Effect of Guided Research Experience on Product Design Performance: A Pilot Study

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Abstract
Teams are used in industry, not only to increase productivity in solving problems but also to form and sustain strategic capabilities through employee learning. To prepare students for similar problem solving responsibilities, and to foster engineering principles learning, a team-based teaching approach is used during the Introduction to Engineering Design (ED&G 100) course at The Pennsylvania State University. Throughout the course, four-student project teams work on two design projects over a 16-week semester. Design projects focus on product improvement or solution designs.

To date, several variables affecting the performance of design teams have been studied, such as team composition, female/male ratio in the organization, and teamwork skills training, to improve the performance of product designs. This study furthers this effort by investigating the effect of guided external research during the concept generation phase of the development process. The premise of the study is that as resources increase in number and complexity, and time constraints pressure an overcrowded curriculum, professors are challenged to find new methods to train students in the skills needed for the constantly changing workplace. A creative collaboration is one technique to address this issue.

This paper discusses this creative collaboration, and its impact on the design team performance. First, the approach for inclusion of guided research into curriculum is explained thoroughly, and then the results of the pilot study conducted in selected ED&G 100 course sections. Design team performance is measured using: 1) peer evaluations of the design demonstration (25%), and 2) a blind evaluation of the team's design report (75%). Criteria for project performance include thoroughness of the project report, timeliness of the project report submission, compliance to project requirements, and utilization of engineering problem solving skills. Results indicate that indeed a higher design performance can be achieved when guided research is added to the design teaching.

1. Introduction

"Many engineers lack skills in accessing and retrieving information. Yet the ability to monitor,

access, retrieve, evaluate, use and communicate information will be critical in a global information society characterized by rapid technological change. Engineers who possess a more thorough knowledge of information retrieval strategies and information resources will be more effective in educating themselves." [1]. Thus begins an abstract for a 1994 conference paper. The need for information literacy has not decreased since that time. While students arrive on campus very comfortable with the World Wide Web, they are not trained in efficient use of electronic or traditional resources, nor are they necessarily able to evaluate resources for quality.
As resources increase in number and complexity, and time constraints pressure an overcrowded curriculum, professors are challenged to find new methods to train students in the skills needed for the marketplace and to encourage learning skills that will prepare them for the life-long learning that is necessary to survive in the constantly changing workplace. Creative collaboration is one technique to address this issue.

A collaborative pairing which directly addresses the need to prepare life-long learners who are comfortable with the changing information environment is the engineering professor and librarian team. The immediate goal is to integrate information literacy skills into the engineering design classroom and specifically as a means to improve product/solution design projects. The long-term goal is to address those issues mentioned in the abstract; to provide future engineers with the skills to succeed in the classroom and to access and utilize the information that will encourage life-long learning and adaptation to the changing technical world.

There have been several studies that have addressed the need for library skills in the curriculum. The University of California at Berkeley has studied this need for years [2]. Their Teaching Library was formed in 1993 to 'ensure that all graduates of the university are thoroughly familiar with the information resources and tools in their respective fields of study, trained in their effective use, and, beyond that, prepared to conduct a search for information resources in any field of inquiry.' [3] The study looks at both lower order skills such as locating information and higher level skills such as assessment and evaluation and application of the new information.

Over the years of study the researchers have found that year after year the students overestimate their knowledge of libraries and resources. When tested on the range of skills and resources they fail by a large margin, even those that thought they were very good or excellent library users. According to this article, studies at other institutions confirm these results. They note that 'the most fundamental conclusion … is that students think they know more about accessing information and conducting library research than they are able to demonstrate when put to the test.' [4]

Another study looked more specifically at science and engineering students. Leckie and Fullerton [5] provide a short review that reiterate the low use of libraries and library resources by the students. If the lack of use and the lack of skills to utilize a library are an accepted fact and information literacy is considered to be important, then strategies need to be devised to address this problem. Citing studies that indicate that instruction is more successful if it has a direct link to a class and is delivered when needed, 'just-in-time instruction' to borrow from an engineering term, then close collaboration between a librarian and teaching faculty is important. Without collaboration library instruction may not be closely focused on course syllabus. In addition, the

examples and assignments may not integrate with engineering assignments. To be judged by the students as worthwhile, library assignments must directly address the immediate needs of the students. In many cases, librarians address general skills or a particular set of resources. The methodology and the resources are used to advance the concept of life-long learning. However, with no immediate application students may pay little attention, not see the relevance and not incorporate the skill into their learning schema.

One other factor that must be considered for a successful project is 'buy in' from both members of the team. The librarian must display both appropriate knowledge of the subject matter and interest in the student projects. The engineering professor must demonstrate that information is important in the engineering process. If the professor appears to place little value on information or to have no interest in information research, the students may perceive the session as a time-filler or busy work.

There are factors that interfere with this collaboration. Professional time constraints, classroom time constraints, and a very crowded curriculum combine with the fact that many classes can use the text for all class work. Another factor that must be considered is a lack of communication between the librarian and the teaching faculty. A clear understanding of what is happening in the classroom, expectations for the class, and the role of the library in meeting these can be lacking. Both may have a set of goals for the class, but they need to coincide. While the each may have very definite ideas of what must be covered, if they conflict or are not communicated, the sessions will not be successful. All of these works against a library assignment that is both timely and seamlessly integrated into the class but can be overcome with discussion and collaboration.

The authors end their survey of engineering and science faculty with several conclusions. Two are especially relevant to this project. First, time and content are very important. The librarian must know and understand the course, the role of the library in meeting the goals of the course, and tailor the instruction to it. It must also be timely so the relevance is very clear to the students. Second, the goal must be self-sufficiency of the student. Handouts, online help, and tutorials are important and must take into consideration the realities of student needs and skills rather than the preferences of the faculty or librarian.

2. Experimental Design and Application

Two sections of the Introduction to Engineering Design course at Penn State were included in the study. The same instructor taught both of these sections during Spring 2002 semester. Each section consisted of eight, mostly four-person teams.

Experimentation was conducted in two phases: design project 1, and design project 2. The first design project involved building a weighing system using strain gages and beams. After a series of guided, hands-on experiments with electrical resistors, strain gages and beams and lectures on the mechanical behavior of materials, teams were asked to build a weighing system that can accurately weigh objects within a specific weight range to a specified resolution.

After the first design project, teams were presented with the second design project. The design

task along with several design requirements was conveyed to 16 design teams. Each team was given eight weeks to come up with their best solution. During this time, they were to act as companies that were competing to get the project sponsoring company's business with their design solution.

The second project was to design and prototype all (or part) of the process required to assemble an inverted tooth chain assembly from its individual components. It was sponsored by Morse TEC (Transmission & Engine Components), one of six divisions of BorgWarner. The design task was to develop an innovative process to assemble the components into a finished chain with the design criteria including quality, flexibility, assembly rate, component sorting performance and ergonomics.

For both projects the performance was measured using team quizzes, peer design evaluations, and a blind review of the design reports. The weights of these grades were 5%, 23.75% and 71.25% respectively. A team quiz is an assessment during which a set of questions is answered by a team of four in 15 minutes. Only one member would need 1 hour to solve the same set of questions. The time allowed for completion of the team quiz was adjusted based on the group size. However, for absent/late members, no time adjustment was permitted. The application of team quizzes was practiced during the first design project for both semesters the study was conducted. Throughout the semester, design teams were kept the same for both design projects: 1 and 2.

The aforementioned grades were used to establish a project grade for each design team. Thoroughness of the project report, timeliness of the project report submission, compliance to project requirements, and utilization of engineering problem solving skills were used as criteria for project performance evaluations.

Peer evaluations of contribution levels within teams during both design projects were used as an independent variable in the study. These peer evaluations were done after the design project was completed. During these evaluations students were asked to rate their teammates performance based on 11 different items using a scale of 0-5. Each student's evaluations completed by his teammates' were then averaged to give his contribution value. Average team contribution level is calculated as the average of these member contribution levels per team.

The gender composition of the design teams was also included in the study as an independent variable. In the data set, gender composition was represented as the number of female students in the design team such as a "0" for an all-male team, and a "2" for a 2-male and 2-female team. Additional independent variables were the meeting time for ED&G 100 course sections that were included in the study, the average GPA of the team, and the training that was varied among sections. Independent and dependent variables of the study are summarized in Table I.

One section was intervened with a high performing team skills training while the other received external guided research experience to be used during product design task. The content and delivery issues of the high performing skills training were discussed in detail in an earlier publication [5].

TABLE I
Independent and Dependent Variables

Independent Variables	Levels
1. Gender composition of the team	All male (0), all female (4), 2 male and 2 female (2), lone female (1)
2. Class meeting time for sections	12:20 pm (Teams 9-16) 2:30 pm (Team 1-8)
3. Training	Teamwork skills training (1), Guided research training (2).
4. Average cont. level	An average of peer contribution evaluation (0-1)
5. Average GPA for design team	An average of student GPAs within a design team (0-4)
Dependent Variables	**Explanation**
1. Design project performance Team quizzes Peer project evaluation Blind review of reports	2 team quizzes (5%) (23.75%) (71.25%)

3. Guided Research Experience: Content and Delivery

The planning of the library sessions for ED&G 100 carefully considered the research done on successful information literacy programs and the specific situations in the engineering classrooms. Before any sessions were planned or web pages developed long discussions of course goals, assignments, syllabus and projects were held. Guided research experience topics and assignments were reviewed as they were created and revised as the semester progressed to address any changes that were needed.

The guided research experience is organized into four sessions that introduce the wide range of resources available to them. Resources and topics covered are progressively more complex and build on the previous class. Each session is approximately fifty minutes long, the same as the traditional class session at Penn State. The structure of the class is demonstration and discussion. An attempt is made to be as casual as possible to encourage interaction and questions. The class is in a computer lab so students can try the databases during the demonstration or after. There are three points that are core to the sessions: no exams on the library sessions, no rote learning expected, and the emphasis is on utilization and transference. The content is practical in nature and should be transferable from one database to another and one university to another or to the workplace. This encourages learning since it is not time spent for just one class or project, but information that can be useful throughout one's academic or professional career.

Session I: This session is both an introduction to the library and to the importance of library research. Many students have not had a great deal of interaction with libraries, have not written many research papers, and the level of research required for these papers was usually minimal. In addition, there is often an underlying attitude of not needing libraries for engineering projects.

Many students believe that all necessary information is provided in class by the professor, in the texts, or freely available on the Internet. Library resources are not needed. Breaching this wall looked as if it would be a challenge but has not proved to be. The key may be in making the material that is presented very relevant to the class while indicating the usefulness of the skills in other classes. It is noted that library knowledge and skills can readily translate to higher grades both in the engineering class and in other subjects.

An overview of the library sessions and the class web site provide a very good 'hook' to gain the students' attention. One common criticism in professional literature and collegial conversation about the teaching activity that has been labeled at different times 'library orientation,' 'bibliographic instruction,' or 'information literacy' sessions is the difficulty in engaging the student. Usually the librarian comes into the classroom, provides a great deal of information and a sheaf of handouts that don't appear to be relevant to the student, and leaves the classroom, possibly never to be seen again. There is not direct connection between the library review session and the class. There is usually no grade that results from the session. If there is a graded exercise, it usually is not created or graded by the librarian and is often marginally linked to the session. Therefore, the students don't see the relevancy, value the information, or need to actually utilize the skills in a meaningful way. The student attitude of 'disconnect' is real.

In the EDG100 intervention the students learn within the first few minutes that a percentage of their grade is linked to the library sessions. It is emphasized that the information gained can improve their final project and has a significant influence on their final grade. The normal 'disconnect' has now become a practical connection to their grade and success in the class.

Once the rationale for the library sessions is clear, the subject matter is reviewed. The starting point for the class is the Web page created for the class [6]. The Web page provides a link to all the resources, contacts, and requirements of the class. It is easily updated and serves to reinforce the class lectures, demonstrations and questions.

Most students have not explored the Library Web site or the catalog. For the first session, the Libraries homepage is used as a starting point for the review of the Cat, Penn State's library catalog. The Cat provides access to the holdings of 'complete' items owned by Penn State at all of its campuses. These 'complete' items include books, conference proceedings, journals, maps, and formats of materials. It does not index what is inside of these items. This is an important and difficult distinction for students.

The Cat is demonstrated with several examples. Exact item searching is reviewed but keyword searching is emphasized. Since there are graded assignments, examples that the students might select are not used in the demonstration. Instead, an engineering example in a related area is selected. For example, when the students were doing a project on timing chains the example was green engineering. The same skills were learned, the topic was applicable to the major, but it did not actually complete the assignment for any one group.

The goal of this particular session was to provide the skills needed to find resources on a topic. The resources were those that would support the work in ED&G 100. In addition, the knowledge

of the formats of these resources would be useful throughout the course of studies in engineering. The skill to search the catalog would be transferable to classes during the entire course of study and beyond. One idea that is mentioned often is there is an underlying logic to library catalogs and databases and once this is clear, students can go from one that is known to a new database and feel comfortable after a short exploration.

The formats introduced in the first session are handbooks, dictionaries, journal, standard, and book. The term 'book' is used since students are familiar with it rather than the librarian term of 'monograph.' These resource formats were selected since each has an important role in engineering education in general and the design project in particular. For example, handbooks provide the student with fast, evaluated facts or formulas they need for their projects. In the example of green engineering, a handbook can provide filter information for wastewater facilities. Subject specific dictionaries are an important introduction to many students, allowing them to find more specific and appropriate definitions than they would find in the general subject dictionaries they used in high school.

While many students will not be using articles from scholarly journals until more advanced classes, they benefit from learning how to identify an engineering journal or magazine. A later class will discuss how to search subject databases for specific articles.

Books are probably the most familiar resource to the students. They provide an excellent example to teach the best ways to search the online catalog of the university. The access points for books are title, author or subject headings. In class the skill of taking what is already know to find additional resources is demonstrated. By working through an example, the students learn to read a record, understand the controlled subject headings, which describe each book, and to manipulate these descriptors to find additional resources. They are introduced to the logic of the catalog. In a sense, the logic and careful description of library resources is contrary to the rather haphazard free-text searching of web pages which students already have a high level of familiarity.

The last format is the standard. Usually none of the students are familiar with standards so this provides an initial introduction to this important resource. To introduce them, an appropriate standard is used as a demonstration. For example, water quality standards can be used to advance the demonstration topic. For fun and to indicate the wide range of standards, examples mentioned might include drop tests for soda containers, emissions tests and tests for materials that might be used for cockpit windows.

At the end of the first session the students walk to the Engineering Library, are introduced to staff and the services available to them. The purpose of the first session is to 'break the ice' with the library catalog, library services and the library faculty and staff.

Students work individually on this assignment. They are asked to pick a topic of interest in engineering. For the assignment they state the topic, the terms used in searching the Cat, copy the record of the resource they find in the Cat and provide a short critique of the process. In this critique they note if they were successful finding each of the five formats and what search method worked the best. They are asked if there are any questions or unclear points that will be answered

in the second session.

The entire assignment takes about 20 minutes and can be submitted electronically. Papers are graded and returned during the second session. This provides a chance to circulate around the room and meet students.

Session II: The second session builds on the first. Any common problems are reviewed in class. For example, keyword searching can be imprecise and if students don't evaluate the record there can be some interesting and unexpected results. For example, one student selected roads as their topic of interest. A keyword search combining roads and journal resulted in a diary of a traveler in Europe in the 1800s. It did have the right words in the catalog record but was not a journal. It provided the opportunity to reinforce the importance of subject headings, a search strategy as specific as appropriate, and the various definitions of words. It was also the perfect time to reinforce the point that libraries have very specific and unintuitive terms they use. Learning what these are will be a big help when searching a catalog. One of these is the term periodicals in the subject heading to describe a journal. If 'periodicals' is used rather than journal, then diaries and other inappropriate works are eliminated.

The topic for the second library session is the long list of databases that Penn State licenses for the use of the students. The Electronic Resource List is shown but only a few appropriate databases are reviewed. The first is *ProQuest*, an interdisciplinary database. A number of the records in this database have full text links, making it especially useful. Many students had some experience using it in high school. A short demonstration is run using the subject green engineering. In addition to *ProQuest*, three others are shown. These are *Compendex*, the premier database for engineering; *NTIS*, the database that indexes technical reports; and *Applied Science and Technology*, an excellent, easy to use database appropriate for beginning students. This provides the students with a range of interfaces to explore and an introduction to the major databases in their field.

It should be noted that the resources are all electronic. Print abstracts and indexes are mentioned in class but almost all of the databases used by the students are now available electronically. However, they are reminded that they may need to use materials that pre-date the online resources, in which case they will need to go to the library and use print resources.

After the demonstration and discussion, the students begin to work in their assigned teams. The team may select a topic from a design project or a general design subject such as a particular CAD software package. The assignment has the team explore each of the four databases with the selected topic. They are to evaluate the database for ease of searching and revision of the search, success of the search, quality of results, and quality of help screens. Last, they need to note a resource that they found in each database and check to see if it is owned by Penn State. This reinforces the catalog skills learned in session one. To assist the students, there is a web tutorial that reviews all of the databases discussed in class.

Session III: This session reviews common problems from session two and moves on to Web resources. While all the resources the students have used to this point have been Web resources,

they are evaluated and purchased databases. This lends a certain level of validity that can be sorely lacking in many other Web sites. Therefore, evaluation is discussed with the typical criteria reviewed. To demonstrate this, each team is given a color coded packet of real Web sites with a sticker noting the one they are to review and discuss with the class. Discussion is based on criteria, which include accuracy, authority, objectivity, currency, coverage level and appropriateness. Most of the sites are legitimate and represent government, non-profit societies and corporations. Each have legitimate and appropriate uses but the students must learn to look for information to indicate credibility, currency, bias, etc. However, the last group always has the 'ringer' in the packet. This is a created page, which conforms with all of the rules of evaluation but is a planted page with false information. Web evaluation is complex and vitally important. It is a fun example that usually generates some discussion while making an important point.

The assignment requires the team to look for a Web page, a newsgroup, and a list service on the topic selected in assignment two and for a more general engineering topic such as internships, scholarships, engineering ethics, etc. They perform each of the two searches twice. The first search is with a search engine of their choice, for example Google or Dogpile. The second is through an evaluated search guide like the Evaluated Engineering Virtual Library (EEVL). A list of evaluated sites with hyperlinks is provided on a web page. The team paper must include subjects that were searched, complete URLs for each of the three types of resources, and an evaluation of the two search modes. The goal is to emphasize evaluation, explore the wealth of resources, the proliferation of sites worthwhile and unusable, and to introduce the students to the use of evaluated web sites.

Session IV: The fourth session begins with a demonstration of the patents database and a discussion of the usefulness of this overlooked resource. When students realize they can find very useful information fast and apply it to their projects, they take notice. As in previous classes, an example is done in class and then the information is expected to be applied when completing the assignment.

The next topic introduced is that of bibliographic citations and correct format. A few real-life examples are provided that are so obtuse it is virtually impossible to find the source material. A web page provides detailed information on the importance of citations and links to several guides. While a very mundane topic, it is necessary for a quality research paper. Different style guides are discussed. The last part of the class is devoted to the topic of plagiarism. The importance of the topic is emphasized with some real life examples and a visit to the academic integrity site at Penn State. For many students, this might be the first discussion of the topic and it is one that must be introduced early in the academic career. The discussion is not long, but students have a number of questions.

The closing part of the class introduces the last assignment. The goal of this paper is to help the students with their final design project. They take that topic and develop an annotated list which includes a handbook, dictionary, journal article, newspaper article, standard, book, report, web page and patent on their topic. The team does the assignment so it is not too time-consuming. Several teams have discovered information that they incorporated into their design. It also can help them find regulations or standards that are needed in the design.

While many of the students may question the need to take valuable time from their design work to explore library resources, the assignments and class sessions integrate with the goals of the class to complement and advance the design project. It is important to make it clear throughout the semester that this is not busy work. This can best be emphasized by integration into the final design project. For example, when the student project was timing chains, the resources found could guide or 'tweak' the design. One team found a coating that allowed quicker release of the completed chain while looking at an article for the library assignment. Another team used the OSHA web page for noise standards and incorporated a design change into their final project. Another student located a patent that redirected their design. Many of the teams cited these resources during their presentations.

When the library research actually advances the design project, it becomes part of the class rather than an added assignment without relevancy. While not everyone of the formats will be useful for any one team, the overall affect is positive.

Good research is integral to the design process in class and in the real world. To accomplish this, several aspects are crucial. The first is communication between the engineering design professor and the librarian. Students can tell if the two are a team with shared goals and commitment, or if the library sessions are unwelcome. Second, the librarian must work within the agenda of the class. While there are skills and topics that the librarian may feel all students must know, if they don't advance this particular class and are outside the framework of what is appropriate, they should not be shoe-horned into the sessions. It will crowd the already full schedule and will be seen as nonessential by the students. This may possibly result in incomplete assignments or negative perceptions of all of the assignments and the role of the library. It is important to keep to the goals and objectives of the class and not try to cram everything a student needs to know about the library and resources into one library class.

Last, the assignments must be clearly described with very clear evaluation criteria. Prompt feedback is important since the later assignments do build on earlier assignments. It is very important that the assignments advance the engineering class and clearly link to improving the project. The assignments should complement the project and not be so long as to distract from the completion of the project. Since the library/engineering pairing is new to most students it helps to provide extra guidance to them. The class Web page serves to provide a place to put sample assignments so the students understand what is expected, as a link to supplemental materials for those who need them, and to provide links to the examples used in class.

An additional aspect that improves success is accessibility. The librarian needs to be accessible to the students whether it is by phone, email, or in the library. It is also beneficial for the librarian and students if the librarian visits the class when design presentations are made. It demonstrates interest to the students and is a great learning experience for the librarian, providing feedback that can be used to revise content and delivery for the next semester.

4. Results

The data set, collected as described with experimental design and application section, is given in Table II. In the table, under the column heading "Training" the type of the training received by teams is represented with numerical values such as a "1" for high performing teams training, and a "2" for external guided research training.

TABLE II
Results- Borg Warner Project

Team #	Gender Composition	Training	Average GPA	Average Cont. Level	Project Grade
1	0	2	2.94	0.92	96.3
2	1	2	3.37	0.94	98.3
3	0	2	2.9	0.82	99.2
4	0	2	3.19	0.95	97.6
5	0	2	2.77	0.90	87.8
6	0	2	3.14	0.98	91.1
7	0	2	2.84	0.9	93.8
8	2	2	2.98	0.94	97.9
			3.02		**95.25**
9	2	1	3.22	0.97	98.0
10	0	1	3.23	0.98	93.3
11	0	1	3.1	0.87	88.1
12	0	1	3.23	0.97	82.9
13	0	1	3.04	0.84	88.9
14	2	1	3.05	0.89	93.0
15	1	1	3.33	0.90	95.2
16	2	1	3.04	0.89	82.5
			3.16		**90.24**

As can be seen in Table II, despite a higher average GPA for team 9-16, their overall average project grade was 90.24, which is about 5% lower where a 100 is the perfect score. Furthermore, in an earlier study it was shown that average GPA of design teams significantly affects their design performance [8]. This result, a higher average design performance despite a lower average team GPA, is attributed to the difference in training they have received, and the positive impact of the guided research experience intervention on the performance of design teams.

When the independent variables were investigated for their potential effect on the design project performance using a multiple regression the following results were achieved, where:

C_2: Gender composition
C_3: Training
C_4: Average GPA
C_5: Average Contribution Level
C_6: Project grade

The regression equation is

$C_6 = 71.7 + 3.04\ C_2 + 6.92\ C_3 + 12.4\ C_4 - 31.C_5$

Predictor	Coef	SE Coef	T	P
Constant	71.70	22.54	3.18	0.010
C_2	3.038	1.236	2.46	0.034
C_3	6.920	2.279	3.04	0.013
C_4	12.447	7.545	1.65	0.130
C_5	-31.53	24.11	-1.31	0.220

S = 3.702 R-Sq = 57.7% R-Sq(adj) = 40.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	186.83	46.71	3.41	0.053
Residual Error	10	137.08	13.71		
Total	14	323.91			

Source	DF	Seq SS
C_2	1	58.62
C_3	1	87.75
C_4	1	17.02
C_5	1	23.44

As can be seen, the model accounted for 58% of the variation in design performance (project grade). Training's relative importance for its effect on the design performance is clear as seen in the statistical analysis, and this effect is significant. The implication of this is very powerful: even when the average GPA in a team is not very high, addition of a guided research intervention to the engineering design teaching improves the design performance of engineering teams. However, with this preliminary study, due to a limited number of design teams, it is not possible conclude. Therefore, further experimentation with a larger number of teams is necessary.

5. Conclusion

To date, several variables affecting the performance of design teams have been studied, such as team composition, female/male ratio in the organization, and teamwork skills training, to improve the performance of product designs. This study furthers this effort by investigating the effect of guided external research during the concept generation phase of the development process. The premise of the study is that as resources increase in number and complexity, and time constraints pressure an overcrowded curriculum, professors are challenged to find new methods to train students in the skills needed for the constantly changing workplace. A creative collaboration "A Guided Research Intervention to Engineering Design Teaching" is one technique to address this issue, which is presented in the paper.

Results of an experiment, which is designed to investigate the potential positive effect of this guided research intervention, yielded the fact that indeed a higher design performance is achieved.

However, more experimentation is necessary to eliminate a possible concern relevant to the size of the data set.

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