Effectiveness of Three Case Studies and Associated Teamwork in Stimulating Freshman Interest in an Introduction to Engineering Course

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Abstract

The effectiveness of three case studies and associated teamwork to stimulate interest of college freshman in engineering was investigated by observing students. Case studies were assigned as laboratory team exercises in an introduction to engineering course at Auburn University. Student interest in the case studies was evaluated qualitatively based on the use of communication, decision making, and application of basic preparatory knowledge. Evaluations were made of laboratory sections as a whole, for four sections. The greatest student interest and enthusiasm in a case study occurred when there was not an existing "right or correct" answer and the answer was open-ended. Student interest was the least when the best answer to a case study was already known by the students. The order in which case studies are assigned was found to be important to prevent biasing student judgment with previous case studies. Case studies selected for a freshman course should be structured and limited in technical scope so students have more time to make and support decisions. Teamwork and student discussion expanded student perspectives of problems when they were part of a case study solution process. Student discussion of case studies continued beyond completion of the formal assignments when case study outcomes were given at the end of the course. The effectiveness of case studies was found to be very dependent upon the purpose of a case study and the preparation by the instructor to invoke the intangible faculties of curiosity and interest in students. The measures of effectiveness in using case studies as learning tools should be based upon thoroughness of student reasoning, ability of students to communicate their ideas, and the presentation of supporting rational for their decisions.

Introduction

A challenging assignment for any engineering instructor is introducing college freshman to engineering. College freshman know only one academic paradigm: that all questions have only one answer or solution and the teacher knows it (Dally & Zhang, 1992). Binary factual truth thinking limits the ability of students to solve engineering problems by preventing them from considering that multiple solutions can exist to a problem. A major goal of engineering education is to expand the problem solving outlook of students beyond the dualistic thinking that an answer is either right or wrong (Marra et al., 2000). Further, the typical engineering course plan has the freshman student taking preparatory classes in math, sciences, and language without linking them to engineering. The greatest challenge an engineering instructor has is to interest freshman students in the subject matter of engineering. Interest is a crucial component needed to engage students with course content. An engineering instructor must provide interesting opportunities for freshman students to engage in and experience the practice of engineering.

Case studies and teamwork are teaching tools that provide opportunities to introduce freshman students to basic engineering skills and to the practice of engineering. Case studies are real-world problem situations that have been structured so students can explore, dissect, and discuss them (Dym et al., 2005). Case studies provide a level of problem detail, complexity, and nuance needed for student development that is difficult to achieve with contrived problems. Teamwork can expand the problem solving outlook of students (Marra et al., 2005). Teamwork adds dimension to the perspective of problem solving that many students have not previously experienced. The use of team assignments also meets the Accreditation Board for Engineering and Technology (ABET) requirement of preparing engineering students to function in the team project environment of industry (Marra et al., 2000). The author has observed that the effectiveness of case studies and associated teamwork can vary greatly in stimulating interest of freshman college students in engineering subject matter.

Investigation Setting and Relevance

To gain insight into how effective three case studies and associated teamwork were in stimulating the interest of freshman students, the author conducted a qualitative investigation by observing classroom behavior of freshman students. The objective of the investigation was to see if gained insight could be used to increase the effectiveness of the three case studies and associated teamwork in stimulating interest. The observations were made while the author was teaching laboratory sections of the Introduction to Engineering course that is part of the curriculum of the Mechanical Engineering Department at Auburn University. Students were observed working with case studies in the summer and fall semesters of 2009 and the spring semester of 2010. Observations were made of four laboratory sections; a total of 80 students worked in teams on case studies in the course laboratory.

Case studies and teamwork are quite applicable to meeting the educational goals of the Introduction to Engineering course. The educational goals of the course are to introduce students to the basic skills required for engineering and to involve students in actual examples of the practice of the profession. The specific engineering skills taught in the course are teamwork, professional communication, engineering design, engineering decision making, integration of math and science principles in engineering, and aspects of business and ethics in engineering. Case studies present multifaceted engineering problems whose solutions require the use of all the engineering skills taught in the course. The case studies also achieve the second course goal: allowing freshman students to experience what practicing engineers do while solving real world problems. Teamwork provides a setting for case study assignments that increases the dimensions of problem perspectives and communication opportunities for students.

Case Study Descriptions

The case studies used in the investigation were included on compact disks with the assigned course textbook, *Introduction to Engineering Through Case Studies, 4th Ed.* (Raju & Sankar 2005), used in the summer and fall semesters of 2009. The textbook *Fundamental Leadership and Engineering Competencies* (Raju, Sankar, & Le 2010) was used in the spring semester of 2010 and also included the case studies on compact disks. The extensively researched and developed case studies were prepared at Auburn University and are presented using a webpage format including electronic document, audio, and video files. The electronic presentations guide students through each case study. Case study assignments have students make decisions based upon given background information, available data, and personal judgment. The problems of the three case studies can be divided into three safety risk categories: a decision with a high safety risk, one with a low safety risk, and one with no safety risk.

The first case study presented was in the high safety risk category and was the Space Shuttle Challenger case study. This case study covers the technical and judgmental causes for the loss of the Space Shuttle Challenger. The students were assigned the task of understanding and presenting the technical details of the design and sealing performance of the solid rocket booster section joints. Failure of the rocket booster joint seal initiated the Space Shuttle Challenger disaster. The joint performance information was to be applied to the decision of whether to launch or to delay the launch of the Space Shuttle Challenger. The Space Shuttle Challenger case study has disadvantages because of the large amount of readily available information outside of course materials, and many people have already formed opinions about it since the incident is common knowledge. It also has an apparent "right or correct" answer, which is less desirable for introductory purposes but was useful for comparative study.

The second case study presented was in the low safety risk category and was the Della Steam Plant case study. The Della Steam Plant case study introduces students to the technology and management techniques used in a commercial electricity generating steam turbine power plant. The students were presented with the problem of whether a turbine could be restarted or needed to be dismantled after experiencing excessive vibration during a safety test. The students were given the data recorded during the safety test and the expert opinions of two engineers about the condition of the turbine. The students must decide whether to just restart the turbine or dismantle it, considering the safety of plant personnel and expenses associated with dismantling the turbine. The relative financial costs of the decisions were analyzed by weighing the expense of success and of failure of each option. The Della Steam Plant case study has a teaching advantage because the only easily accessible information about the incident is that provided in the course material, so students did not know the outcome of the case in advance. Another advantage is that the average freshman student generally does not have prior knowledge upon which to base an opinion about steam turbines. The Della Steam

Plant case study also does not have an immediately apparent "right or correct" answer even though it is an either-or decision.

The third case study presented was in the no safety risk category and was the Chick-fil-A case study. The Chick-fil-A case study presents the students the problem of selecting a sales terminal (cash register) system (hardware and software) to provide the best return on investment while performing the point of service functions of order placement and sale completion. The students are given information on the three possible options presented to the financial and technical managers of the Chick-fil-A Corporation. The students are to analyze the investment costs of each option versus the capabilities each offers to the corporation and its franchises. The Chick-fil-A case study has the advantage that the students could go to a Chick-fil-A location and gather firsthand information and see a system in operation. Student opinions about this case could include firsthand experience. Also, the three options of the case study problem all had merit.

Investigation Methodology

To investigate the case studies, student laboratory sections of sixteen to twenty students were divided into four teams of four or five members each, depending on the number of students in a section. The exercise for each case study was divided into two laboratory periods. In the first laboratory period, the student teams were given the case study assignment and then had the rest of the laboratory period to go through the case study materials as teams. For the first two case studies, two of the four student teams were assigned to prepare Power Point presentations with one team supporting each of the opposing possible decisions. The presentations were given in the second laboratory period, which focused on the team findings and rationale for their conclusions. The other two teams were assigned to listen to the presentations and then write reports stating the decision they had made about the case study question and why they had made their decision.

Student performance was evaluated in three ways. The first way was how well they used the information provided in the case study. The second way was how well they presented their Power Point presentations or composed their reports. Finally, they were graded on their ability to support the conclusions they reached about the subject of the case study.

The effectiveness of case studies and associated teamwork was rated by the level of class interest. Level of class interest was subjectively evaluated on the quality of results produced by the class compared to results expected by the author. For the investigation, the author was interested in overall class performance. Comparison of the relative effectiveness of the three case studies was a topic of investigation, as were teaching purpose and how a case was presented. The points of evaluation for case studies were the quality of results produced in the use of communication, decision making, and application of basic preparatory knowledge (math, sciences, and language).

Communication was evaluated by the number of pertinent questions asked, the amount of discussion, and the extent to which the case study information was utilized in developing presentations and reports. Students asking questions about the relationships between information in the case study was also used as an indicator of interest. Student questions about what was important information in the case study material would be considered evidence of fishing for the "right or correct" answer from the instructor.

Decision making was evaluated by the amount of case information used to develop case positions and the depth of rationale used to support decisions. The expectation was that the more interested the students were in the case study, the greater would be their use of case information in making and supporting their decisions. Less interested students were expected to use the minimum necessary information to support their decisions. Thorough use and explanation of information contrary to a selected decision in presentations and reports would also be used as an indicator of multiple solutions thinking and greater interest on the part of the students. Application of basic knowledge was evaluated by how well students used it in preparing presentations and reports.

The points of evaluation for teamwork were the amount of interaction between team members and cohesiveness of presentations and reports. The amount of discussion among the members of the student teams while working on the assignments would be used as an indicator of the extent to which the students were collaborating and working as teams. Teams that had more discussion were expected to produce more cohesive presentations and reports instead of collections of parts produced by individual students. Cohesiveness of presentations and reports would be used as another indicator of teamwork.

To prevent the reinforcement of right-or-wrong thinking in the students, the author decided, where possible, to withhold the actual outcomes of the case studies from the students until the end of the course. The standard teaching practice of only withholding the outcome information until each case study assignment was completed would still reinforce dualistic thinking in the students. If the outcome was given at the end of each assignment the students would come to expect that they might be assigned to support positions that were considered not to be the best option. They thus would begin to look for clues to which of the assigned choices was considered the best decision. Students "knowing" that they had not been given the best option would be expected to do only the minimum required to complete the assignment. An element of suspense to the case studies was maintained by withholding the case study outcomes until the end of the course. Students not knowing case study outcomes could spur continued discussion as students defended their preferred case decisions after the completion of the assignment.

Investigation Results

Space Shuttle Challenger Case Study

With the above points in mind, the case studies were presented to the students. The first case study, the Space Shuttle Challenger, provides the students an opportunity to experience a real-world decision making situation where there is a large amount of available information with which to work. The case study requires students to investigate the details of the incident since the events occurred in 1986 and are not part of the collective memory of the current freshman student generation. Unexpectedly, students immediately searched for information about the Space Shuttle Challenger on the internet using available laboratory computers even before they went through the extensive amount of information provided in the case study. The Space Shuttle Challenger disaster being an event of national importance made it possible for students to find a large amount of material on the internet beyond that presented in the case study. Reading summaries about the Space Shuttle Challenger on the internet greatly diminished interest in exploring the large amount of provided case study material. Students quickly focused on the right-versus-wrong nature of the launch decision. Even being told to think about the case objectively, and to consider for themselves the pressures on the National Aeronautics and Space Administration (NASA) decision makers to stay on schedule, did not increase their general interest in the case or their desire to support the decision to launch.

As the students began to work on the Space Shuttle Challenger case study, two predominate behaviors appeared among the student teams. Some teams split up as individuals to begin reading the material both with and without discussion about how to proceed. Other teams stayed together and went through the material as a team. Teams that worked together generally had more cohesive presentations and reports than teams that worked most of the time as individuals and came together at the end to combine individually-produced parts.

Student teams making Power Point presentations for the Space Shuttle Challenger case study were mostly average in communicating the facts of the space shuttle case. The level of proficiency students demonstrated in relating and supporting their conclusions was greatly affected by the interest team members showed in the subject. The teams showing average or little interest covered the required information and provided minimum support for their assigned launch decision in their presentations. However, the presentations of a few teams showed considerable interest and exceeded the performance of the professional engineers described in the case study. The most outstanding example was when one team discovered a pattern in what the experts called random and inconclusive data. The data was the depth of O-ring erosion at different launch temperatures. In the original presentation to NASA before the launch, the booster engineers focused on the erosion at low temperatures with the high temperature erosions treated as outliers. The lack of explanation for the high temperature erosion weakened the argument of the booster rocket engineers not to launch and shows that trained professionals can still be myopic when it comes to problem solving. The most interested student team included all the erosion versus temperature data in a graph in their presentation. The graphed data led them to the original idea that the amount of O-ring erosion increased as the launch temperature diverged either lower or higher from the designed operating temperature of the rocket boosters. They explained how the recorded high temperature erosion events demonstrated that the booster rocket only operated safely in a narrow temperature range. The graph presented by the most interested student team indicated that the launch of the Space

Shuttle Challenger occurred at the greatest temperature difference from the safe temperature range for any launch. Presenting the O-ring erosion data in this way provided a very strong argument against launching the Space Shuttle Challenger.

The students on teams that did not give presentations but were to write reports on whether they decided to launch or to delay the launch of the Space Shuttle Challenger did not use information from the presentations in reaching their launch decisions. They did not ask questions of the presenters or reference the arguments made in the presentations. The lack of discussion was attributed to the fact that the "right or correct" launch decision is known by all the students. The "right or wrong answer" mindset of the students did not motivate them to investigate or consider arguments to the contrary of the apparent "right or correct" answer.

The insight the author gained from the Space Shuttle Challenger assignment was that the lack of student interest and therefore effectiveness of the case study was not because of the case study material but because of the established purpose of the assignment. The assignment asked students to support or reach a decision either to launch or to delay the launch of the Space Shuttle Challenger, but the students already knew the best answer. The reactions of the students confirmed the anticipated inherent difficulty in the assignment since it did not have an element to arouse student interest. The Space Shuttle Challenger case study would be effective in the future with the purpose changed to a forensic exercise looking for the cause of the disaster and recommending solutions to correct flaws. The students could then discuss the importance of various factors in the failure. They would also need to defend the ability of their suggested fixes to correct the original design flaws. Students being assigned to investigate and correct problems removes obvious "right or correct" answers from the case assignment while still keeping the assignment structured for freshman students. The suggested fixes by the student teams could also be compared to the actual redesign of the booster rocket NASA used. A change in the purpose of the assignment should also increase communication and teamwork, with students focusing on investigating causes and suggesting fixes. Increased communication has been seen to increase application of basic preparatory knowledge in math, sciences, and language.

The Space Shuttle Challenger case study needs to be made interesting to students because it is useful in emphasizing the value in engineering of going beyond what is immediately apparent through careful and thorough analysis of all available information. The Space Shuttle Challenger case study highlights the fact that how effective a case study will be as a teaching tool is very dependent upon the purpose for presenting a case study and how it is presented to the students. A change in the purpose of the Space Shuttle Challenger assignment would greatly increase student interest. Student interest is a very important intangible element in whether a case study is an effective teaching tool. Therefore, case study effectiveness is very dependent upon preparation by the instructor to invoke in students the intangible faculties of curiosity and interest.

Della Steam Plant Case Study

The second case study presented to the students was the Della Steam Plant case study. Student teams were again assigned to make Power Point presentations supporting two opposing positions. This time the opposing positions were whether to restart or to dismantle a steam turbine after an automatic safety shutdown. The student teams that wrote decision reports for the Space Shuttle Challenger case study were assigned to give Power Point presentations for the Della Steam Plant case study. The student teams that had made presentations for the Space Shuttle Challenger case study were assigned to write decision reports for the Della Steam Plant case study. Unlike the Space Shuttle Challenger case study, the Della Steam Plant case study incident was not publicized. Students again searched for materials on the internet, but the lack of results from internet searches caused some students to ask where they could find information on the case even though they had extensive case study material. The students were informed there was no source of information other than the case study materials. The case study materials presented background information, evidence, and the opinions and supporting arguments of two experienced engineers about whether to restart or to dismantle the commercial power plant steam turbine.

Student interest in the Della Steam Plant case study was much greater than for the Space Shuttle Challenger case study. The students spent more time going through the Della Steam Plant case study material since student curiosity in the outcome of the case had not been quickly satisfied by an internet search.

The options either to immediately restart the turbine or to dismantle it had equal merit, so the students had to think about how best to support their assigned position for their presentations. Students assigned to write decision reports showed considerable interest in determining the best option or answer for the Della Steam Plant case study given that there was no apparent "right or correct" answer.

The Della Steam Plant case study introduces the financial aspect of engineering decisions. Unlike the Space Shuttle Challenger case study, safety considerations for personnel did not totally outweigh any financial considerations in the Della Steam Plant case study. The turbine at the Della Steam Plant had just been rebuilt and was undergoing post repair testing when it experienced unusual and possibly dangerous vibration. The vibrations caused the turbine to be shut down by an automatic safety shutoff system. The engineer from the turbine manufacturer in charge of rebuilding the turbine held the opinion that the components of the turbine had been damaged by the vibration event. She thought the possible damage required the turbine to be dismantled and inspected to ensure that there would not be a catastrophic failure of the turbine. The inspection would cost the power company $900,000 dollars in labor and operating expenses for the reserve power generators. Inspecting the turbine, while expensive in the short run, would eliminate the possibility of a catastrophic failure costing the company an estimated $19.5 million.

The Della Steam Plant chief maintenance engineer presented the second opinion that the startup testing had been conducted too early in the turbine startup procedure. The chief maintenance engineer held that the vibration was due to the lubricating oil and the bearings of the turbine being too cold at the time of the test instead of being caused by component failure or damage. The turbine therefore would not need to be dismantled and could be restarted immediately. Immediate restart would not incur any additional expense for the company but it did place the turbine at risk of catastrophic failure if indeed a part had failed or was damaged. The chief maintenance engineer, however, considered the possibility of failure extremely remote based on his experience and interpretation of the data.

The students were given the data the manufacturer and plant engineers had used to reach their conclusions. The students were also instructed in how to calculate the relative costs of the decisions based upon the expenses incurred in applying them and those incurred if they were incorrect. The students were introduced to the effect the assumed probability of failure has on the calculation of the cost of a decision. The determination of how accurate the assumed failure probabilities are formed a basis for discussion both in and between student teams. As no "right or correct" answer was available to the students, they had to examine their personal points of view and assumptions as engineering decision makers.

Student teams making Power Point presentations for the Della Steam Plant case study were better than average in communicating case study facts and presenting and supporting their conclusions. The decision making teams that were to write reports this time asked questions of the presenters. The decision making teams still based their reports and conclusions mostly on their reading of the case study material, with some use of materials from the presentations of the other teams. The conclusions reached by the decision making teams did favor the dismantling and inspection option but not by a large margin. The reasons cited for taking the more cautious option were worker safety and the expense of catastrophic failure of the turbine. Worker safety was given as the primary reason for being cautious. The students were informed in the last lecture of the semester that the Della Steam Plant manager decided to restart the turbine and allow the full warm-up period to elapse before resuming the testing procedures. The turbine subsequently passed all the tests without experiencing unusual vibration and operated normally. Student discussion of the Della Steam Plant case study continued beyond completion of the formal assignment when the case study outcome was given at the end of the course.

The insight the author gained from the Della Steam Plant case study assignment was that presenting the spectacularly disastrous failure of the Space Shuttle Challenger as the initial case study could have biased the students' thinking about being cautious in decision making in the Della Steam Plant case assignment. The case study order was undesirable because the Della Steam Plant case study is an outstanding example of the value of good professional judgment that is attained through knowledge and experience as demonstrated by the plant chief maintenance engineer in the incident. Students need to understand and appreciate how good professional judgment is attained and its immense value to industry and to society as a whole. Important lessons to be learned by the students from the Della Steam Plant case study were seemingly overshadowed by the previous emphasis on the need for caution in the Space Shuttle Challenger case study. In the future, the Della Steam Plant case study should be presented before the Space Shuttle Challenger case study. The pair of case studies would then create a powerful and interesting learning experience about the value of good professional judgment and how good professional judgment can be overridden even in highly developed engineering organizations that function in our complex world of business and politics.

Chick-fil-A Case Study

The third case study, the Chick-fil-A case study, did not involve issues of safety like the previous two case studies. The Chick-fil-A case study dealt with choosing the point-of-service terminal (cash register) that would provide the best return on investment for the Chick-fil-A Corporation and its franchisees. The Chick-fil-A case study illustrates one of the most common tasks practicing engineers have: selecting technology that provides the best performance both technically and financially for an enterprise. The Chick-fil-A case study was the first study that allowed the students to personally experience the subject matter. The students could inspect most of the operations of the point-of-service device by going to lunch at the Chick-fil-A restaurant located near the building where the laboratory sessions were held.

All student teams were assigned to give presentations for the Chick-fil-A case study to give them more practice in making presentations. The Chick-fil-A case study assignment was to research and support one of the three possible options for point-of-service equipment available to the Chick-fil-A corporate board. One of the three technology options was assigned by the instructor to each team to research and support. The students were required to include all the costs of purchasing and utilizing the technology in a retail business environment. The first option was to request the manufacturer to continue to make the current but obsolete point-of-service system. The first option avoided the cost of changing employee training but maintained the current level of performance. A consideration of this option was that the physical components of the system were no longer being manufactured. The current system also did not allow for easy replacement of menu items.

The second option was a touch screen computer based system using Windows CE. The CE based system allows for menu updates and interface modifications to meet changing business conditions. The CE based system has the capability to transfer information to the corporate headquarters computers. The CE based system can operate as a stand alone unit if communication is severed with the network. The stand alone capability does come with limitations related to the ease with which the system can be changed. The purchase cost for the hardware for the CE based point-of-service system was less expensive than the third option but more than the first.

The third option presented to the students was a touch screen networked Windows NT based system. This point-of-service system has the greatest capabilities for interface editing and information gathering and processing. The NT based system has the highest initial equipment cost. The NT based point-of-service units do not operate as standalone units and must be connected to a manager computer located on the restaurant premises.

The students showed considerable interest in the Chick-fil-A case study, as evidenced by their enthusiasm to work on a case study where they could make firsthand observations. Without the worry of safety considerations, they delved into the cost-versus-benefit analysis of the three point-of-service technologies. Each team gave a well thought-out presentation on its assigned technology. As there was no "right or correct" answer to be found outside of the students' own choices, the teams were observed to engage in more discussion of the presented information than for the previous case studies. Unlike the previous case studies, the students asked a number of questions of the presenters, inquiring into their thought processes and supporting evidence for their conclusions. The presentations were better than those previously given and the improvements were to a large extent attributed to the freedom of personally researching and considering the material without a known "right or correct" answer. Another factor was the absence of any fear of causing physical injury with their decisions. The students were informed in the last lecture of the semester that the Chick-fil-A board had chosen the CE based system as the best trade off between performance and cost with cost being the predominate factor. Student discussion of the Chick-fil-A case study continued beyond completion of the formal assignment when the case study outcome was given at the end of the course.

The insight the author gained from the Chick-fil-A case study was that student interest is much greater when a case study is open-ended and does not have a "right or correct" answer.

Also, the opportunity for firsthand observation and experience by the students increased interest. The greater interest had a cascading effect, stimulating communication, discussion of options, teamwork, and professional judgment, which in turn meant an increase in application of basic preparatory knowledge.

Conclusion

In summary, the findings and insights of assigning the three case studies were that student interest and enthusiasm was greatest when a case study had no existing "right or correct" answer and the case was open ended. The lack of a "right or correct" answer gives the students an open intellectual vista in which to assume the role of a practicing engineer and think beyond the single answer paradigm. Student interest was the least when the best answer to a case study was already known by the students. Care must be taken to prevent biasing student judgment with the subject matter preceding the use of a case study. Using the life-or-death Space Shuttle Challenger case study first appeared to produce overly cautious decisions in the Della Steam Plant case study. Students need to be encouraged to seek and investigate multiple courses of action and compare possible solutions in order to select the best solution for a case study problem. The greatest demonstration of multi-solution thinking occurred in the no-safety-risk and open-ended Chick-fil-A case study. The Chick-fil-A case study being open-ended made it more conducive for students to use their judgment, be thorough in their reasoning, and provide supporting rationale for their decisions. Selected case studies should be structured and have the technical scope of a problem limited to what the students already know or can learn in the time available for an exercise. Problems with limited technical scope allow students more time to apply their judgment to reach a conclusion. Teamwork and student discussion expanded student perspectives of problems when they were part of a case study solution process. Discussions should extend beyond team discussions to involve the class as a whole when the teams present their findings and conclusions to the class. Case studies should be presented in order of increasing safety risk involved in case study decisions. Students practicing their engineering judgment skills on no and low safety risk decisions allow them to build confidence in their abilities to make decisions in cases with greater safety risks. Student discussion of the Della Steam Plant and Chick-fil-A case studies continued beyond completion of the formal assignments when case study outcomes were given at the end of the course. The Space Shuttle Challenger case study highlighted the fact that how effective a case study will be as a teaching tool is very dependent upon the purpose for presenting a case study and how it is presented to the students. Therefore, case study effectiveness is very dependent upon preparation by the instructor to invoke in students the intangible faculties of curiosity and interest. The measures of effectiveness in using case studies as learning tools should be based upon thoroughness of student reasoning, ability to communicate their ideas, and presentation of supporting rationale for their decisions.

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