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Activities of the Japan Society for Graphic Science — Research and Education[1]

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Abstract. In this paper the research and educational activities of the Japan Society for Graphic Science (JSGS) will be briefly reviewed. The membership in the JSGS stands now at around 330 made of mostly individual members who are university and college instructors of graphics-related subjects. The JSGS holds nation-wide meetings twice a year, once in spring and the other in autumn. In each JSGS meeting a forum on graphics education is also held. The JSGS publishes the *"Journal of Graphic Science of Japan"* four times in a year. The JSGS also occasionally publishes books. In addition to these activities in Japan, the JSGS has been making efforts in promoting international cooperation.

Keywords: Graphic Science, descriptive geometry, computer graphics, spatial ability, spatial visualization

MSC 2000: 51N05

1. Introduction

The *Japan Society for Graphic Science* (JSGS) was established in 1967. Before reporting the activities of the society, it may be useful to explain what *"Graphic Science"* (GS) is.[2] In the JSGS prospectus written at the time of establishment of the society, it is stated,

> *"Graphic Science includes not only descriptive geometry but also engineering and architectural drawings, graphics in arts, and all other applications of geometry and graphics."*

In this statement one can see two characteristic features of GS in Japan.

[1]Lecture presented at the Plenary Session of the Tenth International Conference on Geometry and Graphics, July 28 to August 2, 2002, Kyiv, Ukraine. The author is chair of the Japan Society for Graphic Science.

[2]It is noted here that the term "graphics" is used to denote not only line drawings but also all other two-dimensional representations of three-dimensional objects so that the term today has a much wider meaning than its original meaning of line drawings.

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- The first is that GS is about descriptive geometry and in fact descriptive geometry can be considered as the mother of the GS.
- Secondly, though GS originates from descriptive geometry, it includes many other applications of geometry and graphics, and hence, covers a much wider range of topics than just descriptive geometry.

The *membership* in the JSGS stands now at around 330 made of mostly individual members who are university and college instructors of graphics-related subjects. About one third of the membership comes from engineering fields, a second one third from architectural fields, and the remaining one third from other fields such as arts and information technology.

Since university instructors constitute the largest group within the JSGS, the JSGS puts emphasis not only on research but also on graphics education.

The JSGS holds nation-wide *meetings* twice a year, once in spring and the other in autumn. The spring meeting is held in a different venue each year, for example this year it was held in Nagoya. More than 80 colleagues participated in the meeting, and approximately 30 papers were presented. In each JSGS meeting a *forum on graphics education* is also held.

The JSGS publishes the journal *"Journal of Graphic Science of Japan"* four times in a year. The JSGS also occasionally publishes books, for example,

- *"Handbook for Graphic Science"* in 1980 as a commemoration of the society's tenth anniversary,
- *"Computer Graphics Handbook"* in 1989 as a commemoration of the twentieth anniversary, and
- *"Graphic Science in Arts and Design"* in 1998 as a commemoration of the thirtieth anniversary.

These books are the result of the contributions of many members of the JSGS who worked together to complete the books.

In addition to activities in Japan, the JSGS has been making efforts in *promoting international cooperation*. For instance, the JSGS has been co-sponsoring the International Conferences on Geometry and Graphics since 1994. In the year 1994, the 6th Conference of this series was held in Tokyo, Japan. The JSGS together with the China Engineering Graphics Society has been holding the *Japan-China Joint Conferences on Graphics Education* since 1993. The topics of the Japan-China conferences are limited only to graphics education and are held once for every two years. The last one, the fifth conference in the series, was held in Osaka in 2001.

2. Research

2.1. Re-definition of Graphic Science

As I mentioned before, GS covers a wider range of topics than just descriptive geometry (DG) and with the emergence of computer graphics (CG) Graphic Science now encompasses an even broader set of topics. Therefore, it was felt necessary to re-define Graphic Science and involve the GS community in discussions on what Graphic Science is (Suzuki [7], Ino et al. [2]).

It is now recognized that Graphic Science has *three major aspects:*

- theoretical,
- technical and

- cognitive.[3]

The first aspect is a *theoretical* one. Since three-dimensional objects have their shapes and forms and their two-dimensional representations have their own shapes, the theory on the treatment of shapes, i.e., geometry, forms the fundamental basis of Graphic Science.

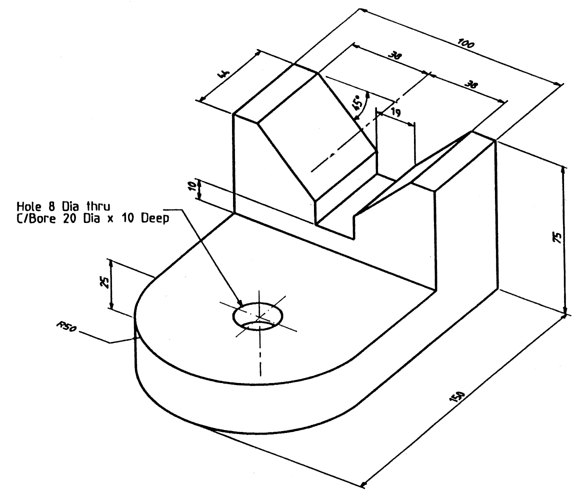
The second aspect is a *technical* one with most of the emphasis these days on computer-based techniques. Also, geometric modeling techniques are important as graphic representations are generated on the basis of geometric modeling.

The third aspect is a *cognitive or psychological* one. We, human beings, have very fundamental means for recognizing the world and communicating with each other, such as languages and numerals. Graphics is also considered to be one of such fundamental means that we humans use.

This fixture is made from mild steel and consists of a rectangular block 75mm high, 44mm long and 100mm wide. It has a 25mm thick by 100mm wide flange protruding from the 100mm face of the block with the lower surfaces (base) aligned. The free end of the flange is rounded with a 50mm radius and at the centre of that radius is a hole 8mm diameter through the flange with a 20mm diameter counterbore 10mm deep in the top surface of the flange. The overall length of the fixture is 150mm.

The rectangular block has a Vee shaped slot symmetrically through the top surface in a longitudinal direction. It is 38mm each side of the centre at the top surface and is 45 degrees to this surface. The bottom of the Vee slot is removed by a rectangular slot 19mm wide with its bottom face 10mm above the top face of the flange.

(a)



(b)

Figure 1: Description of a mechanical object (Platfoot [5])

In Fig. 1(a) a mechanical object is described in English but making an image of the object based on this description alone is not an easy task. In fact the task is almost impossible. In Fig. 1(b), the same mechanical object is shown graphically and we are able to recognize the shape at only a glance. We are more easily able to recognize shapes through graphical representations than through the use of the language.

Fig. 2 shows a classic textbook illustration for illustrating projection theory. It is well known that given a three-dimensional object and a projection system, the projection of the object, i.e., graphic representation of the object, is determined uniquely. However, the reverse is not true. Infinite numbers of objects exist for a given graphic representation, and hence, it is not possible to determine the three-dimensional object uniquely from the graphic representation. This means that, if the cognitive system of humans works only on the basis of projection theory, the three-dimensional shapes cannot be recognized from their two-dimensional representations. On the other hand, we humans are able to easily recognize the three-dimensional shape of objects from their graphical representations. The cognitive system of human beings, in which reasoning and/or inference processes may play an important role, make it possible to

[3] G. Bertoline has proposed in [1] a new discipline called *"Visual Science"*. Graphic Science in Japan and his Visual Science are similar to each other.

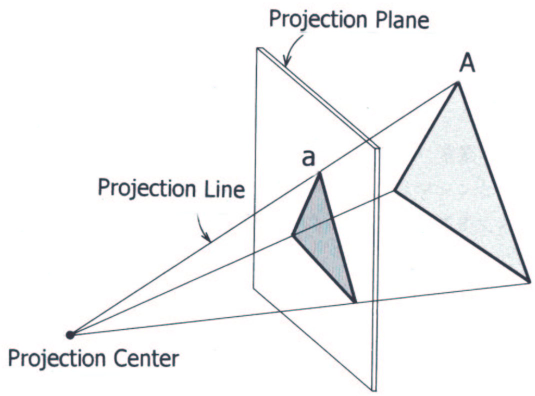


Figure 2: Projection theory

recognize graphical representations. The human ability to recognize graphics is called *"spatial ability"* or *"spatial visualization ability"*. Without this ability, graphics would not be particularly useful for human beings. Therefore, the cognitive aspect of graphics is a very important part of Graphic Science.

Geometry is a branch of mathematics, graphics techniques are studied in the fields of information technology, and cognitive aspects of graphics are studied in psychology and/or cognitive science. All applications of graphics, such as application in engineering and architectural design, are also included in Graphic Science. Therefore, *Graphic Science has a multidisciplinary or trans-disciplinary nature.*

2.2. Example of research on cognitive aspect of Graphic Science

It has been widely believed among graphics educators that one of the most important goals of graphics education is to develop the spatial ability of students. Recently, much work has been carried out in the evaluation of spatial ability of students with the goal of understanding how this ability is related to graphics curricula (Suzuki [9, 10]).

In this research, the *Mental Cutting Test* (MCT) has been the most widely used measure of spatial ability. In the MCT, subjects are given sets of pictorial views of objects and cutting planes (Fig. 3), and asked to select the correct sections. The MCT typically includes 25 problems.

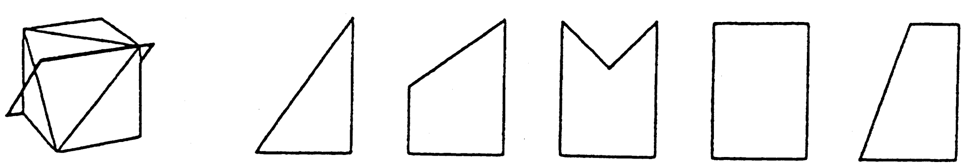


Figure 3: MCT sample problem

The MCT was administered before and after graphics related courses at more than 30 universities in Japan. The results of the pre-course are summarized in the scatter plot of Fig. 4. The horizontal axis shows the normalized score of the *National Center Test for University Entrance Examination* (NCTUEE) that is a nationwide test in Japan, and many students who wish to enter Japanese universities take this test. Fig. 4 also summarizes the results at some universities in other countries, such as Australia, Poland, Germany and the USA. A trend that can be seen clearly in Fig. 4 is the noticeable difference in the spatial ability between the sexes with the spatial abilities of male students higher than those of female students. Another trend that can be seen is the very strong correlation of spatial ability with the scores of NCTUEE, suggesting, perhaps, that *spatial ability is highly related to general intelligence.*

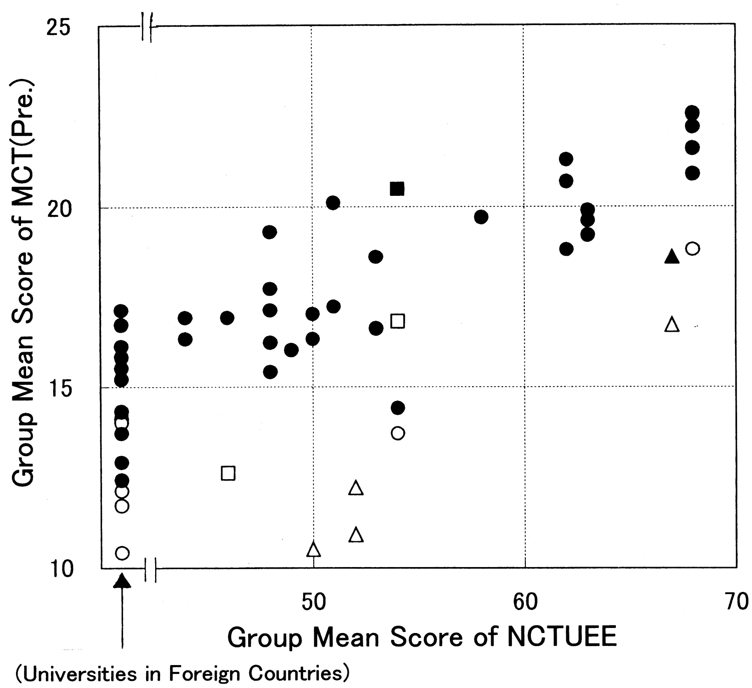


Figure 4: Group mean MCT score as a function of NCTUEE
(*circle:* science and/or engineering, *triangle:* literature, *square:* art;
solid: male, *blank:* female.
Results at universities (science and/or engineering) in foreign countries
are shown on the left, and are unrelated to NCTUEE)

The difference between the pre- and post-course MCT scores is shown in Fig. 5. The difference can be taken to be an indicator of the enhancement of spatial ability as a result of taking the courses. The courses cover a wide range of topics such as traditional descriptive courses, engineering drawing or engineering graphics (EG) courses, and recent 3D-CAD courses. As part of the test protocol, control experiments were also performed on students taking classes with no graphics education. Slight increases were observed in the scores of the students in the control experiments as well. These increases are called *practice effect.* Fig. 5 shows that *spatial ability* as evaluated by the MCT *is enhanced through descriptive geometry courses.* The ability is also enhanced by traditional engineering graphics courses, though the enhancement is a bit smaller than seen for descriptive geometry courses. On the other hand, the increase resulting from the newer 3D-CAD courses is of the same order as the practice effect, meaning that the ability wasn't significantly enhanced through these courses. These results suggest that hand-drawing and geometric content play an important role in the enhancement of spatial ability. The mechanism of the enhancement is, however, not clear, and it is necessary to make further research in this field.

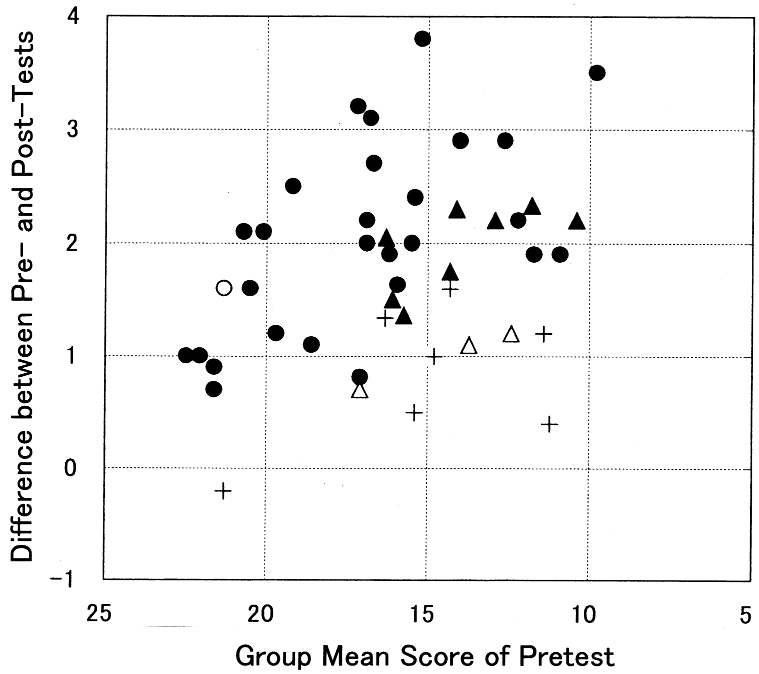


Figure 5: Difference between pre- and post-course MCT scores (*solid circle:* DG, *open circle:* CG, *solid triangle:* traditional EG, *open triangle:* 3D-CAD, *+:* control)

Approximately 40 papers by Japanese authors will be presented at this conference[4]. These paper present research in various fields of Graphic Science in Japan.

3. Education

In the traditional Graphic Science curricula in Japan, descriptive geometry was taught first after which engineering/architectural design drawings were taught. In Japan, these subjects are taught in universities and technical colleges and are not taught in high schools. The widespread use of computer graphics and its application to engineering/architectural design, i.e., CAD, have strongly influenced the growth of Graphic Science and such new technologies are being gradually introduced to the curricula.

3.1. Two categories of traditional descriptive geometry

Before discussing the new trends in graphics-related curricula, it is useful to review the textbook contents of traditional descriptive geometry. They can be classified into *two categories.* Traditional descriptive geometry is a beautiful combination of these two categories.

- The first category includes *theory and practical techniques of projection* and it covers two-dimensional representations of three-dimensional objects. It is worth noting that the same projection theory is also used in 3D-CAD/CG. In addition, *free hand sketching* is still used even in the modern 3D-CAD/CG era.
- The second category includes *solving three-dimensional problems* using their two-dimensional representations, i.e., graphics. Examples of basic problems that are given to students

[4]Editor's note: Tenth International Conference on Geometry and Graphics, Kyiv 2002, Ukraine

are finding the true length of a line and finding intersection lines between two solid objects. These problems are solved more quickly and accurately by using 3D-CAD and descriptive geometry techniques are now loosing their earlier practical importance. Some graphic educators, especially educators of engineering design graphics in the USA, believe that descriptive geometry is now behind the times, and has become obsolete (Juricic and Barr [3]). It should be, however, noted here that 3D-CAD is not a universal geometric-problem-solver, though it is a useful system (Suzuki [11], [12]).

3.2. Approaches to graphics education curricula in Japan

Surveying the curricula for graphics education at various universities and technical colleges in Japan, *three different approaches* to graphics education can be seen.

- In the first, the emphasis is put on the *first category* of traditional descriptive geometry. The theory and practical method of making graphics are taught, but the second category is not taught at all. Instructors in mechanical engineering fields prefer this type of curriculum.
- In the second, the emphasis is put on the *second category* of traditional descriptive geometry. Descriptive geometry is taught in the traditional way. However, it is taught not as a set of practical techniques instead is geared towards the training of geometric thinking. In other words, space geometry is taught through descriptive geometry. Instructors in architectural fields and arts prefer this type of curriculum.
- The third way is to introduce *new technology* for graphic representation, i.e., 3D-CG and/or 3D-CAD through a combination of computer graphics programming and the use of commercialized CG/CAD software.

Actual curricula at most universities are the combination of these three.

3.3. Example of graphics education

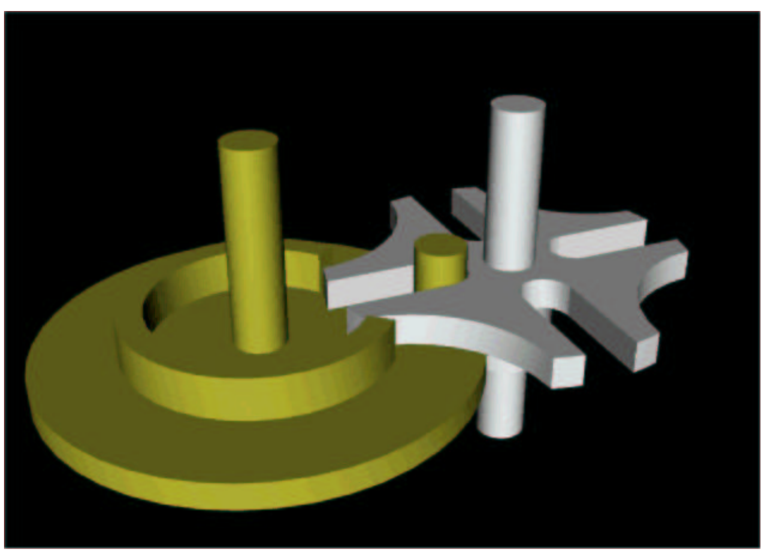


Figure 6: Example of students' works (Overall exercise - 1: Modeling and animated presentation of a Geneva Cam)

Table 1: Course outline of "Graphic Science – Laboratory Exercise" (experimental course) in the year 2000 at the University of Tokyo

Week	*Topics*
⟨*AutoCAD*⟩	
1.	Overall guidance
2.	Interface of AutoCAD (+line)
3.	2-D constructions-1 (circle, arc, editing operations)
4.	2-D constructions-2 (spline curve, layers)
5.	Views of solid models (views, 3-D primitives, set operations)
6.	Solid modeling-1 (extrusion/revolution operations, 3-D transformations)
7.	Solid modeling-2 (solving solid geometric problems with AutoCAD)
⟨*3D Studio*⟩	
8.	Interface of 3D Studio (+perspective projection)
9.	Rendering (colors, shades, mapping)
10.	Dynamic presentation (key frame animation)
⟨*AutoCAD+ 3D Studio*⟩	
11.	Overall exercise-1
12.	Overall exercise-2
13.	(Spare week/ students' evaluation)

I will discuss the graphics-related subjects at the University of Tokyo as an example of a combination of the three approaches discussed in Section 3.2. In the first two years all students at the University of Tokyo take courses from the College of Arts and Sciences. Starting in the third year, the students go on to take courses from one of the eleven faculties, such as the Faculty of Engineering, Faculty of Science, etc. Subjects called "Graphic Science" are offered at the College of Arts and Sciences, and subjects called "Engineering or Architectural Design Drawings" are taught in each of the departments of Faculty of Engineering.

"Graphic Science" consists of a lecture course and a laboratory exercise course [8]. The lecture course called "Graphic Science" is offered to the first year students. In this course, traditional descriptive geometry is taught. The course is taught for one semester and the lecture session lasts for 90 minutes per week for a total of 13 weeks. The laboratory counterpart of the lecture course is called "Graphic Science — Laboratory Exercise" and it is offered in the spring semester of the second year. The laboratory session lasts for 3 hours per week for a total of 13 weeks. At present, hand-drawings and computer programming for 3D-geometric processing are taught in this course [6]. There is currently a move to change the class content of the laboratory sessions by introducing commercialized 3D-CAD/CG software in place of teaching computer graphics programming.

Table 1 shows the class content of the experimental laboratory course on Graphic Science for the 2000 academic year [4]. Two-dimensional and three-dimensional modeling is taught at first, and are followed by graphic representations including rendering and animated display. Fig. 6 shows an example of the students' works for the final exercise. Students were required to make a model of the Geneva gear and then make an animated display.

4. Concluding remarks

Graphics is one of the most fundamental and useful means by which human beings recognize the world and communicate with each other. Therefore, the science of graphics, that is, Graphic Science, should be studied and taught.

We, the members of the JSGS, would like to develop GS in collaboration with colleagues all over the world.

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Through these activities, it strives to accomplish the mission of creating "Society 5.0" by the comprehensive organization, 'Center for Cybernics Research'. Center for Research in Isotopes and Environmental Dynamics (CRiED). Website.Â Microbiology Research Center for Sustainability (MiCS). In light of the diverse global problems that humankind is facing today, the importance of microorganisms in the maintenance of life on Earth must not be overlooked.Â To promote research and education in biomedical science, the center manages laboratory equipment and systems for animal experiments and provides supervision including the development, maintenance and supply of bio-resources including induced mutant mice. Top. Education and Student Support Service Centers. In this paper the research and educational activities of the Japan Society for Graphic Science (JSGS) will be briefly reviewed. The membership in the JSGS stands now at around 330 made of mostly individual members who are university and college instructors of graphics-related subjects. The JSGS holds nation-wide meetings twice a year, once in spring and the other in autumn. In each JSGS meeting a forum on graphics education is also held. The JSGS pub-lishes the "Journal of Graphic Science of Japan" four times in a year. The JSGS also occasionally publishes books. In addition to these