DOCUMENT RESUME

ED 243 643 SE 041 441

AUTHOR	Brooks, Austin E.
TITLE	Graphic Biology Laboratory Modules for the Blind.
INSTITUTION	Wabash Coll., Crawfordsville, Ind.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	82
GRANT	SED80-22031
NOTE	25p.; Appendix A is not included, not available in paper copy.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Biology; *Blindness; Braille; *College Science; Higher Education; *Material Development; *Raised Line Drawings; Secondary Education; *Secondary School Science; Tactile Adaptation; Visual Impairments

ABSTRACT

The goal of this project was to devise new methods of producing tactile facsimiles of microscopic images for the blind and visually impaired biology students at the secondary and college level. The numerous raised-line images that were produced were assembled along with brailled and large print student instructions, audio cassette tapes describing the lab materials and instructor suggestions into nine laboratory modules that include: microscopy, mitosis, leaf structure, algae, fungi, plant and animal cells, protozoans, stem structure, and root structure. The tactile facsimiles of microscopic views were made through the sequential combination of standard photomicrography, direct stencil photo silkscreening methods, and printing with heat polymerizable ink. Classroom testing under a variety of settings indicate that the durability, degree of relief and the detail of the raised-line facsimiles as well as the usefulness of the ancillary module materials was very good. Other important features of the tactile diagrams and photos produced using the new method include their low cost and portability. The potential of using the methods in other sciences (mathematics, physics, chemistry, geology, etc.) as well as non-science areas (geography, history, economics, psychology, etc.) is significant. (Author)

Graphic Biology Laboratory Modules for the Blind

Principal Investigator

Austin E. Brooks

SED80-22031

Wabash College
Crawfordsville, IN 47933

1982

APPENDIX F

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I—PROJECT IDENTIFICATION INFORMATION

1. Institution and Address Wabash College Crawfordsville, Indiana 47933	2. NSF Program DISE	3. NSF Award Number SED-8022031
	4. Award Period From 1-1-81 To 1-1-82	5. Cumulative Award Amount $19,900

6. Project Title

GRAPHIC BIOLOGY LABORATORY MODULES FOR THE BLIND

PART II—SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

The goal of this project was to devise new methods of producing tactile facsimiles of microscopic images for the blind and visually impaired biology students at the secondary and college level. The numerous raised-line images that were produced were assembled along with brailled and large print student instructions, audio cassette tapes describing the lab materials and instructor suggestions into nine laboratory modules that include: microscopy, mitosis, leaf structure, algae, fungi, plant and animal cells, protozoans, stem structure and root structure. The tactile facsimiles of microscopic views were made through the sequential combination of standard photomicrography, direct stencil photo silkscreening methods, and printing with heat polymerizable ink. Classroom testing under a variety of settings indicate that the durability, degree of relief and the detail of the raised-line facsimiles as well as the usefulness of the ancillary module materials was very good. Other important features of the tactile diagrams and photos produced using the new method include their low cost and portability. The potential of using the methods in other sciences (mathematics, physics, chemistry, geology, etc.) as well as non-science areas (geography, history, economics, psychology, etc.) is significant.

Program Code - 7775 Andrew Molnar

PART III—TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (√)	Approx. Date
a. Abstracts of Theses	X				
b. Publication Citations		X			
c. Data on Scientific Collaborators		X			
d. Information on Inventions	X				
e. Technical Description of Project and Results	▨	X			
f. Other *(specify)* Laboratory Modules Descriptive Videotapes	▨	X		X	9-20-82

2. Principal Investigator/Project Director Name *(Typed)* Austin E. Brooks	3. Principal Investigator/Project Director Signature Austin E. Brooks by Mary Emily Johnson	4. Date 6-18-82

NSF Form 98A (5-78) Supersedes All Previous Editions

Form Approved OMB No. 99R0013

SEDR DATA FORMAT

1. Award Number
SED80-22031

2. Award Date
1/1/81

3. Termination Date
1/1/82

6. Title
Graphic Biology Laboratory Modules for the Blind

4. Amount of Award
$19,900

5. Type
Final Technical

7. Performing Organization
Wabash College
Crawfordsville, IN 47933

8. Pagination
23

9. Accession Number
00842

11. Principal Investigator; Field or Specialty
Austin E. Brooks

10. Performing Organization Report Number

12. NSF Program Manager

13. SEDR Program
DISE

14. SEDR Subprogram

15. Abstract

16. Descriptors
Biology
Blindness
Secondary schools science
Laboratory equipment

17. Identifiers

18. Discipline

19. Subject

20. Target Audience

21. Availability

22. Supplemental Notes
NSF/SED-82026

The technical aspects of the project, "Graphic Biology Laboratory Modules for the Blind," can be discussed most conveniently in the following sections: I. The Best Method for Creating Raised-Line Drawings Using Heat Polymerizable Ink; II. Development of Raised-Line Microscopic Facsimiles; III. Raised-Line Images Created by Flexographic Techniques; IV. Production of Ancillary Module Materials; V. Field Testing; VI. Dissemination of Information and VII. Significance and Future Potential.

I. The Best Method for Creating Raised-Line Drawings Using Heat Polymerizable Inks.

In the sections of this report that follow details regarding all aspects of this project are discussed in some detail. So that a reader interested only in the final methods will not have to sort through all of this material, we thought it would be helpful to begin this narrative with an outline of the best method that we developed.

1. Photomicrography - Use a high contrast film (for 4 x 5 use Kodak Contrast Process Pan of 35 mm Kodak High Contrast Copy Film).
2. Prints - Make enlargements of the desired size on 8 x 10 high contrast paper (Kodak - Kodachrome II - RC).
3. Retouching - If cell parts require highlighting, it may be done at this time using a drawing ink or "white out."
4. Copy Work - Prints may be enlarged or reduced with an 8 x 10 copy camera using a litho line film (Kodalith or Polychrome). A film positive is made from the negative using the same film using the contact exposure technique.

5. Screens - Screen frames are made from 16" and 20" miter sticks, a cord stretch system. They are held together with glue and corrugated fasteners.
6. Fabric - 86 mesh (8TXX) multifilament polyester was stretched across the 16 x 20 frames by forcing cotton cord into the routed grooves on the surface of the frames. These surfaces were covered with solvent/water resistant tape. Tape is also placed around the inside of the frame where fabric and wood meet.
7. Photosensitive Emulsion - Before coating the screens they should be treated first with Ulano Microgrit and the Ulano Degreaser. After adding the diazo sensitizer, Ulano TZ, direct emulsion is scoop-coated onto the screen. The coater should be as wide as the small dimension of the screen. Several layers should be applied on each side of the screen, preferably before the previous layer dries. Emulsion is handled only under a yellow safe light. Coated screens are dried before a fan and may be stored in a cool dark location for at least one month.
8. Screen Exposure - Contact film positives are placed in contact with the printing surface of the screen and then exposed for 3½ minutes to the carbon arc illumination of a NuArc Rapid Printer plate maker.
9. Screen Washout - Unexposed emulsion is washed out using lukewarm water and the soft spray created by a garden hose pistol-type spray nozzle. Screens are then dried before a fan.
10. Screen Dressing - Pinholes and open areas near the edge of the emulsion can be filled in using Ulano Screen Filler #60.
11. Ink - Super Puff Ink from the Union Ink Company should be used.

12. Printing - Printing should be done using a vacuum frame, the flood coat technique and a squeegie with a hard rubber or polyurethane blade.

13. Polymerization - Ideally polymerization should be done immediately after printing in a 175°C lab oven for 20-30 seconds.

II. Development of Methods to Produce Raised-Line Microscopic Facsimiles

Following a computer assisted literature search, the development of the methods phase of the project was initiated. Although the methodology was continually adjusted and "fine tuned" throughout the entire funding period, this aspect of the project was essentially completed by April 1981. Two half-day trips to the Indiana School for the Blind during this time allowed seven blind and partially sighted advanced biology students to use the raised-line drawings made under varying experimental conditions and to provide feedback on what combination of methods and materials gave the best results.

SCREENS - Several types of silkscreening frames were tried including aluminum roller frames, pressed wood frames with tongue and groove corners and wood frames with mitered corners and cord grooves. In spite of the fact that fabric could be stretched quickly to a very tight condition, the roller frames tended to hold water in the tubing which proved to be a nuisance in later steps of the process. The cost of roller frames was also quite high relative to the others that were tested.

Pressed wood frames were the least expensive that we used but since the material would not take fasteners very well, the frames had to be glued. In many cases the glue did not hold up well to the water that must be used for other steps. Furthermore fabric must be stapled to the frame, a time consuming task that did not always provide tight, evenly stretched fabric.

Wood frames 1-5/8" thick and with mitered corners and a routed groove on their surface proved to be the best overall screen frame for this work. The low cost frames which could be assembled with glue and corrugated fasteners resisted warping and the stretching procedure which involves the forcing of cotton cording and fabric into the surface groove, could be done quickly and with uniformly excellent results. A 16 x 20 inch frame, the standard size, employed throughout the study could be made for less than ten dollars.

FABRICS - Two kinds of fabric were used: mono-polyester and multi-filament polyester. The adhesion of the stencil is said to be better with polyfilament but we found both to be quite acceptable. The most important aspect of the fabric is the mesh count. Meshes that varied between 74 (6TXX) and 140 (8TXX) openings per inch were tested. Although the more open meshes result in a greater ink deposit and theoretically, following polymerization, a higher degree of relief, they also produce facsimiles that are wanting for resolution. On the other hand the sharp edges of raised-line drawings prepared with finer mesh screens were often of inadequate relief. Furthermore, fine mesh screens tend to clog easily. The 86 mesh (8TXX) fabric proved to be the best compromise.

PHOTOMICROGRAPHY - All photomicrographs were made from prepared slides or fresh wet mounts using a Wild M2 light microscope equipped with a 4" x 5" sheet film holder or a 35 mm camera back. Kodak Ektapan 4 x 5 film proved less satisfactory than the higher contrast Kodak Contrast Process Pan sheet film. Of the 35 mm films tried including Kodak Plus X, Tri X and High Contrast Copy film, the latter proved most useful. Whatever film is employed, it is desirable to utilize one of high contrast in order to eliminate many of the intermediate grey tones. All films were processed using Kodak chemicals according to the manufacturers' instructions.

Routinely the negatives were enlarged using a Durst Laborator Model 138S enlarger to make 8" x 10" prints. Once again the use of a hard or very hard grade resin coated paper (Kodak Kodachrome II R.C.) further eliminated some of the grey tones.

At this point in the process a minimal amount of retouching was carried out. This most often involved the highlighting of certain indistinct portions of the cell such as membranes.

The prints were then copied using 8" x 10" litho film (Kodak Kodalith or Polychrome) in a copy camera that allowed for enlarging or reducing the image as required. Positives were then made from the large format negatives by contact exposure onto litho film unless further size changes were necessary in which case the 8" x 10" negatives were rephotographed with the copy camera. The litho sheet films were developed in a two step process according to the manufacturers' directions. If further augmentation of the images was deemed desirable it was done at this point. A typical modification might involve clearing the dense cytoplasm around a nucleus so that the latter might be more easily identified on the final raised-line drawings.

Black and white line drawings of the correct size did not require any further copy camera work. If they were prepared on frosted acetate, a photo-stencil could be prepared directly from them. Artwork on standard drawing paper could be made into transparencies using a standard photocopy machine (Minolta Model EP-520) and the appropriate transparency sheets. (It is also possible to enlarge crisp black and white artwork without going "on camera." One simply needs a copy machine that has enlarging capabilities. We used a Canon 400 which enlarges at increments of 27%. We have enlarged some artwork four successive times without loss of detail. A transparency can then be prepared from the final enlargement.)

STENCIL PREPARATION - Before stencils can be applied to the screens it is necessary to lightly scrub the fabric with an abrasive containing solution (Ulano Microgrit) using a small brush. This roughens the threads of the fabric so that the stencil emulsion adheres well. This is only necessary on new fabric and thus represents a one time treatment. Next the fabric is treated with another solvent to remove oils and grease (Ulano Degreaser). Degreasing must be done each time a new screen is applied.

Two kinds of photographic stencil materials were used in this project. For nearly all of the stencils that were used, we employed the direct emulsion technique using a diazo sensitized, water resistant product (Ulano TZ). The mixed emulsion which has a shelf life under refrigeration of at least six months, was applied to both sides of a cleaned screen using a scoop coater. To avoid overlap of emulsion in the center of the screen the scoop coater should be nearly as wide as the shorter dimension of the screen. Several coats are layered on each side before the previous layer has dried, a technique known as the "wet on wet method." All coating operations must be carried out under yellow light.

Screens were allowed to dry in the darkroom in front of a fan. Fan drying is important because it sets the emulsion quickly preventing sags and runs. Dry coated screens were stored in black plastic garbage bags in a cool dry location. Prepared screens could be stored in this way for at least a month with no loss in quality.

The indirect stencil method was also used to prepare several raised-line drawings. Since a variety of sizes and small quantities are readily available, this product (Ulano Poly Blue II or Ulano Hi Fi Green) is in some ways more convenient to use and store than the liquid emulsions.

STENCIL EXPOSURE AND WASHOUT - The film positive was placed directly in contact with the unexposed coated stencil. The positive side was placed in front of the carbon-arc illumination system of a Nu-Arc plate maker for 3½ seconds. Other kinds of light sources may be used such as mercury vapor lamps, pulsed xenon, metal halide and, for the films, even banks of 4-6 fluorescent tubes or photoflood bulbs. With any of the possible systems, films or emulsions, a calibration relative to light intensity, exposure time and development time must be done.

After exposure the emulsion treated screens are simply washed out using lukewarm water with a garden hose spray nozzle. Areas protected by the dark regions of the positive film readily wash away leaving only the mesh work of the fabric. In other words a negative type image again is apparent on the screen. It is important that washout is extensive enough to clear all of the openings. Screens are then dried with a fan.

The film type stencils are exposed in contact with a film positive before being placed on the stretched screen. The stencil is then developed in a tray according to the manufacturers' instructions and then washed out as previously described. The wet film stencil is adhered to the fabric by laying the rinsed stencil film, sticky side up, on a stack of newspapers. The screen is then placed on the film and blotted with newspapers. Use of a roller helps insure good contact of stencil and fabric. The screen is dried before a fan and then the acetate backing of the stencil film is peeled away making the stencil ready for printing.

The principle characteristic of photographic stencils is that the light exposed parts of the stencil film or coated emulsion, harden, -- the emulsion type immediately, the film type only after development. The parts of the film or emulsion that are protected from the light by the opaque artwork or film positive remain soft and then can be washed away leaving openings defining a faithful negative replica which can be printed through the unobstructed fabric to make a positive.

SCREEN DRESSING - With either stencil film or emulsion coated type screens, the screens must undergo a final "dressing" to block out any pinholes in the image area and to any fabric near the edges of the screen that did not receive a complete coating of emulsion or film. Ulano Screen Filler #60 was applied to the inside of the screen. When the block-out is dry a strip of solvent resistant tape is then placed over the edge seam, on the down side of the frame, and along the right angles of the printing side, to prevent ink from getting under the frame and to allow for easier cleanup.

INKS - Two inks were used in this project. Paint Puffer Paint (Polymerics Inc.) is a water-base ink that may be polymerized or puffed in either a wet or dry condition by placing prints in a 120°C (250°F) oven for between one and two minutes. Although the water cleanup feature of Paint Puffer Paint is desirable, the ink tends to dry so quickly that screens clog after only a few prints. Diluting Paint Puffer Paint with water did slow the drying time but it also reduced the ink deposit to the degree that the resulting polymerized prints had inadequate relief. Even flood coating opposed to the normal clean application did not alleviate the rapid drying problem significantly.

The second ink used, and by far the most useful, is known as Super Puff (Union Ink Co.). This petroleum base ink is very slow to dry which made printing much easier. However, if it is not polymerized within a half hour of printing a solvent halo is usually apparent around the pigmented material. This did not in any way impair polymerization. Ideally polymerization should take place just after printing in an oven at 175°C (320°F) for 30-40 seconds. The texture of polymerized Super Puff feels very much like latex which the visually impaired students found to be more desirable than the softer feel of Paint Puffer Paint. Super Puff may be cleaned from the screen using mineral spirits or turpentine. If it is allowed to air dry the screen is very hard to reclaim.

PRINTING - Printing was done on a small (30" x 30") vacuum table that was made by routing grooves in plywood every inch to make a checker board pattern of ¼" wide/¼" deep channels. The grid pattern was joined by two diagonal grooves. After laminating Formica to the surface, a 1/32" hole was drilled at the center of each intersection of the grooves. At the very center where the diagonal grooves intersected a 3/4" hole was drilled from the bottom. Standard 3/4" plastic plumbing fixtures were used to cover the hole and link the routed channels to a small shop vacuum.

The use of a vacuum table is essential with the two inks that were used in this project. Their extreme viscosity meant they had a tendency to stick to the screen following printing and removal very often caused smearing of the print. With the vacuum table prints being held down to the table, the screen could be lifted away with no chance for lateral movement and smearing of the image. All prints were on 8½" x 11" light or heavyweight braille paper (Howe Press).

III. Raised-Line Images Created by Flexographic Techniques

The end result of the flexographic process is flexible high relief 8" x 10" printing plates. Although these plates are used with flexographic presses for a variety of commercial printing operations, they also are used to make the image forming layer or dye of a rubber stamp.

Using flexographic methods it is possible to create an elastic, high relief dye from a high density photographic negative in essentially a single step. Negatives are placed in contact with the unexposed plate material in a special ultraviolet light vacuum top exposure unit.

The ultraviolet light cures or hardens the plate material (the transparent areas of the negative) and any area that has been protected from the illumination (the dark areas of the negative) can be brushed away with the appropriate solvent (equal parts perchloroethylene/trichlorethylene). Following drying the plate is ready for use.

In consultation with Dr. Peter Wacher, a photochemist with the DuPont Chemical Company, and Mr. Richard Jacob of the Photoproducts Division of Uniroyal Inc., the potential for producing raised-line microscopic facsimiles by flexographic methods was explored.

The 8" x 10" plates of micrographic images that were produced (please see the attached samples in Appendix A of the narrative) were judged to have very good potential for use with the visually impaired and totally blind students. The degree of relief on these facsimiles is very high and the durability is exceptional.

The single disadvantage of raised-line materials created by the flexographic process is their relatively high cost. A typical 8" x 10" plate of Cyrel ® (DuPont Chemical Co.) would cost nearly $5.00 as compared with about $0.25 for the heat polymerized ink/paper counterpart. Besides the exposure of the unexposed plate material itself, several large pieces of equipment are required, including: an exposure unit, a processor, a dryer and a finishing hood. Total cost for these items would be nearly $11,000. There would also be a reoccurring cost for solvents. Nevertheless a residential school for the blind or a large school system or university that regularly has a number of blind students might find that the investment in flexography microscopic facsimiles is cost effective over a long time.

IV. Ancillary Materials

In addition to the raised-line drawings and high relief microscopic facsimiles that form the heart of each of the nine graphic laboratory modules, all of the modules have taped audiocassettes, a set of student instructions presented in braille as well as large inkprint formats, suggestions for the teacher, and an inkprint translation of the cassette script. Most of the modules contain a set of self stick labels which may be used in combination with the Student Instructions and raised-line images.

AUDIOCASSETTES - After writing and editing, audioscripts were recorded onto a master tape using a standard tape recorder (Panasonic). Duplicates were then made on standard 30-minute cassettes (TDK) using a high speed tape duplicator (Wolunsak 2770).

STUDENT INSTRUCTIONS - Large print student instructions were prepared on standard bond paper using the upper case characters of an Orator element on an IBM Selectric typewriter. Since carbon ribbon type has a tendency to smear, multiple copies were prepared using a photocopy maching (Minolta Model EP-520).

Brailled student instructions were typed page by page using an IBM Model D braille typewriter. Grade I braille was used exclusively at the suggestion of Ken Ricker (University of Georgia) who is well known for his work in developing lab materials for blind students. According to Dr. Ricker, the derivation of and relationship between technical terms is more easily appreciated using a Grade I translation than it is using Grade II, which makes use of numerous contractions and truncations to conserve space.

LABELS - Initially combination large print/brailled labels were prepared on standard pressure sensitive computer address labels. Using the upper case of an Orator element on an IBM Selectric II Typewriter the appropriate words were typed on the bottom edge of each label. Duplicates were then made by hand feeding fresh label sheets into a photocopy machine (Minolta, Model EP-520). Brailling was done on each set of labels by typing on the reverse side of the labels near the top so the embossments were properly oriented on the final labels. The labels were then stapled onto a standard three-hole punched page so that they could be inserted into a three-ring notebook with the raised-line microscopic facsimiles and other ancillary materials.

Although the computer labels were satisfactory, several features proved undesirable. The amount of hand work required to prepare them was excessive. More importantly, blind students found the labels difficult to use because they were so sticky. Even if a small corner inadvertently touched the paper the label was stuck. Removing it caused some of the paper to be torn away leaving a damaged raised-line drawing and a label that would not stick tight when reapplied.

A second problem was that once a label had been used on a drawing the raised dots still were apparent on the computer label backing sheet. Although the texture of the backing sheet was smoother, some students had trouble making the distinction between the backing sheet and the labels.

An attempt was made to screen braille, using the heat polymerized inks, onto pressure sensitive labels but the temperatures required for polymerization of the ink reduced the adhesiveness of the labels to the degree that they would not stick very well.

The last set of modules utilized an 8½" x 11" page of heavy braille paper which contained 16 perforated units per page. Large print was photocopied onto the units and braille was screened using heat polymerizable ink. On the reverse side of each label unit, we placed 3M HiTac-LoTac tape. This material has high adhesive characteristics on one side so that when applied it becomes permanently attached to the back of the perforated labels. Removal of a paper backing strip exposes a layer of adhesive that is tacky. This sort of adhesive allows the separated labels to be positioned and then moved without any damage whatsoever to either the raised-line image pages or the labels. Replacing the paper backing on the tacky side of the label protects the adhesive so the labels may be reused again and again.

V. Field Testing

Classroom testing was started in November of 1981, and will be completed at the end of the spring semester 1982. The materials will have been used under a variety of academic settings which include the following: 1) with students at a residential school for the blind, 2) with adult students at a technical college, 3) with undergraduates at two different state universities, 4) with a blind/deaf college student, 5) with a high school student/itinerant teacher team, and 6) with a mainstreamed high school student. A list of the test schools and the supervising teachers appears in Appendix B of this narrative.

A questionnaire accompanied each of the laboratory modules. The short answer questions on the questionnaire were directed at both the blind or visually impaired student and his or her teacher. A sample questionnaire is included in Appendix B.

Although some of the field testing is still ongoing at the time of this writing, there have been enough responses to draw several tentative conclusions. First and perhaps most importantly, all of the users agree that the raised-line microscopic facsimiles are a useful teaching tool. Several were judged to be, as we expected, difficult to interpret but most were of adequate relief and detail to be most instructional. The student instructions/activities were deemed to be clear and of educational value. The weakest part of the modules were the audio cassette tapes. It was generally agreed that the information presented was accurate but that it would have been more useful in the educational sense, if tapes were more closely related to the individual courses in which the modules were being used. Perhaps the most productive way to utilize the raised-line microscopic facsimile methodology is to supply the tactile illustrations in groups of related subjects with optional student directions/activities and no audiotape. Teachers then could make their own tapes, tailored in their vocabulary and depth of presentation to individual needs.

VI. Dissemination of Information

Information regarding the project has been disseminated in several ways. Between October 1981 and April 1982, the Principal Investigator has made eight presentations regarding various aspects of the project. This includes two workshops, two poster session presentations and five lectures. The dates, nature and location of these presentations are listed in Appendix C.

A paper describing the methods and teaching materials developed in the course of this work is currently in manuscript form. It will be submitted in August 1982 to the Biology Teacher, the official journal of the National Association of Biology Teachers. Assuming that the paper is accepted, it should be published by January 1983.

A second paper will be prepared describing a new method of producing multiple copies of heat polymerized Grade I braille text. This method, which will be described in detail in the "Significance and Future Potential" section of this report, will be written up in August 1982 for publication in the Journal of Special Education Technology.

A third method of disseminating information about the project will begin in July 1982. A fifteen minute videotape will be produced describing and demonstrating the various methods that have been developed, the modules themselves and how the modules may be used. A free-lance video technician, Jennifer White, will be involved with all aspects of this phase of the project including script review, filming and editing. The master tape will be duplicated and distributed to each of the Special Education sections of the various State Departments of Public Instruction as well as to several national service organizations for the blind.

VII. Significance and Future Potential

The raised-line drawings that have been produced using the methods developed in the course of this research have three significant attributes including: 1) faithful rendition of the microscopic image, 2) very low cost relative to other methods of representing microscopic views (e.g., thermoform and plastic three-dimensional models) and 3) excellent portability-packaged in a three-ring notebook students can easily take home for further study.

Virtually any microscopic preparation be it a living wet mount or a view of a prepared slide may be made into a raised-line drawing using materials that are available from any art store and equipment that is standard in all college biology and art departments.

Although we have not made raised-line drawings for academic areas other than biology, it has not escaped our attention that the methodology may have applications in several other of the sciences including: chemistry, physics, geology, engineering, architecture and especially, geography. Outside of the sciences the technique may provide useful tactile materials for economics, psychology, political science, history, theatre, mathematics, and certain areas of art. There are also certain technical subjects such as electronics that might benefit from these techniques.

A literature search also has revealed that the learning of students with certain cerebral dysfunctions is greatly improved if they are presented with tactile as well as visual educational materials. This suggests that the new methodology may have educational uses for a much larger student population than we had originally anticipated.

One further aspect of the present project that was alluded to earlier should be mentioned at this point. With the help of Mr. Roger Hoover, a Wabash undergraduate at the time, we have developed a computer program that allows for the translation of a text file, constructed through the use of word processing software (Data Design, Word II) into Grade I braille. The output device is a high speed dot matrix printer (Printronix). The inkprint braille pattern output is then converted to a transparency using a photocopier. From the transparency we can make a screen using either the indirect film or the direct emulsion method. The resulting prints are polymerized as previously described.

The tactile braille that we have produced by these technologies has been read by four different blind braille readers. Each has indicated that the computer generated/silkscreened braille is read without difficulty.

Being able to make multiple copies of braille that is one hundred percent accurate without the use of highly specialized equipment could be an important development for the education of the blind and visually impaired.

VIII. Summary

In the past 12 months we have developed two methods to translate microscopic images into tactile raised-line drawings. The first combines the techniques of photomicrography and photo-silkscreening with the use of heat polymerizable ink. The raised-line drawings that result are of low cost, high relief, good desirability and most importantly, represent faithful facsimiles of the original microscopic images. With the second method photomicrographs are converted to elastomeric printing plates. Although these facsimiles are relatively expensive, their relief is very high and they are of exceptional durability.

Using the heat polymerizable ink method, 63 raised-line microscopic facsimiles have been produced. They have been assembled along with audio-cassettes, self-stick labels for the drawings, a set of student instructions, and suggestions for the teacher into the following nine laboratory modules: microscopy, animal and plant cells, mitosis, algae, fungi, protozoans, leaf structure, stem structure and root structure.

Field testing was carried out in public and private secondary schools, at several different universities and at a residential school for the blind. Information regarding the work was disseminated at two national meetings and several regional conferences. At least two publications will result from the work and a descriptive videotape will be sent to each of the state departments of education and several national service agencies for the blind.

Also in the course of this research a computer program was written that allows for the translation of a standard text file into an inkprint braille facsimile. A screen can be made from this and subsequently multicopies of legible heat polymerized braille can be produced.

Appendix A was removed by author.

APPENDIX B

Becky Hunton
Indiana School for the Blind
Indianapolis, Indiana

Clark O. Wilder
Roy J. Wasson High School
Colorado Springs, Colorado

Pat Willman
Instructor
Department of Biological Sciences
Purdue University
West Lafayette, Indiana

Bashir A. Masodi
Special Education Coordinator
Lew Wallace High School
Gary Community Schools
Gary, Indiana

Margot Gusick
United Nations School
24-50 East River Drive
New York, New York

Regina Potter
VI Department
Milwaukee Area Tech
1015 N. 6th Street
Milwaukee, Wisconsin

Carole Bateman
Gallandet College
Washington, D.C.

Ruth Deweel
Department of Biology
Appalachian St. University
Boone, N.C.

GRAPHIC BIOLOGY LABORATORY MODULES FOR THE VISUALLY IMPAIRED QUESTIONNAIRE

MODULE ON ____________________

STUDENT SECTION

A. Raised-Line Drawings and Photos

1. The relief is inadequate______ adequate______

2. THe detail is too simple______ about right____ too hard______

3. The size of the drawings and photos are

too small______ about right____ too large______

4. The number of raised line drawings in this module is

too small______ about right____ too many______

B. Student Activities

5. The directions for activities are unclear______ clear______

6. The amount of work required is

too little______ about right____ too much____

7. The braille is accurate__________ inaccurate________

readable__________ illegible________

The large print is readable______ illegible__________

8. Student understanding of the topic presented in this module is

helped by the activities______ not helped by the activities______

C. Audio Tapes

9. The information presented in the tapes is

too detailed______ about right______ of not enough detail______

10. The speed of the narration is slow______ about right______ fast______

11. The audio quality of the tapes is poor______ good______ very good________

D. Other Student Comments

12. The notebook format is a good idea________ bad idea________

13. Labels were hard to use__________________ easy to use________

14. Designations for identifying pages, tapes, etc. were

easy to follow______ hard to follow______

15. My overall rating of this module is poor ____ fair ____ good ____

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TEACHER SECTION

1. The grade level of this student is ______

2. The age of this student is ______

3. The visual acuity of this student is ______

4. This student became visually handicapped at age ______

5. Setting in which module was used laboratory______ classroom______

special session ______ other______

6. Amount of time student spent on module______

7. The amount of time teacher had to spend with student to complete work was

small______ about as much as with sighted______ great______

8. In terms of biological education, the materials included in this module

did little to enhance the student's understanding______

helped the student to understand the topic______

helped greatly in understanding the topic______

9. The quality of the materials including tapes, notebooks, paper, labels and so forth is poor______ good______

10. These materials should be marketed yes______ no______

11. What would you consider a fair price for a given module? ______

12. Are there components in the modules that are not useful? no______

yes______, explain______

13. What should be added to the module to make it more useful? ______

______

14. Other biological topics that would be useful to have in this form:

1. ______
2. ______
3. ______
4. ______

15. Overall rating for this module is poor______ fair______ good______ very good______

16. Other comments:

APPENDIX C

TALKS AND MEETINGS

October 9-10, 1981
Association of Midwestern College Biology Teachers
Carroll College, Waukesha, Wisconsin

October 17, 1981
Workshop, Expanding Horizons
Crawfordsville Public Library
Crawfordsville, Indiana

November 19, 1981
Seminar - Microscopy for the Visually Impaired
Biology Department
Wabash College
Crawfordsville, Indiana

November 6-7, 1981
National Association of Biology Teachers
Annual Meeting
Las Vegas, Nevada

November 20-21, 1981
Indiana Academy of Science
Annual Meeting
Wabash College
Crawfordsville, Indiana

February 2, 1982
Lecture, Workshop
Biology and Education Departments
Purdue University
West Lafayette, Indiana

February 5, 1982
Hoosier Science Teachers Association Inc.
Annual Meeting
Indianapolis, Indiana

April 1-5, 1982
National Association of Science Teachers
Annual Meeting
Chicago, Illinois

April 23, 1982
Conference on Science for the Handicapped
Anderson College
Anderson, Indiana