Multi-Image or Lap-Dissolve Slide Techniques and Visual Images in the Large Lecture Section

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Long before research in cognitive psychology focused on differences between visual and verbal modes of learning (*1*), chemists intuitively recognized the importance of presenting visual information to their students. In 1925, H. F. Davison noted (*2*)

> Chemistry is a study of matter and it can never be adequately learned from books. Students must see the material that is talked about and must eventually handle it themselves . . . The eye is wonderfully quick to perceive what the brain cannot, at the moment, encompass, but the mental impression provoked by the eye will last for years, to be better understood in later days perhaps.

In the same paper, Davison also succinctly summarized the problems associated with teaching chemistry in large lecture rooms.

> The author deplores very much the great increase in the size of lecture rooms in recent years, for in only a relatively small lecture room holding 250 students he finds it is difficult for the students in the rear of the room to see what is going on in front. In one very large lecture room in a University which he visited, the author was told that many of the students had to bring field glasses in order to see much of anything that was going on at the lecture table.

The subsequent decades have seen the development of a number of techniques to obviate the need for field glasses, including the use of overhead projectors (*3*), films and videotapes (*4*), and multi-image slide techniques such as lap-dissolve (*5*).

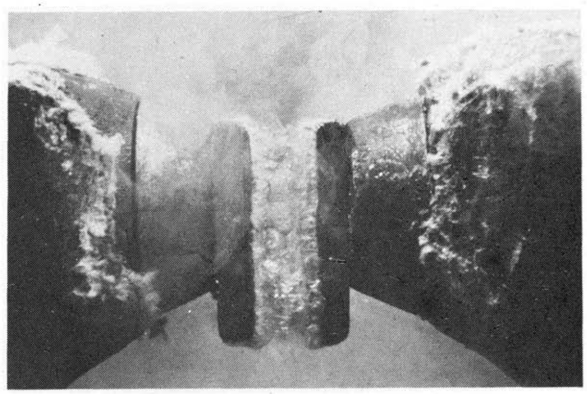

Figure 1. A horseshoe magnet with liquid oxygen bridging the pole gap.

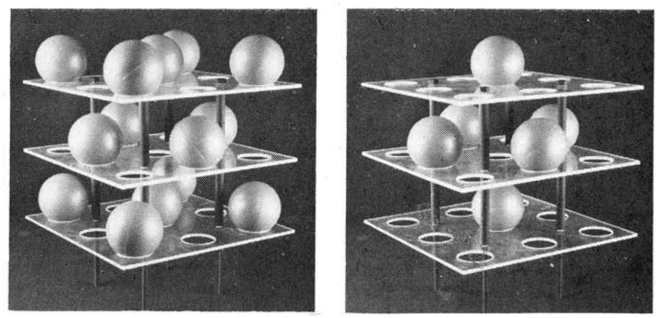

Figure 2. (left) A model of a face-centered cubic unit cell built using "green" spheres. (right) A model in which the six positions corresponding to the centers of the faces of a FCC unit cell are indicated using "orange" spheres. A model of the FCC unit cell is then shown in which the six faces contain orange spheres and the eight corners are represented by green spheres. This helps convince the student that the FCC unit cell is indeed a simple cube with atoms in the centers of each face.

The Project

When this work was begun in the 1977–78 academic year, there were 13 courses, 23 faculty, and 9,474 students in the general chemistry program at Purdue University. Most of these courses were taught in a 465-seat lecture hall. To compensate for the size of this room, a variety of special equipment had been built and a number of demonstrations adapted for use with an overhead projector (*6*). At this time, we began to investigate the use of multi-image slide techniques as an alternative, and perhaps more versatile, way of presenting visual information in the large lecture classroom. These techniques have now been used in both general and organic chemistry to introduce a variety of topics including

General Chemistry	*Organic Chemistry*
Atomic Theory	Reaction Mechanisms
Periodic Properties	Interpretation of IR and NMR Spectra
Molecular Geometry	Optical Activity
Lewis Structures	
Crystal Structures	
Qualitative Analysis	

Our work on teaching crystal structure concepts using lap-dissolve techniques has already been described (*7*).

The use of slides enables us to introduce art work or line-drawings that are superior to the drawings we can effect at the blackboard. It allows us to add graphs to discussions of tables of data. It allows us to introduce demonstrations that are either too difficult, too expensive, too time-consuming, or too dangerous to perform in the live lecture, and to show demonstrations that occur on a scale that is difficult to see regardless of the size of the lecture hall (Fig. 1). Finally, it allows us to project photographs of models which are visible to the entire class, rather than just the students in the first few rows.

It is the pseudo-animation that results from the controlled fade between the image thrown by one projector to the image from the next, however, that provides the main attraction to multi-image techniques. We can use progressive disclosure to build complex visual images step-by-step, and we can use the registration between slides to show the relationships between models or figures (Figs. 2a and 2b).

Since the effects available from lap-dissolve (LD) can also be obtained using videotape (VT) or film, it can be useful to compare and contrast these techniques.

Advantages of Lap-Dissolve

(1) A complete LD production facility, "with all of the bells and whistles," can be purchased for a fraction of the cost of a similar VT facility.

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(2) LD programs can be shot by chemists working in their own laboratories, rather than at a central production facility.

(3) LD programs do not compete in a medium where the student has experienced "Happy Days" and "Sesame Street," and good slide programs often can be produced in a fraction of the time of equivalent VT lessons.

(4) LD programs are designed to *enhance* the lecture, whereas VT programs and films are typically used to *replace* the lecture. Regardless of whether one selects a few slides to augment a portion of the lecture or builds an entire lecture around a series of 150 or more slides, the lecture is still "live."

(5) LD programs are more flexible than VT, they can be edited in minutes and changed from semester to semester or from course to course.

(6) The instructor retains control over the material to be included or excluded, the order in which this material is presented, and the rate at which the material is introduced. This factor greatly enhances the popularity of the LD technique among colleagues who are more likely to use than to develop instructional materials.

(7) The fact that the instructor retains control also enhances the ease with which instructional materials can be transferred from one course to another. This is particularly important in large programs such as ours where there are a number of courses taught by a diverse and, some might argue, opinionated faculty.

(8) By using multiple sets of projectors, and either oversized or multiple screens, it is possible to develop LD programs in which two or even three images are shown at the same time.

(9) Individual slides can be culled from LD programs, copied, and made part of audio-tutorial programs that review major concepts from difficult lectures.

(10) LD programs can be copied onto VT and made available for student use outside the classroom.

Disadvantages of Lap-Dissolve

(1) LD does not provide the true animation available with either film or VT, which can be particularly important when demonstrating psychomotor skills for pre-lab instruction.

(2) While demonstrations using LD may appear less "canned" than similar demonstrations on VT or film, since the instructor can advance the slides at whatever rate he or she desires, the LD technique is still inferior to live TV.

(3) To take advantage of the flexibility discussed above, LD programs must be disassembled and reassembled each time they are used.

(4) LD entails a continual fight to control registration during the production, mounting, and projection of the slides.

(5) It is difficult, if not impossible, to go backwards in a LD program to review a slide.

(6) It is much easier to make duplicate copies of VT programs.

Production and Use of Lap-Dissolve Programs

Multi-image techniques provide the potential for dramatic effects ranging from pseudo-animation to streaks, zooms, superpositions of images and fades. Unfortunately, these techniques require a very high order of precision or registration during the production and projection of the slides.

The slides are registered, once shot, with special slide mounts[2] that contain pins which align the sprocket holes in the film. Registration during photography therefore requires that the camera advance the film by precisely the same amount each time, so that the image lies in exactly the same position relative to the sprocket holes. When photographing large models with diffuse edges, a good 35 mm camera may provide sufficient registration. To copy artwork or line-drawings, where very tight registration is needed, a pin-registered camera is preferred. These cameras are modified so that a pair of registration pins enter and align the sprocket holes before and during exposure, thereby ensuring that the placement of the image relative to the sprocket holes is controlled with precision from exposure to exposure.[3]

Once registration has been achieved in the original photography, and maintained with special slide mounts, a pair of slide projectors are leveled and aligned[4] so that their images overlap. Since the images can overlap only if the focal lengths of the lenses are properly matched, a pair of high-precision projector lenses can prove useful.[5] There are a number of reliable dissolve control units to choose from which differ in features, convenience of operation, and price.[6]

Evaluation of Lap-Dissolve Programs

Although a carefully controlled study has not been completed, we have indirect evidence from exam statistics to support the contention that lap-dissolve programs can improve instruction. In each case we will compare results for the fall semester of a main-line general chemistry sequence with an enrollment of 1200 to 1450 students taught from the same basic set of lecture notes.

There appears to be a modest improvement in performance on hour exams. For simple questions that address concepts emphasized in the lecture, such as item 1 below, we found that 40–45% of the students answered this type of question correctly before the introduction of the lap-dissolve programs, and 60–65% answered correctly afterwards.

> Item 1. The ionic radius of Ti^{4+} is 0.068 nm and the ionic radius of O^{2-} is 0.132 nm. TiO_2 crystallizes in a closest-packed array of oxide ions. Which of the following best describes the location of the titanium ions? (a) All of the tetrahedral holes, (b) half of the tetrahedral holes, (c) one-fourth of the tetrahedral holes, (d) all of the octahedral holes, or (e) half of the octahedral holes.

Before the LD programs were implemented, 46% of the students were able to deduce the stoichiometry of a salt when told that there was a unique Mn atom at the position 0,0,0 in the unit cell and unique F atoms at ½,0,0; 0,½,0; and 0,0,½ (*8*). After these programs were used, 65% of the students were able to determine the stoichiometry of perovskite ($CaTiO_3$) from similar information, even though this should be a more difficult problem.

By using the same question on successive final exams we have been able to obtain indirect evidence on the retention of information, and the degree to which this information can be applied to questions which were not explicitly covered in the lectures.

> Item 2. CdO crystallizes in a cubic unit cell with a cell edge length of 0.47 nm. The density of CdO is 8.2 g/cm^3. How many Cd^{2+} and O^{2-} ions are present in each unit cell?

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[2] The standard slide mount for multi-image projection is produced by Wess Plastic, 50 Schmitt Blvd, Farmingdale, NY 11735. We use the #2 mount, although special slide mounts with a tolerance of ±0.001 inch are now available for use where maximum registration is needed.

[3] We use a Pro-Copy F2 pin-registered camera from Oxyberry-Richmark, 180 Broad Street, Carlstadt, NJ 07072.

[4] Projector level slides which consist of a spirit level sealed in a clear plastic slide mount are available from Wess Plastic, and registration slide sets for the alignment of pairs of projectors can be obtained from Visual Horizons, 208 Westfall Road, Rochester, NY 14620 or by contacting the author. A good projector stand such as the stacking dissolve rack (577-520) from Buhl Optical Company, 1009 Beech Avenue, Pittsburgh, PA 15233 can drastically decrease the time required to align the projectors.

[5] We use the 7.000 in. f2.5 lenses available from Buhl Optical.

[6] Further information on dissolve control units can be obtained by contacting the author.

Before the LD programs were available, this question was answered correctly by 35% of the students. Now, 50–55% of the students get the right answer.

There are several factors that complicate the analysis of these statistics. In addition to 2 or 2½ lectures on crystal structure concepts there is a 3-hour lab during which the students build models of various crystals and answer questions about these models. Over this five-year period of time we have used three different textbooks which treated the structures of solids in more or less detail. Finally, selected slides from the lap-dissolve programs were used to construct five audio-tutorial programs on crystal structure concepts, and these programs were used by 10–15% of the students on a self-selected basis. Regardless of these competing factors, we feel that there is evidence to suggest that the LD programs are an effective way of improving instruction on visually-oriented topics.

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