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Do Hands-On, Technology-Based Activities Enhance Learning by Reinforcing Cognitive Knowledge and Retention?

Anthony R. Korwin
Ronald E. Jones(1)

INTRODUCTION

Technology education has passed through explicit phases from manual training through manual arts through industrial arts, to contemporary programs in industry and technology. These phases have been based on different psychologies and therefore, have produced varied rationales. Since the 1900's, one common link has been that the field is purported to be an important part of general education and therefore, can provide a meaningful educational experience.

In St. Louis around 1870, Calvin Woodward decided that the most effective method to "...illustrate certain mechanical principles..." was to have his students construct models out of wood (Barlow, 1967, p.34). Woodward felt that this particular hands-on experience demonstrated a practical use for various engineering precepts. It was this reliance on objects, tools, and materials to teach mathematical and engineering theory that produced manual training and eventually, industrial arts ideology.

Industrial arts, though, evolved more into a discipline oriented toward developing skills for the skills themselves rather than developing a knowledge of industry. Hands-on activities included building projects that incorporated the learning of "...technical processes without conscious concern of the socio-cultural context in which they exist..." (Lauda & McCrory, 1986, p.28). In recent years, technology education has focused on the use of tools and materials to help students understand concepts in technology and its relationships to various areas of education.

In the transformation of curricula, the common denominator has remained hands-on experimental activities. Industrial arts has always used various projects to stimulate interest, develop skills, and increase learning. Technology education has continued to focus on hands-on activities and modified them, helping students become technologically literate by developing problem solving adaptation skills and a positive attitude toward technology (Martin, 1985). However, one might question the hands-on activity approach as an appropriate and effective basis for learning in industrial arts and technology education.

The purpose of this study was to determine if hands-on technology-based activities enhance learning among eighth grade students by reinforcing cognitive knowledge and improving retention. Generally, it was designed to find out if increases in knowledge and subject interest were greater for those students given the opportunity to reinforce learning through laboratory activities. Specifically, the study addressed the following questions:

1. Is there a significant, measurable, knowledge increase when technology-based hands-on activities are used to supplement regular classroom presentations? RESEARCH HYPOTHESIS #1: Students participating in a hands-on group assignment would have higher scores the day after instruction than students receiving an illustrated lecture.

RESEARCH HYPOTHESIS #2: Students participating in a hands-on group assignment would have higher scores (on a test given after two weeks) than students receiving an illustrated lecture.

2. Do these hands-on activities establish greater retention of information presented?

RESEARCH HYPOTHESIS #3:There would be no retention loss between the first and second post-test for the hands-on method of instruction.

RESEARCH HYPOTHESIS #4: There would be no retention loss between the first and second post-test for the illustrated lecture method of instruction.

BACKGROUND

Educational theory supporting psychomotor activities to aid cognitive growth had its origins in the 1700's. Though experiences were often part of personalized education, such as apprenticeships or trades passed from generation to generation, Jacque Rousseau and JoHann Heinrich Pestallozzi proposed that doing was not an end in itself, but a way of expanding learning (Barlow, 1967). Later, many theorists provided support in favor of learning experiences that allowed the student active involvement with the subject matter. Jean Piaget, who developed a continuum of cognitive development, believed that a child could construct a more permanent knowledge base by experiencing something rather than just being told (Schwebel, 1973).

John Dewey, known for his many innovative educational philosophies and support of industrial arts education, was of the strong opinion that experiences, specifically hands-on activities, were imperative in the educational process. Students could blend theory and practice, success and failure, and school and society into a mental foundation for future thought (1980). Furthermore, activities allowed them to see, raise, and seek out solutions for personal and motivational questions. Dewey believed, however, that teaching skill for skill's sake was "...illiberal and immoral" (1963, p. 260). His ideas concerning skill training in education are summarized as follows:

> The educator is to engage pupils in activities in such ways that while manual skill and technical efficiency are gained and immediate satisfaction found in the work, together with preparation for later usefulness, these things shall be subordinated to education -- that is, to intellectual results and the forming of a socialized disposition. (p. 197)

Dewey further commented that "...any mode of skill which is achieved with deepening of knowledge and perfecting of judgement is readily put to use in new situations and is under personal control" (p. 259).

Bruner (1966, p. 41), a supporter of varied learning experiences, stated that "...increasing the manipulability of a body of knowledge" creates both a physical and mental optimum learning structure and contended that physical operations create feedback of learning that allow children to see it happen. Lipson and Fischer (1983) sustained this reasoning, stating "Experiences without words are difficult to integrate, describe, and retrieve. Yet, words without experience tend to have limited meaning. The two reinforce each other and are defined by one another" (p.254). Martinez (1985) further explains this in saying that a student who is introduced to a concept such as walnut wood will grasp a different meaning than a student who actually uses walnut and experiences its properties firsthand.

Human memory has been the basis for much research and speculation on how information is processed, saved, and retrieved. Researchers have identified two types of memory: short term and long term. During the past ten years, developments in memory research identified four separate memories within the long and short term. Just as a computer requires different microchips to handle screen memory, printer memory, computer language, and so forth, Adams (1976) identified separate memories each for auditory, visual, tactile, and body motor functions. This implies that any information that more fully utilizes all four memories would be stronger and more easily retrieved. Craik and Lockhart (1972) believed that memory is reliant on the depth that information is processed by more memories and strengthens the learning potential. In their research, Boothby and Alverman (1984) found that visuals, used in conjunction with lecture material, increased comprehension and retention of information.

A myriad of studies were found that dealt with the cognitive, psychomotor, and affective domains. Many research combinations concerning the three domains were located, with the exception of those addressing the use of psychomotor activities to increase or enhance cognitive learning and affective attitudes and motivation. Clark (1967) studied physical performance as it related to both cognitive and psychomotor learning activities.

A review of literature revealed that technology education has a basis in using hands-on activities to relate concepts. Educational theorists have stated that hands-on activities or experiences can lead to greater cognitive gains. Previous research, however, has not addressed the cause and effect relationships between psychomotor activities and cognitive results; therein lies the basis of this study.

METHODOLOGY

The objective was to find out if any measurable knowledge increases occurred when hands-on technology-based activities were used to supplement regular classroom presentations. First, objectives and lesson plans for two separate teaching environments were developed by the instructor and validated by a team of educational and technical experts. Then, four eighth grade classes in industrial arts and math were selected to participate, as they were considered representative groups of students. The students were randomly divided into two groups. Duplicate enrollees were scheduled only once, resulting in a sample of 50 of 72 possible eighth grade students.

Two methods of instruction were used by one instructor in teaching a 40 minute technical concept on geodesic domes to the 50 students. Group A (25 students) received information through reading and a hands-on group assignment, while Group B (25 students) received information through reading and an illustrated lecture. The hands-on assignment involved the construction of a model geodesic dome, using straws and pipe cleaners, while the illustrated lecture used slides and transparencies to show examples of designs and construction. A post-test was administered the day following the lessons to determine cognitive gains of each group. Two weeks after the presentations, students were again given the post-test to measure retention levels. Post-test results were compared to test the hypotheses.

The testing instrument was developed using the objectives and information to be covered as guidelines for test questions. An effort was made to avoid creating a test that was only repetition of facts. While some questions did require simple fact recognition (for example: "Domes were used as early as...") other questions required mental calculations or thought (example: Which of the following is not an advantage of using triangles over rectangles?). Questions were pilot tested by administering them to a seventh grade reading class. A computer generated test-item analysis was completed to identify possible poor discriminators. A re-analysis of those questions resulted in one item being removed, leaving the total number of questions at 22. A Kudar-Richardson analysis (KR 20) calculated a coefficient of reliability of 0.618 for the first post-test scores.

After the first post-test scores were finalized, the average score of Group A and Group B was calculated based on the number of students in each group. These mean values were compared, (using the Statworks program for the Apple Macintosh computer,) to calculate an unpaired t-test. Two weeks later, the second post-test for each group was administered and the results were compared using an unpaired t-test of significance. In addition, the second post-test scores of each group were compared with the initial post-test scores, using a paired t-test, to specify knowledge retention for each group. The scores were tested at the .05 level of significance using critical values of statistical results based on 48 degrees of freedom (Hinkle, Wiersma, and Jurs, 1979).

FINDINGS AND DISCUSSION

Specific questions were posed to study the effectiveness of hands-on activities versus stand-alone classroom lecture presentations. The findings are illustrated in Tables 1 and 2.

TABLE 1
T-TEST COMPARISON OF THE MEANS FROM THE FIRST POST-TEST, NEXT DAY

Group	N	Mean	SD	DF	T	P

A (Hands-on Assignment)	25	14.52	2.74			
B (Illustrated Lecture)	25	11.88	3.02	48	3.24	.002

TABLE 2
T-TEST OF MEANS OF THE SECOND POST-TEST COMPARISON, AFTER TWO WEEKS

Group	N	Mean	SD	DF	T	P
A	25	13.76	2.91			
B	25	11.56	3.54	48	2.40	.020

QUESTION #1: Is there a significant, measurable knowledge increase when technology-based hands-on activities are used to supplement regular classroom presentations?

CONCLUSION: As shown in Tables 1 and 2, Group A had a greater score on both post-tests. From the statistical comparisons of Group A and Group B on post-test #1, it can be stated that there is a significant difference between learning with and without hands-on activities. The results suggest that organized psychomotor participation increases the learning of a given technological concept. It can be generalized that hands-on activities are effective learning experiences for any applicable concept.

QUESTION #2: Do hands-on activities establish greater retention of information presented?

CONCLUSION: As shown in Tables 3 and 4,

scores between post tests did not support any significant loss of knowledge for either Group A or Group B. It was concluded that both teaching methods were adequate to enable students to retain information they had learned. Group A did lose slightly more information after two weeks, but still had significantly more knowledge than Group B. It can be generalized that retention abilities are consistent for most individuals; therefore, if one student learns more than another student, he/she will retain more information over a period of time.

TABLE 3
T-TEST COMPARISON OF RETENTION, GROUP A

Post-test	N	Mean	SD	DF	T	P
Next day	25	14.52	2.74			
After two weeks	25	13.76	2.91	24	1.58	.127

TABLE 4
T-TEST COMPARISON OF RETENTION, GROUP B

Post-test	N	Mean	SD	DF	T	P
Next day	25	11.88	3.02			
After two weeks	25	11.56	3.54	24	.54	0.591

IMPLICATIONS AND RECOMMENDATIONS

The results of this research have significant implications for general education and specifically technology education. The results suggest that hands-on activities enhance cognitive learning. Previous studies neglected to address psychomotor effects on cognitive growth, even when many educational theorists, like Dewey, supported learning using psychomotor experiences. The results also suggest that technology education has a strong basis in learning theory in its use of hands-on activities to relate technological concepts. This is done in part by improving short and long term memory retention of information through greater use of visual, auditory, tactile, and motor memory storage areas of the brain.

The study is a foundation on which additional studies can construct a more concrete platform of support for the use of hands-on activities in all educational subject areas. To aid further research attempts, the author recommends:

1. other research utilizing various technology-based hands-on activities should be conducted to further delineate the findings of this study;
2. research should be completed using different age levels (K through 12) of subjects; and
3. research should be completed with regard to levels and degree of cognitive understanding, for example, analysis, synthesis, and evaluation.

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1 Anthony Korwin is Coordinator, Industrial Cooperative Education, East Aurora High School, Aurora, Illinois. Ronald Jones is Professor, Department of Industrial Technology, University of North Texas, Denton, Texas.

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