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ABSTRACT

This paper describes a reality-based learning project in which sophomore accounting and engineering students collaborated in interdisciplinary teams to design and build a million-dollar waterslide park. Two weeks into the project, the teams received a briefing from an industrial panel of engineers, bankers, entrepreneurs, and other professionals. Three weeks later the teams presented oral and written preliminary reports to their peers and instructors, followed by a progress report presentation at mid-term. The industrial panel then evaluated the progress reports and provided feedback. At the final presentation, teams provided drawings, scale-models, marketing materials, and financial statements to the industrial panel, which evaluated the projects and decided that two of the team projects were worthy of funding. Team members kept journals during the entire project, and evaluated their fellow team members through a fictitious $10,000 bonus to be divided among each team based on the work of each member. The paper concludes by evaluating the strengths and weaknesses of the student teams, which often had difficulty working together and responding to change. (MDM)

Reality-Based Learning and Interdisciplinary Teams: an Interactive Approach Integrating Accounting and Engineering Technology

By Robert L. Rogers and Michael J. Stemkoski

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Introduction

What do you get when you mix a sophomore accounting class, a sophomore fluid mechanics class, a top notch industrial panel, and a real-world accounting/engineering problem? A viable plan to design and build a million dollar waterslide park in the Klamath Basin of Oregon complete with location site plans, forecasted financial statements, marketing analysis, engineering drawings, scale models and business plans.

We intended in the Accounting and Mechanical Engineering Technology Departments, to develop a team-based project allowing accounting and engineering students to work together. We had worked in industry on cross-functional team-based projects in product development, but there were many questions to answer when students were involved.

Would students respond to team-building efforts at the *sophomore* level? How would students work together in *interdisciplinary teams* with no prior training? How would students handle a *reality-based* project? How would they react to being *observed and evaluated* by an industrial panel?

We had no guidance to undertake this type of endeavor with students. We were entering the unknown. There was risk from the beginning as colleagues became critics, lining up as "in support of" or "opposed to" the concept. Could technical and interactive qualities be integrated to allow for quality improvements in the student? What would be the outcomes?

Objectives

The objectives of the team-based interdisciplinary project were to have accountants and engineers learn the technical knowledge in the courses they where taking and enhance their abilities through interdisciplinary team-based learning. They were to learn and enhance their:

- Ability to effectively communicate orally and in writing,
- Ability to think creatively and listen effectively,
- Ability to resolve conflict and develop knowledge in leadership,
- Ability to develop team-based unstructured problem solving skills,
- Ability to make suitable inquiries and gain an awareness of the benefits of continuous self-directed learning,
- Ability to organize effectively and meet deadlines,
- Ability to integrate quality and process improvements in product development,
- Ability to integrate technology and ethical considerations in product development, and
- Ability to reorganize problem solutions through cooperative team-based analysis.

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These "interactive qualities," sought by industry, are widely supported by current literature. The MIT Commission on Industrial Productivity wants to:

> Create a new cadre of students and faculty characterized by (1) interest in, and knowledge of, real problems and their societal, economic, and political context; (2) an ability to function effectively as members of a team creating new products, processes, and systems; (3) an ability to operate effectively beyond the confines of a single discipline; and (4) an integration of a deep understanding of science and technology with practical knowledge, a hands-on orientation, and experimental skills and insight (Dertouzos 157).

Future graduates must be able to cross boundaries and function in many capacities. Steven R. Rayner states in his book *Recreating The Workplace: The Pathway To High Performance Work Systems* "Today, virtually every major corporation is experimenting with team-based work design, up from a tiny percentage a decade ago. It is staggering to consider that by the turn of the century half of all employees will find themselves operating as members of a team" (5).

Since industry is using cross-functional teams, we felt a need to implement the team-based learning experience with a practical real-world problem. Technology programs throughout the country claim to be different because they offer practical experience, along with laboratory or engineering classes. Practical experience enhances real-world awareness within these classes. To create a practical experience and achieve the required technical skills and the interactive course objectives, we designated the following characteristics to be necessary:

1. A real-world, team-based and cross-functional project was needed to transfer echnical and interactive skills to the students.
2. A real-world, team-based project was needed to provide the industry outcomes desired for cross-functional, interdisciplinary work skills.
3. The students needed to understand the objectives of Integrated Product Development (IPD).
4. Evaluations were needed to determine if interactive abilities have improved.
5. The project proposal needed to be completed in one term.
6. The interdisciplinary approach needed to effectively place the student at the center of the learning process.
7. The students needed to develop work-ready product development and team-building skills.

Even though we still had more questions than answers, we decided to go ahead with the classroom experiment. Students were intuitively analyzing the cost and benefits. A common question was: "What about our other courses?" The students agreed to participate and enter the unknown, but there was skepticism. They questioned the amount of time and work the project would take. A student questionnaire was completed and exchanged with everyone. This questionnaire assessed student talents, interests, hobbies, work experience, technical skills and other pertinent information. Students formed four teams, with each team consisting of six accountants and two engineers. Teams decided to choose their own names by color: red, green, blue and gold. The teams received project description sheets, a project proposal outline, evaluation criteria, presentation suggestions, reading lists and a pat on the back. They were empowered with the responsibilities of choosing their own coordinators and developing the entire project.

However, team problems arose immediately. There was a lack of interest, concern and respect for each others responsibilities. Leadership skills, confidence, and trust in each other was lacking.

The Project

The mission of each team was to develop a waterslide park that could engender funding. The students' mission was to identify how their education in this project would relate to industry and product development. The waterslide project was chosen because it included elements of fluid systems design and major accounting issues. The design involved complex water distribution networks, pumping systems and environmental issues. The accounting functions included the generation of financial forecasts and budgets, coordination of information flow and evaluation of results. The accountants and engineers jointly determined the rate of return on investment (ROI), organizational structure, legal structure, marketing and pricing decisions. The responsibilities of the engineers and accountants involved cross-functional decision-making for estimating costs, determining equipment specifications, developing the product design, and detailing site plans.

The idea of successfully proposing a waterslide park in Klamath Falls would be a difficult task. The area is located at an elevation of 4,000 ft. and usually has harsh spring weather. The population of the area is about 60,000.

Two weeks into the project, the teams convened on campus for an introductory meeting with the industrial panel. The panel included an attorney/certified public accountant who handles acquisitions for a large international company, a banking executive who manages commercial lending for a large bank, two entrepreneurs, a city planner and a mechanical engineer. Each industrial panel member spoke for ten to fifteen minutes, explaining critical factors considered important in funding a project. Rate of return on investment was emphasized along with organizational structure and design possibilities. Environmental and traffic issues were discussed. Sample business plans were presented. The panel advised that teams maintain a spirit of cooperation. In interest of good-will, they created skits while competing against each other for prizes. The skits were effective "ice breakers." Although sessions were video-taped throughout the term, students were encouraged to do additional taping of their individual team meetings.

The relaxed atmosphere of this first meeting was short-lived as pressure and stress mounted. Some team members become over zealous in promoting their own ideas. Three weeks after their first meeting, the teams returned to the auditorium to present oral and written preliminary reports to their peers and instructors. This was the first "shakedown" session. Five weeks later, the panel read final reports, judging the projects for fundability. The schedule seemed overwhelming to the students and tension increased as deadlines approached. The compression of time and interaction among team members required students to direct their own learning. We had successfully placed the student (learner) in the center of the educational and training experience. R. C. Heterick, President of EDUCOM, states, ". . . we must find a way to put the learner at the center of the educational experience. Yet we live in a world where the teacher is at the center of the educational experience." EDUCOM is a non-profit consortium of over 600 colleges and universities and 100 businesses, focused on leading the nation's education community in integrating information technology into the disciplines.

Cross-Discipline Teamwork

This project brought together accounting and engineering students into project teams, facilitating creativity through cross-functional teamwork. There was cross-functional use of technology, with interdisciplinary learning in Computer Aided Design (CAD), financial spreadsheets and energy issues In his book *Reengineering—Leveraging the Power of Integrated Product Development*, Hunt states,

> At the heart of Boeing's Developmental Operations (DO) approach is the Product Development Team (PDT) initiative. The Product Development Team is a multi-functional team with a common goal of developing a specific product (78).

> Chrysler . . . adopted a platform team approach and this meant forming a small multifunctional team composed of specialists in engineering, manufacturing, and marketing as well as outside suppliers (84).

Like Boeing and Chrysler, our project engineers were learning from accountants, and accountants were learning from engineers. Students were learning how to complete a team project, while discovering the need for cooperation. From the first meeting with the industrial panel, the students knew it would take a *high quality* presentation, with *integrity* and *valid* information, to obtain financing. The business panel became the teams' "customer" during the financing stage. Students realized the project had many customers; governmental agencies, utility companies, vendors, suppliers and waterslide park trade associations were all customers.

The teams experienced difficulties with coordinators and leadership. There were delays in telephone calls and getting organized, meeting deadlines, and team member scheduling. Student journals kept throughout the project referred to lack of direction by the instructors. The frustration emerged as anger at other students in the group for not doing their share and annoyance at not being told step-by-step what to do and how to do it. Competitiveness of team members versus cooperation hindered progress. Individuality versus team-building caused delays on decisions that were critical to advancing the project. Students realized that diversity, though helpful to the creative process, needed to be melded together if success was to be achieved. Mere awareness of the need for cooperation and recognition of barriers did not result in immediate solutions. Barriers needed resolution in order to improve performance. Barbara Cofsky, CMA, CFA and general accounting manager for the Eastern Financial Management Center of Digital Equipment Corporation writes,

> Both between teams and between members, we should focus on each other's strengths and positive qualities in order to build off and benefit from them. High performance work teams not only allow a business to do more with less, but they provide an excellent vehicle for employees to grow, improve and constantly challenge the status-quo.

The immediate response between the engineers and accountants was "Us and Them!" In the beginning, bickering between the two groups was common. Part of the problem was defining and handling individual responsibilities. Students found it difficult to assign responsibility when there was a conflict. If a cost was involved it was accounting, but if it was an equipment specification decision it was engineering. Equipment purchases involved costs and engineering specifications that often conflicted with the initial budgets and the required ROI. Revisions were needed and conflict resolution was necessary.

At mid-term, a *progress report presentation* was given by each team. The instructors were merely observers. The team members were responsible for presenting their conceptual ideas and were questioned by their peers. The tension was extreme. Some teams felt competitive and chose not to share information with the other teams. Other teams felt an alliance and knowledge link with each other and elected to share their information. Team members began noticing the behavior and strategy of the different teams. Although the groups all performed well, dressed formally, and presented professionally, the underlying theme was that of "us engineers and them accountants."

The progress report revealed that information collected from vendors, realtors, and governmental agencies was similar for all teams. None of the teams seemed to have a competitive advantage. The students began exploring different measures to gain a competitive advantage and add value to their project. How was an advantage going to be achieved? Team members began to discuss ways to improve their project through process improvement initiatives. Students learned the need for creativity and self-direction in coming up with new ideas to add value to their projects. Alliances with existing businesses and institutions became part of the financial solution. We observed the progress of the students from the information gathering stage to the stage where they began using information to create new ideas. The standards of excellence had increased since the first meeting. Teams were trying to find advantages to out perform their competitors. With only five more weeks until "show time," the students were having to deal with more pressure.

Breaking Down Barriers

Effective melding of the accountants and engineers became apparent in some teams and not in others. Each team was working against deadlines and trying to organize workloads. The teams using information and knowledge to meld the two disciplines of accounting and mechanical engineering technology were performing the best. They developed a high quality product that satisfied or exceeded engineering and customer's requirements while meeting financial objectives.

In the eighth week, the industrial panel evaluated the students' written rough-drafts and gave feedback to the teams. With one week left before their final report, corrections suggested by the panel needed to be made by the team members. Figure 1 (page 31) gives an example of the panels feedback to the teams.

Figures 2 (page 32) and 3 (page 33) illustrate some of the evaluation points considered by the panel in evaluating the students' written reports and oral presentations.

At the final presentation, engineers provided drawings and scale models in a trade-show atmosphere. Accountants displayed graphs, charts, marketing materials, forecasts, and financial information in the lobby. The atmosphere was professional, with printed brochures, music, and refreshments. The panel and students' names and responsibilities were listed in the brochure. We discovered from the students' journals that the brochure listing the students' names and responsibilities was extremely important to students. Students included total quality initiatives into the evening. They displayed pride with special guests, friends, faculty, and administrators present. The professional atmosphere helped to motivate the students.

The stage was arranged similar to a congressional hearing with table cloths, microphones, and name plates. This format modeled development team presentations found in industry. The panel was provided with final written proposals listing each team member's responsibilities in the project. Teams were allowed fifteen minutes to make their oral presentation. The panel was allowed to ask questions for ten minutes. The teams were well prepared and enthusiastic. We observed teams evaluating each others performance. After the last team presented, the industrial panel took twenty minutes to evaluate the teams. This gave the audience and teams time for refreshments and informal discussion. The panel, returning to the stage, announced that two of the projects qualified for funding and gave each team feedback on their presentations. Panel members discussed what they felt was outstanding and what they thought could be improved. The teams not funded, though greatly disappointed, recognized their own accomplishments. We observed the non-funded team members having some difficulty in accepting the decision of the panel. After all, every team put a lot of work into this project.

This behavioral and social experience provided the students with ethical dilemmas on handling team-based learning and competition. During the next class period, time was taken to review the process. Open discussion and written evaluations were conducted by the students and instructors. Recognition was given to all team members for their accomplishments.

Fictitious rewards of $10,000 were given to each team as a financial bonus to be allocated to team members. Distribution of the money was the means to assessing the work done by each team member. Team coordinators received the highest allocation of the bonus from the team members, usually from $4,000 to $6,000. Team members receiving the smallest allocations were usually those who allocated their $10,000 equally. The team members generally allocated bonuses to themselves fairly consistent with the bonus received from others. Those receiving lower bonuses usually gave themselves higher amounts than what they received.

Journals kept by the students were useful in assessing outcomes and giving continuous accounts of setbacks and achievements. These journals evaluated the project from the learner's perspective and were not graded. The students indicated the corrective actions they would have to take to improve team work and organization on future projects. Students expressed how they would have used presentation software and bulletin boards more effectively. Many students stated the project built their confidence. This indicated that the students could make self-assessments and implement elements of continuous learning and process improvements. The non-funded team members wrote about their feelings regarding the results and revealed to us the experiences of students handling disappointments. The journals were read at mid-term and at the end of the term. The journals provided students with an outlet. They expressed humor, frustration, and anger with us for the amount of work and pressure put on them. Students felt they had learned a great deal, but were uncertain of the degree of technical knowledge they had acquired.

Team Problem Solving

Teams divided up the workload in a baseball team style with each member having a particular responsibility. When an individual did not fulfill his/her responsibility, the team was unable to respond adequately to the required change. Most teams individualized the project. Students used over the wall engineering versus moving toward concurrent engineering. Their journals reflected their resistance toward change and the difficulties of working together, trusting, and listening to each other. The journals gave the instructors and the students the opportunity to speak to each other in an open, non-threatening manner.

The funded teams were not made up of the highest GPA students. In fact, the highest GPA student team had difficulty agreeing and making decisions. This resulted in bottlenecks and lack of participation. The psychology behind this observation is not obvious. Perhaps it suggests that the traditional structure of education promotes individual competition instead of cooperation.

Findings

The groups who practiced teamwork and surmounted disciplinary boundaries, produced the greatest achievements. Cofsky states, " . . . they must orchestrate the work and the processing particularly in terms of integrating them with other organizations." The need for cross-functional teamwork is obvious, but the means for developing this end is not readily discernible. The main elements in this project that developed the "interactive qualities" are as follows:

1. The project had a unique structure of being reality-based, cross-functional, and team oriented.
2. The unstructured nature of the project provided costs and benefits to the students.
3. The project was open-ended and allowed for an increase in scope.
4. The interdisciplinary nature of the project enabled students to learn from one another as in a one-room schoolhouse.
5. The project allowed alliances and knowledge links outside their own discipline for helping each other.
6. The journals facilitated communication among students and instructors.
7. The project gave students the opportunity for interdisciplinary peer review and feedback throughout the process.

Conclusion

Through review of journals, open discussion with the students. and overall observations, a significant conclusion can be drawn from this project. Interactive characteristics of students are poorly measured by traditional individual testing. Methods for giving valuable weight for interactive characteristics in addition to traditional testing for technical skills is necessary for complete evaluation. Interdisciplinary team projects may be the answer to identifying self-starters, hard workers, and communicative individuals. Integration of interactive qualities and technical knowledge throughout a students educational experience is needed to satisfy industry's needs.

Technology classes should contain a practical project demonstrating students' future roles in industry. Industry-based projects give the students the opportunity to work on "real-world" problems. Projects should involve industrial panels and mentors for evaluation and feedback for the students and instructors. Projects help develop a cooperative and professional student/teacher relationship with industry. Students at higher or lower achievement levels are capable of benefitting from reality-based learning. Graduate programs often utilize reality-based projects for learning, but reality-based learning can also be utilized at the undergraduate level. Project solutions and experiences may be more or less valuable depending on the knowledge and motivation of each team member and their ability to work together. The project process and dynamics are part of the educational endeavor.

The reality-based project should relate to technical information presented in class. The project m: · integrate a job function where students participate in the work environment. Classes at the lower- and upper-division design levels can easily incorporate an interdisciplinary project. For example, a static class could include a project involving the static analysis of a bicycle frame, while a thermodynamics class could incorporate a study of the heat balance at the local power plant. There are many accounting and engineering problems on campuses that allow for integration of real-world problem solving.

Reality-based learning should be practiced at every opportunity, not only in senior projects. Many of the concepts learned by our students are being practiced in elementary school with group learning and mentoring. Projects can be instituted on a term, semester or roll-over basis with many disciplines. From homework assignments to senior projects, interdisciplinary teamwork can be used. We learn cooperative problem solving techniques through experience. It makes sense to introduce this experience into the classroom, where risks are minimal, rather than on the production floor where risks involve lives and major monetary commitments. Interdisciplinary teamwork is an enhancement in the educational process and does not replace individual technical assessment of students.

An interdisciplinary reality-based project requires faculty to take a risk and be receptive to handling the dynamics of team building. This integrated approach benefitted us and required a risk by our students and ourselves. We often participated in each others classes. We learned from each other and gained many of the same benefits as our students. Personal commitment of individual faculty in different disciplines is the key element to the success of this type of cooperative effort. The educational reform required to meet industrial trends needs to come from a "grass roots" faculty effort. It is essential to involve industry as a functional discipline in reality-based project education.

The nature of our project resulted in the American Accounting Association and the Boeing Corporation recognizing the project as one of the "outstanding innovations in accounting education." Our conclusion regarding reality-based learning may not represent the right organizational approach for all, but it certainly is worth a look.

Marshal and Tucker, in their book, *Thinking For a Living: Education and the Wealth of Nations*, sums up the skills needed "to power an emerging economy" as follows:

- A high capacity for abstract conceptual thinking,
- The ability to apply that capacity for abstract thought to complex real-world problems,
- The capacity to function effectively in an environment in which communication skills are vital,
- The ability to work easily and well with others (80).

Reality-based learning has information retention benefits for the students when they learn by "doing the real thing." Figure 4 (page 34) presents the Cone of Learning which demonstrates a students retention rate through "doing the real thing." It is not necessary for a real-world project solution to work like a problem solution at the end of a chapter in a text book. It is better if it doesn't. Part of learning is working out creative solutions to problems that emerge during the process. This approach gives students the opportunity to use their knowledge, be creative, and be at the center of learning.

One project can foster other expanded projects. For example, we are exploring the possibilities of an international team-based experience. Students from Utah Valley State College, Oregon Institute of Technology, and American-Ukrainian College of Business in Kiev are considering networking a project. Steve Teeter, Department Chair of Accounting, Utah Valley State College, will be teaching at the Kiev campus. This would allow students in the U.S. and Ukraine to experience an international real-world engineering/accounting problem. Difficulties will be experienced in this international arena. Experiential learning creates an active learning environment and motivates students to expand their understanding by using and applying their knowledge.

Acknowledgments

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Figures

Figure 1. Illustration of Industrial Panel Feedback to Teams (Partial).

Figure 2. llustration of Written Evaluation Form (Partial).

Figure 3. Illustration of Oral Evaluation Form (Partial).

Figure 4. llustration of Learning Activity and Retention Rates.

Assuming this is a preliminary proposal and that further development would be undertaken to consummate a final proposal, please consider the following questions:

GOLD TEAM

1. Your Proposal reflects a ROI for investors or 20%. How are you calculating this figure? What is the NET ROI? Without a pro-forma Income Statement this will be difficult to substantiate.

Question: In the proposal, we mention using a $6.00 admission price as the basis for our Income forecast. Why did we use $8.00 in the actual calculation? The result of this calculation was $706,320 as the "most likely" scenario.

Question: Earlier in the proposal the short term sales objectives (one year) was $750,000. The difference is material.
Question: Why the difference?

4. Your forecast of profitability reflects first year profit to be approximately $225,000.

Question: Is this before tax or after tax, and does it contain interest associated with any borrowing you may need to undertake to complete your project?

5. Will this operation require Working Capital? If so, how much? If working capital is required, is it included in the amount requested as a bank loan?

6. How do you intend to capitalize this project?

7. Who is going to own the project and what operating structure (i.e. Not-for-profit, trust, corporation, partnership) is the operation going to be. As you may know the operating entity can have a material influence on the profitability and the return to investor.

PROJECT BLUE

1. Your Proposal reflects a start up cost of just over ???? including land acquisition, equipment, etc. with the plug figure being the Loan Fee and Working Capital. Congratulations...you did remember that you will need some working capital! In reviewing your start up costs, the land acquisition figure is easily reconciled. The figure for the Equipment/pool appears to be an exact figure, however I don't locate any kind of engineers equipment cost breakdown to substantiate this figure.

7 Question: As a potential investor, exactly what tangible assets am I purchasing with my investment? How did we arrive at the daily cost of operation of the equipment?

Figure 1. Illustration of Industrial Panel Feedback to Teams *(Partial)

Written Proposal Review

Reviewer___________________.

Proposal Submitted by__________________.

Day and time proposal received____________________.

1. **At first glance, does the written proposal appear well organized, neat, and professional?**

Note strong and weak points, please.

*2. **Does the "Proposal Summary" or "Executive Summary" quickly answer these questions?**

		Y	N
•	How do the benefits justify the commitment of resources to the project?		

•	What general or special resources will be required to accomplish the project?		
•	How much will the project cost?		
•	What are the major project phases?		
•	How long will the project take?		

Are there aspects of this section that are especially noteworthy? Please note them.

4. **A proposal's technical details need to be communicated effectively. Communication includes organization, layout, grammar, spelling, use of illustrations, and so on. Please indicate how well you feel the ideas in each area were** communicated.

5 Communication was extremely effective.
Very easy to understand, well formatted, clear, unambiguous, well written, well documented, well illustrated, no grammar or spelling errors.

3 Communication was fair.
Understandable, ideas generally in order. Grammar, spelling generally OK.

1 Communication was poor.
Difficult to understand, poor grammar, spelling errors, inaccurate illustrations, hard to follow, disjointed, illogical, does not read well.

		5		3		1
•	Executive Summary					
•	Sponsor's Background & Problem Statement					
•	Solution Proposal & Benefits Summary					
•	Costs/Benefits Analysis					

Figure 2. Illustration of Written Evaluation Form *(Partial).

Oral Proposal Presentation.

Reviewer____________________.

Presentation by__________________.

Day and time presented_____________________.

Please read the written proposal in preparation for the oral presentation. Please be prepared with questions to clarify issues that occurred to you as you read the proposal.

Please evaluate aspects of the presentation using a scale of 0 to 10, with 10 representing "Excellent, Outstanding" and 0 representing "Very Poor".

	10					5					0
Were the purpose of the presentation and the main points to be covered presented in the first 30 seconds to 1 minute ?											
Did the presentation hold your attention ?											
Did the speaker maintain eye contact?											
Was the speaker confident?											
Was the speaker animated?											
Did the information presented support that in the written proposal?											
Was the speaker organized?											
Were the visual aids effective?											
Did the speaker field questions well?											
Was enough time allowed for questions?											

Please note here any strong points in the presentation.

Please note any weak points or points that could be improved.

Figure 3. Illustration of Oral Evaluation Form (Partial).

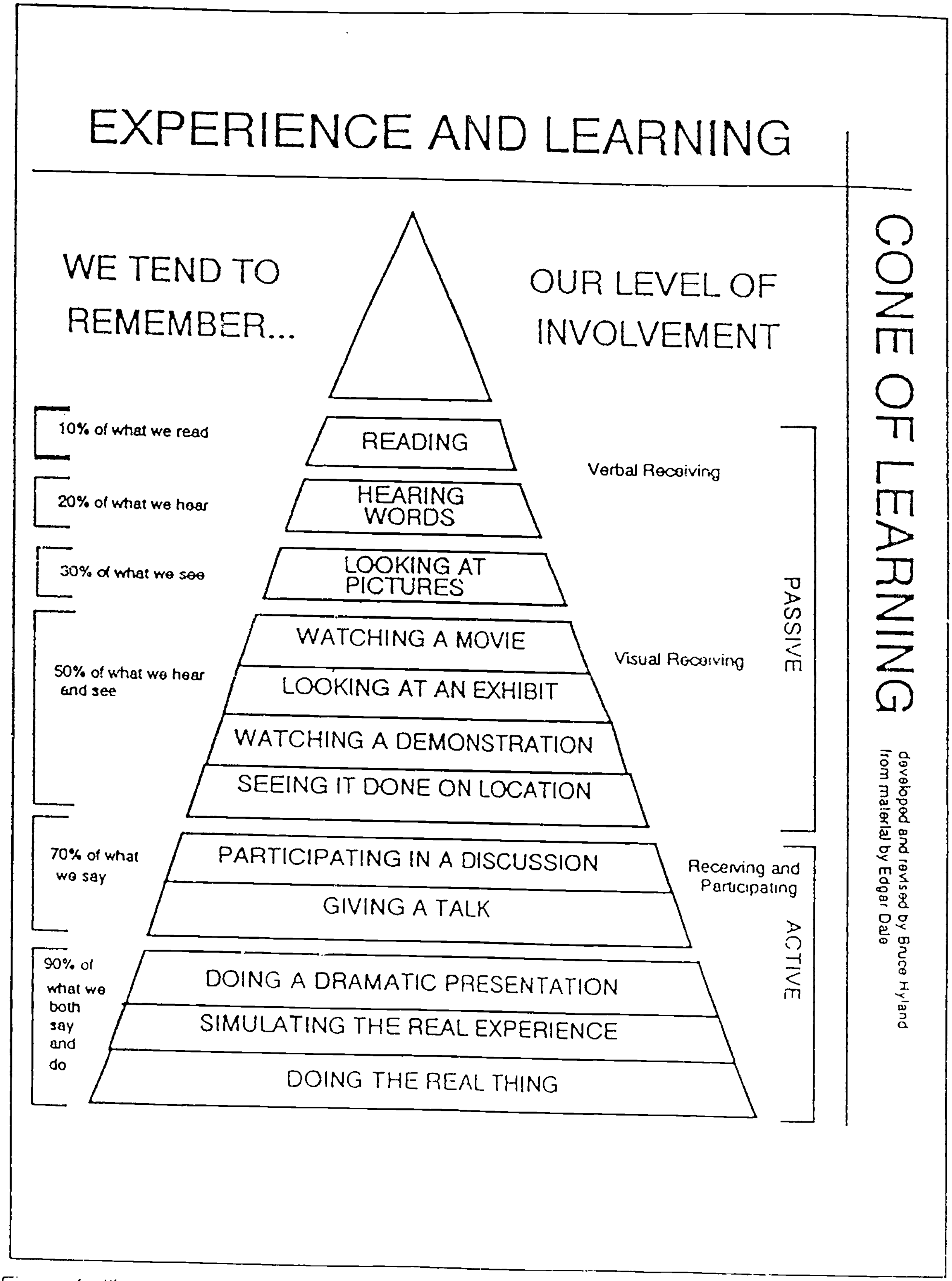

Figure 4. Illustration of Learning Activity and Retention Rates