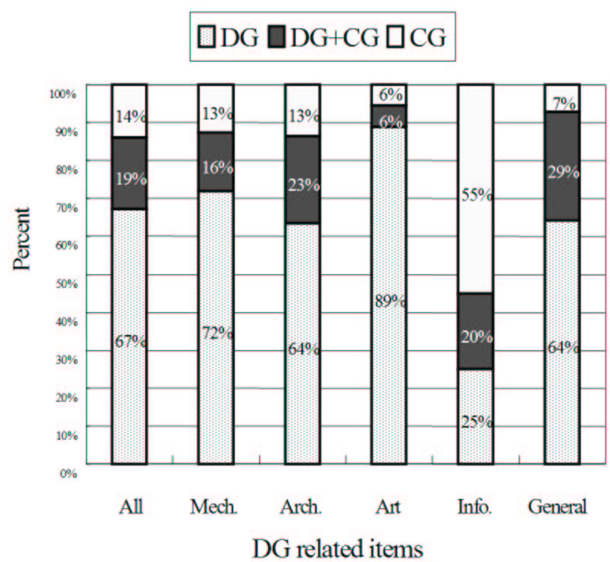

Figure 4: Subject contents items

subjects. Looking at this by area, apart from the Information-related area, most subjects in every other area (up to 90%) had some Descriptive Geometry content. As will be discussed below, the introduction of CG/CAD in graphics-related subjects has progressed, but it can be seen that a lot of importance is still placed on hand drawing education.

The results of Descriptive Geometry-related items by area and overall are shown in Fig. 5.

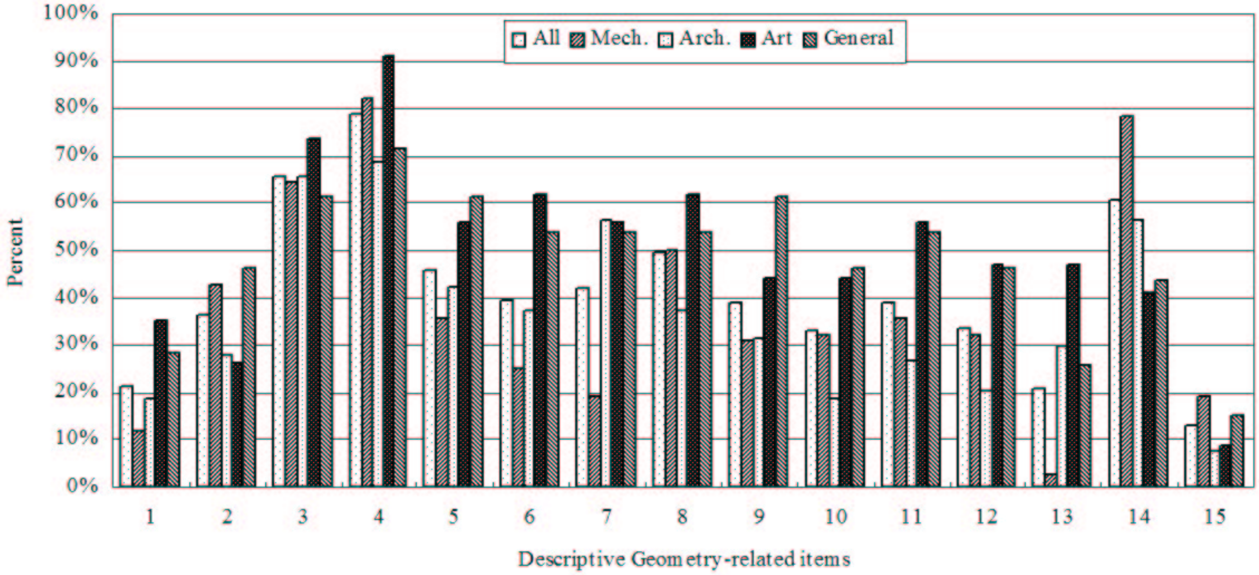

Figure 5: Covering ratios of Descriptive Geometry-related items:
1) Graphic Science history, 2) perception of graphics, 3) two-dimensional graphics, 4) orthogonal projection, 5) axonometric projection, 6) oblique projection, 7) perspective projection, 8) points, lines and planes, 9) polyhedra, 10) curved lines and curved surfaces, 11) cuttings and intersections, 12) developments, 13) shade and shadows, 14) fundamentals of engineering drawing, 15) other

There was only a low response from the Information-related area so these results are not shown in this figure. Overall, the items taught in over 50% of the subjects are “4. orthogonal projection” (79%), “3. two-dimensional graphics” (66%), “14. fundamentals of engineering drawing” (60%), and “8. points, lines and planes” (50%), in this order. It is suggested that importance is placed on “4. orthogonal projections” as basic graphic representation of three-dimensional objects, “3. two-dimensional graphics” as basic training of drawing ability, and “14. fundamentals of engineering drawing” as basic engineering drawing.

Looking at the content of these subjects, as noted above, with regard to Graphic Science-related subjects, it can be seen that importance is placed on Drawing ability and the training of the ability to transmit information using drawings. In addition, it is seems that importance is also placed on “8. points, lines and planes” as basic three-dimensional geometric processing.

Looking at the items less than 50%, with regard to the projection-related items, after “4. orthogonal projection” came “5. axonometric projection” (46%), “7. perspective projection” (42%), and “6. oblique projection” (40%), showing about 40% of the subjects covered these items. With regard to the geometric elements and geometric processing-related items, after “8. points, lines and planes” came “9. polyhedra” (39%), “11. cuttings and intersections” (39%), “10. curved lines and curved surfaces” (33%), and “12. developments” (33%), showing about 30% of the subjects covered these items. “13. shade and shadows” was low at 21%.

As noted in Section 3.2, f above, several subjects are taught in most departments and courses, and looking at the percentage of departments that covered these items in at least one subject, for each of the items, this is at least 10% higher than the figures shown in Fig. 5. With regard to the typical geometric processing items of Descriptive Geometry, 62% of the institutions covered “8. points, lines and planes”, and 48% covered “11. cuttings and intersections”. From this it could be said that geometric processing in Descriptive Geometry is taught in around 50% of the departments responded to this survey.

The results by area are shown below:

Mechanical Engineering-related: "4. orthogonal projection" (82%) and "14. fundamental of Mechanical Engineering drawing" (79%) are both high, showing that in Engineering-related area importance is placed on producing engineering drawing by the use of "4. orthogonal projection". There are a low number of subjects covering one-plane pictorial projection including "5. axonometric projection", and "13. shades and shadows" (2%) is hardly covered at all.

Architecture and Civil Engineering-related: The trend in this area is similar to that in the Mechanical Engineering-related area, but more importance is placed on "7. perspective projection" (59%). Also, about one-third of the subjects covered "13. shade and shadows".

Art and Design-related, and general: compared to the Mechanical Engineering-related, and the Architecture and Civil Engineering-related areas, more importance is placed on the various projection methods and three-dimensional geometric processing in both these areas.

3.4.3. CG-related items

a. *Percentage of introduction of CG/CAD:*

As shown in Fig. 4, an overall one-third of subjects that responded to either "Computergraphics-related items" only, or both "Computergraphics-related items" and "Descriptive Geometry items" had introduced CG/CAD in some manner. It is thought that the introduction of CG/CAD is progressing rapidly in Graphic Science-related subjects [2, 3].

By area, of course the Information-related area was high (75%), and apart from Art-related (11%), CG/CAD has been introduced in about one-third of the subjects in the Engineering-related, Architecture-related and General areas. As noted in Section 3.1 above, about 15% of the subjects mention CG/CAD in the subject name, and about 18% of the rest have retained their original subject names while teaching CG/CAD related contents.

b. *CG-related items:*

The results of Computergraphics-related items by area and overall are shown in Fig. 6. There was only a low response from the Art and Design-related area (8%, three institutions), so these results are not shown in Fig. 6. The highest result was "8. geometric modeling" (55%), showing that over half the subjects covered this area. Geometric modeling covers the basics of 3D-CG/CAD. Next came "3. projective transformation" (32%), and "4. two-dimensional CG processing" (31%). It is thought that the former covers the basics of three-dimensional graphic representation in CG, and the latter covers the basics of 2D-CAD. Compared to hand drawing, "9. curved lines" (28%) and "10. curved planes" (26%) are the areas where the most strength of CG/CAD can be displayed. In this way, the most fundamental CG/CAD content and content where the most features of CG/CAD can be displayed are being covered.

As will be discussed below, off-the-shelf software is being used in most of these subjects. It is, therefore, clear that off-the-shelf software is being used to teach the above items, but it has not become clear from this survey to what extent the contents are being taught. Another survey needs to be done in the future to ascertain this point. By area,

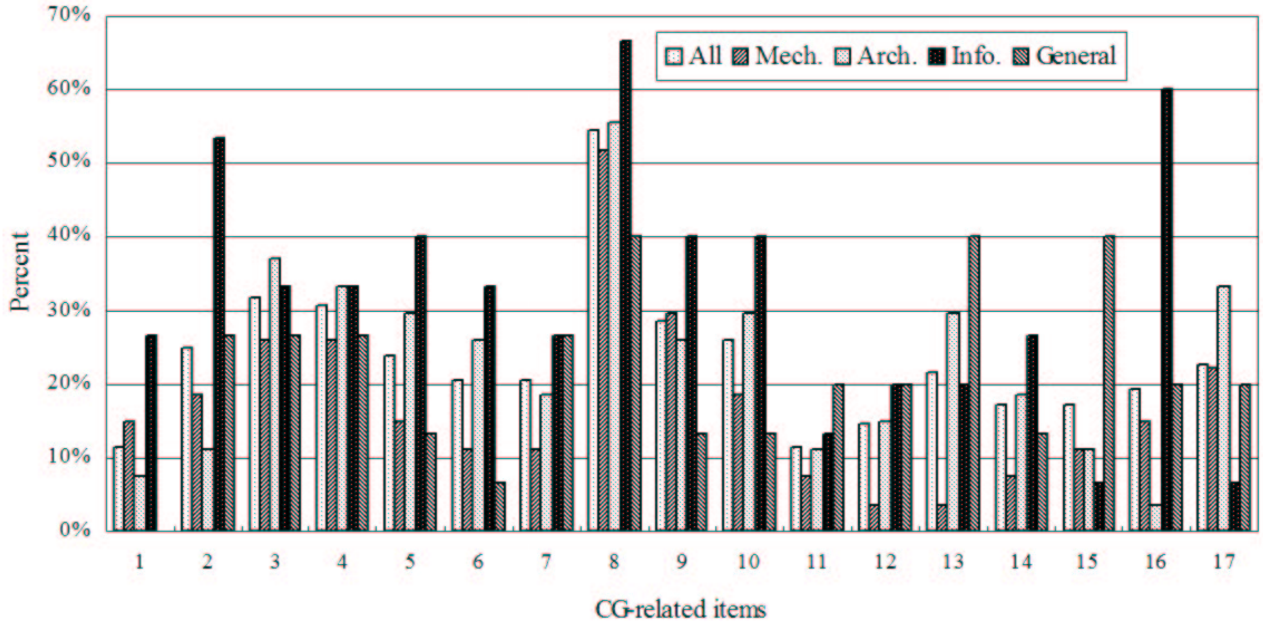

Figure 6: Covering ratios of Computergraphics-related items:
1) CG history, 2) geometric transformation, 3) projective transformation, 4) two-dimensional CG processing, 5) hidden surface elimination, 6) shadings, 7) realistic representation (rendering), 8) geometric modeling, 9) curved lines, 10) curved surfaces, 11) generation of artistic forms on mathematical relations, 12) animation, 13) image processing, 14) colors, 15) CG system, 16) programming, 17) other

in the Information-related area, most importance is placed on "16. programming" (60%) and "2. geometric transformation" (53%), a trend different to other areas.

c. *Off-the-shelf software or programming:*
With regard to the subjects shown in Fig. 6, overall, in 68% of the subjects, the students were made to use off-the-shelf software, in Engineering-related 74%, Architecture and Civil Engineering-related 81%, Art and Design-related 100%, Information and Media-related 33%, and General 60%. In the remainder of the subjects, some subjects were taught as classroom lectures, and some subjects were being taught by using general programming languages. In this way, off-the-shelf software is being used in many cases in the Engineering, Architecture and Civil Engineering, and Art and Design-related areas, and programming is used for teaching in the Information and Design-related area. This shows that with the former, CG/CAD is taught as a tool for design and drawing, and with the latter, the processing of CG/CAD is being taught. In the General area, the teaching is in between these two.

3.5. Graphic Science peripheral subjects and the relationship

Graphic Science and drawing subjects are taught in the first and second years, and afterward Design-related subjects (design and drawing, and design) are taught in the second and third years. CG/CAD is often widely used in Drawing and Design-related subjects. Later, mechanical or architectural design (in the Mechanical Engineering, or Architectural-related areas) and individual figurative design subjects (in Art and Design-related area) are being taught.

4. Summary and conclusion

The Japan Society for Graphics Science undertook a survey on the education of Graphic Science and related subjects at Japanese universities and colleges from 2002 to 2003. The items surveyed were subject name, implementation details, ability being trained, subject contents, etc. The principal results of the survey are as follows.

1) With regard to the ability being trained, the importance is placed on the Drawing ability and the Information transmission ability by the use of drawings, while less importance is placed on the abilities to generate and analyze three-dimensional shapes, i.e., geometrical abilities.
2) A lot of importance is still placed on hand drawing (Descriptive Geometry), though the introduction of CG/CAD is progressing rapidly in Graphic Science and related subjects.

References

[1] K. Suzuki: *Activities of the Japan Society for Graphic Science — Research and Education.* J. Geometry Graphics **6**, no. 2, 221–229 (2002).

[2] K. Suzuki, K. Takeyama, S. Nagano: *Present Status of Computer Graphics Education in Graphic Science Courses at Japanese Universities.* Proc. 3rd ICECGDG, Vienna (Austria) 1988, vol. 2, 250–257.

[3] K. Suzuki, K. Yoshida, K. Kajiyama: *Restructuring of Graphic Science/ Engineering Design and Drafting Courses at Japanese Universities — Based on Implementation of CG/CAD* [in Japanese]. Proc. China-Japan Joint Conference on Graphics Education, 17–32, 1993.

[4] K. Kondo, K. Mende, K. Suzuki: *Present Status of Graphic Science and Graphic representation Education in Japan.* Proc. 11th ICGG, Guangzhou (P.R. China) 2004, 191–197, (Compiled by the Survey Committee, the Japan Society for Graphic Science).

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