

AC 2009-2227: USE OF RESEARCH NOTEBOOKS BY UNDERGRADUATE STUDENTS

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Use of Research Notebooks by Undergraduate Students

Abstract

Previously, the authors investigated the use of design notebooks as indicators of student participation in team activities. The authors have used *design* notebooks in freshman *design* classes and senior capstone *design* class. It was demonstrated that design notebooks are a good indicator of teamwork practices. The motivation of this study is to enhance creativity in design research by undergraduate students. In order to effectively enhance creativity, tools have to be developed to map it. Here an attempt will be made to differentiate team creativity from individual creativity. Individual creativity here will relate to the process of generating ideas on the basis of learning types and brainstorming techniques. Team creativity will relate to the additional creativity, which is generated through synergy and team dynamics. In this study, the authors extended the use of *design* notebook used in *design* project to *research* notebook used in a *research* project on the selection of freshman design projects. For the research notebooks, a coding rubric will be constructed that is used describe and quantify the creativity instances that occur in the course of a design research project. The study will involve undergraduate students. Half of the participants had used a design note in freshman engineering design class. At the beginning of the project, the students will be provided with (a) clear instructions on how to document entries in the research notebook, and (b) rubric on the evaluation scheme. The goal will be to make sure that the students understood the expectations for the research notebooks. The research will develop rubric for research notebooks, and will attempt to show that research notebooks can be used as an effective tool to map creativity instances during team activities in a research project on design.

Introduction

Design notebooks are an essential pedagogical tool in the area of design. In literature they have been shown to be an essential tool for (1) reflection, (2) documentation of the design process, (3) historical archive, (4) course grade, (5) incidental writing tool, and (6) instant assessment of course for instructor. The use of design notebooks as indicators of student participation in team activities has been investigated.¹ It was demonstrated that design notebooks are a good indicator of teamwork practices. Design notebooks have also been used to track students' cognitive patterns in engineering design.²

Well formulated design notebooks have been shown to have pedagogical and cognitive benefits³. To reap these benefits however, it is very important to teach the students how to complete an effective design notebook⁴. Svarovsky and Shaffer⁵ used design notebooks in conjunction with design meetings to shed light on the learning processes of undergraduate students during an engineering design course. Seepersad et al.⁴ demonstrated that design notebooks were an essential element for effective experiential learning. Essentially, the construction of design notebooks, reflective thinking, and design thinking, takes place in a team environment⁶.

Motivation and Objective

The motivation of this study is to enhance creativity in design research by undergraduate students. In order to effectively enhance creativity, tools have to be developed to map it. Here an attempt will be made to differentiate team creativity from individual creativity. Individual creativity here will relate to the process of generating ideas on the basis of learning types and brainstorming techniques. Team creativity will relate to the additional creativity, which is generated through synergy and team dynamics.

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Methodology

The ?? Scholars and Mentors Program is a research institute within the School of ??, at ?? University. The institute was founded to advance interdisciplinary and/or multidisciplinary team research among students. The students perform their research with faculty as their mentors. The projects supported by this institute usually involve more than one traditional engineering and science discipline. The authors used the innovative approach to mentoring a team were developed in two published references.^{7, 8}

During the ?? research project, the authors mentored six students in a team (two prospective freshmen females, two freshman minority student, one junior minority student, and one sophomore). This was an eight week project on “Introduction of Undergraduate students to Engineering Design Research”. Each student was given a research journal, where they were to record their daily activities, including team meeting notes and assignments, class notes, sketches, raw data and personal reflections. The students were provided with clear instructions on how to document entries in the research notebooks, and examples of good design journal entries. The goal was to make sure that the students understood the expectations for the research notebooks.²

A detailed research schedule was developed to guide the student research activities during the nine weeks. The schedule is shown in Table 1. The tasks in the research schedule grouped in seven categories, namely, (1) Research Methods, Equipment, & Venues, (2) Purchases of items for the project, (3) Info Gathering, (4) Documentation (using research notebooks), (5) Summary, (6) Coding & Analysis, and (7) Posters, Conferences, Seminar, Presentations, Reports, Questionnaire, & Abstracts. The seminars included topic such as “What is research?” and “Living in diverse society.” Additional to the activities listed in the schedule, the students were also required to attend writing workshop (e.g., “Writing the research paper”), field trip (e.g.,

Student conference, Renewable Energy firm), and participate in some reading (e.g., Kuhn's "The Structure of Scientific Revolutions").

In this study, the elements of the research notebooks were adopted from the five elements developed by authors.¹ The five categories were (1) Dates: Each of the entry in the research notebook has be date stamped. (2) Content: Here the students describe in detail the activity that was carried out in some technical detail. Additional to the technical detail, the students also write down there reflection on the technical entry. Additionally, all the team members participating in each research activity have to be noted. (3) Continuity: This relates to the continuity between two or several entries. For this the students are encouraged to have at the end of an entry that involves most of the team members to have action items for the next task. (4) Duration: Here the students indicate how much time was spent on specific research task. (5) Signatures: Since each team member is familiar with the research tasks of each other, they are required to read each entry and to write their initials at the end of the entry.

Results and Discussions

For this study, the students were trained on how to use the research notebooks. Specifically, they were instructed on the five essential elements of research notebooks. In this study, the elements of the V notebooks were grouped into five categories, namely, date, content, continuity, duration, and signatures. The coding used in this study is similar to that in reference⁹ which was adopted from Atman et al.^{2,10} The coding consisted of ten elements, namely, problem definition, gather information, generate ideas, modeling, feasibility analysis, evaluation, decision, reflection, synthesizing knowledge, and communication (see Table 2). Each of this element may have a set of sub-elements to precisely define each activity. For example the "gather information" element was further broken up into nine distinct information gathering activities, namely, ask client-expert, library research, internet use, ask other-expert, plan to gather, gather info (general), and procedure: gather info. Typical pages from the research notebooks are shown in Figure 1 and Figure 2. Figure 1 shows a page out of the research notebook on the activity "Information Gathering." And Figure 2 shows a page out of the research notebook on the activity "Reflection."

Conclusion

The objective of this research was to develop a rubric for research notebooks, and attempt to show that research notebooks can be used as an effective tool to map creativity instances during team activities in a research project on design. For this study, the authors mentored six students in a team (two prospective freshmen females, two freshman minority student, one junior minority student, and one sophomore). The duration of the study was eight weeks. A rubric for research notebooks was developed and discussed. The rubric has a potential for usage as an effective tool to map creativity instances during team activities in a research project on design.

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Table 1 Nine-week research schedule.

Tasks	Notes	Research Team						Week # 1	Week # 2	Week # 3	Week # 4	Week # 5	Week # 6	Week # 7	Week # 8	Week # 9
		Mentor	Student # 1	Student # 2	Student # 3	Student # 4	Student # 5									
		Student # 6	Student # 7	Student # 8	Student # 9	Student # 10	Student # 11									
1 Weekly meetings with Mentor (team, individual)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
2 Setup meeting lab (desktop, printer, laptop)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
3 Intro to Research in Design		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4 Intro to Research Notebooks		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5 Submission of Research Notebooks		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
6 Submission of Research Notebooks		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
7 Submission of Research Notebooks		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
8 Submission of Research Material & Equipment		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9 Purchase orders (laptop, ext. hard drive)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
10 Purchase orders (notebooks, ring binders)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
11 Purchase order (Boe-bot kit)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12 Purchase orders (Items for Proj # 1 & 2)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
13 Purchase orders (Items for Proj # 3 & 4)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
14 Purchase orders (Items for Proj # 5 & 6)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
15 Intro to information gathering (by Librarian)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
16 Information gathering for ME projects		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
17 Information gathering for ECE projects		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
18 Information gathering for EE projects		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
19 Information gathering for Bioeng projects		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
20 Information gathering from websites		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
21 Bibliography Software (EndNote)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
22 Meeting with faculty from ME, ECE, EE, Bioeng		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
23 Selection of Proj # 1 thru 6 (compiled in EXCEL)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
24 Intro to Data Collection		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
25 Design Proj (Robot 1)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
26 Design Proj (Mindstorm 1)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
27 Design Proj (Mindstorm 2)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
28 Proj # 1		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
29 Proj # 2		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
30 Proj # 3		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
31 Proj # 4		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
32 Proj # 5		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
33 Proj # 6		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
34 Proj # 1 -- Think Aloud		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
35 Proj # 2 -- Think Aloud		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
36 Intro to Summarizing Findings		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
37 Summarize findings		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
38 Intro to Coding of Notebooks Data		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
39 Intro to Coding of "Think Aloud" Data		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
40 Design notebooks (coding & analysis)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
41 "Think aloud" Data (coding & analysis)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
42 Individual Presentation to Research Group		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
43 Preparation of final report # 1		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
44 Preparation of final report # 2		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
45 Preparation of abstract for conference		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
46 Research Mentor's ASEE conference		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
47 Presentation from Practicing Design Engineer		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
48 Preparing Posters (Due Date)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
49 Student Conference (Presentation of Posters)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
50 Completion of Research Questionnaires		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Table 2 Research Notebook Rubric

Activity	Context			
	1 Expert/Client Meeting	2 Whole Team Actions	3 Partial Team Actions	4 Individual Actions
PROBLEM DEFINITION				
GATHER INFORMATION				
1.1 - Ask Client-Expert				
1.2 - Library Research				
1.3 - Use Internet				
1.4 - Ask Other-Expert				
1.5 - Plan to gather				
1.6 - Gather info (general)				
1.7 - Procedure: Gather info				
GENERATE IDEAS				
MODELING				
FEASIBILITY ANALYSIS				
EVALUATION				
DECISION				
REFLECTION				
SYNTHESIZING KNOWLEDGE				
COMMUNICATION				

10/10/08

MMS - MENTORS 8:30-10:40am

ET LAB - COMPUTERS + PROGRAMMING 12-2 PM

LIBRARY SESSION #2 2-4:30 RANDALL

LIBRARY SESSION

① RESEARCH - ARTICLES A-Z - E

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FOCUS ON RECENT ARTICLES - may limit yrs (2009-2008)

② May search journals on research - find articles

IEEE

↳ E journals

FIND ARTICLES - ACM FORUM - highly technical problems

may browse specific parts of LIB. → general

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④ SEARCHING DATABASES - META-SEARCH

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Figure 1 Entry in Research Notebook (Activity: Information Gathering)

Exploring the design process, which lies at the core of any engineering practice, has enlightened my understanding of an engineer. In one of my favorite articles, Engineering design is described as "a systematic, intelligent process in which designs generate, evaluate, and specify concepts for devices, systems, or processes whose form & function achieve user's needs while satisfying a set of constraints." I have ~~not~~ learned that it is an intricate, cognitive process that takes time, decision-making, and confidence to ~~be~~ successfully go through. This newly acquired perception has ~~not~~ changed my understanding and will certainly influence ~~my~~ me as I ~~will~~ plan my path in design in my future studies. In learning the design process, I have realized the importance of integrative, project-based learning.

Figure 2 Entry in Research Notebook (Activity: Reflection)