Computer-Aided Learning of Project Planning Within a Constructivist Framework

Barbara Crump
Craig Godley

Department of Business Information
Massey University at Wellington
B.J.Crump@massey.ac.nz

ABSTRACT

Constructivism is a theory of how learners come to know. Over the past decade science educators have increasingly adopted a constructivist approach to teaching and this approach could be equally valid to the teaching of computing. This paper describes results of a survey of 45 students studying a project management course for a Graduate Diploma of Business Computing. A simple computer based (Excel) tool has been created that allows students to undertake resource planning in a project situation, and gain planning experience from seeing immediately the results of their decision making. Although computer based, this project management tool has eliminated the complexity of fully featured computer project planning software. Its approach is to concentrate on the resources management aspect of project planning, and through its operations ensure students experience the dynamic nature of resource planning. The tool was used with constructivism as a referent. The results of the survey showed the majority of students viewed very positively both the software and constructivist teaching and learning approaches.

Keywords

Constructivism, learning, group work, project management, tertiary education

1.   INTRODUCTION

Today's business graduates must be competent not only technically but in their ability to work in teams in a collaborative environment. They are also expected to acquire, interpret, evaluate and organise data, reason, prioritise and problem-solve. For those who plan and lead projects, essential skills are communication, collaboration, leading, negotiation, guidance and the ability to deal with increasingly large volumes of data. Mentally holding the complexities and making informed, effective decisions is an essential ability in project planning. The question for educators is how students can acquire these skills in order to "get the bubble" (Rochlin, 1997).

Over the past decade there has been intense interest, particularly in science and mathematics education, of providing a teaching and learning environment within a constructivist framework (Treagust, Duit, & Fraser, 1996). Studies have focused on using computer-aided tools for teaching a variety of subjects (Azemi, 1995; Maor & Fraser, 1993) but there has been little research into the application of constructivism as a pedagogy for computing subjects in tertiary education where the use of computers has been both as a subject of study and as a tool to assist in the learning process.

This paper briefly backgrounds constructivism, describes issues in the teaching of a project management course, outlines features of the computer software which

are designed to address these issues and evaluates the design and use by tertiary students, of a computer tool within a constructivist framework

2.   CONSTRUCTIVISM

Constructivism is a theory of knowledge and learning; a theory of how learners come to know. Jean Piaget was a leading theorist of constructivism with the view that children construct knowledge of the world through assimilation and accommodation, emphasising biological maturity as a necessary condition (Piaget, 1954). Whilst there are many varieties of constructivism, all have as their basis the tenet that knowledge is individually constructed; it is not acquired through accumulation but is an active process which draws on the existing beliefs and experiences of the knower (von Glasersfeld, 1993). Vygotsky (1986), stressed the importance of the cultural and social environment on cognitive development, recognising that the individual learner is a social being who cannot be immune to the influences of social mediation (Alexander, 1999; Prawat, 1993; Taylor, 1993). The learner constructs his/her knowledge by accepting responsibility for their learning and becomes actively engaged in the process. It was with these principles as a referent, that the computer software was used. We hoped it would enhance the social environment by providing a facilitative and collaborative way of learning that fostered problem-solving and conceptual development in our students. It was not the only teaching method used but a way of providing a problem solving environment in which the learner actively participates in a meaningful and authentic manner.

3.   TEACHING PROJECT MANAGEMENT

The application of formal project management techniques allows complex outcomes to be achieved within a set timeframe. The role of the project manager requires a variety of skills be brought together to achieve the defined project objectives. The skills necessary for good project planning are those that deal with the formal planning process, as well as those dealing with the understanding and management of people and resources.

A central goal for students is the understanding of the balance between "soft" people-oriented understanding, and "hard" formal planning techniques. Project management requires the application of a wide range of skills, often disparate and in conflict, to the wide range of problems presented by the project process. Important is the balance in the use of "hard" and "soft" tools, particularly when there is the need to evaluate the wide range of information available

Education in project management requires that all ranges of skills are taught. The relationship between the mechanistic processes of formal planning, and the more intangible values associated with people and resources need to be clearly understood. All factors, not just tangible ones, come into the equation in order that a good project plan is formulated. Understanding and learning is facilitated when students are placed in situations where they are able to gain experience of the balance between "hard" and "soft" outcomes.

3.1   The Formality of Mechanistic Processes

Once understood students tend to like the formal project management techniques. They appear to provide a very tangible approach to solving a complex problem. Techniques such as GANTT and Critical Path Analysis provide a straightforward, yet mechanistic way of manipulating project information. The "black box" approach needs to be tempered with a more balanced view considering wider aspects.

3.2   Integrating Student Learning

Good project planning comes from being able to integrate these two aspects of the planning process. Students need to not only understand the idea of a critical path, but also need to consider the concept of the "float" or "slack" associated with tasks not on the critical path. Thus for students to consider the needs of effective project planning the following concepts have to be accepted and understood:

◆ There are two type of tasks that make up a project (critical and non-critical), and they have to be considered differently when [resource] planning.
◆ When planning for resources non-critical tasks are considered first.
◆ The use of float influences how resources may be managed, and they are closely linked.
◆ The use of float on one task may influence the behaviour of other tasks.
◆ The management of one resource may have an effect upon other resources.

It is interesting to note that critical path and float considerations tend to be influenced by the "hard" tangible

aspects of the project, whereas resource management tends to be influenced by "soft" intangible aspects. Concepts, which have been dealt with singly, now need to be brought together, and the student shown how these parts of the planning process need to be considered holistically. Only when the student is presented with relatively complex examples can the relationship between the "hard" and "soft" aspects of project planning be understood. The difficulty is that meaningful examples are too complex and time-consuming for students to use the manual methods that have been used to this point.

An approach to help students to overcome the problems of treating the project planning process as a "black-box" is through the use of software packages. It is with the use of this software that students may deal with problems of sufficient complexity thereby integrating their learning. Computer based tools need to be used so that students may concentrate wholly on the planning problem instead of the mechanics of calculating the critical path, task float, or resource allocation. This requires conceptual understanding of abstract building blocks and an understanding of the many varied relationships connecting the abstract blocks (von Glasersfeld, 1995). If a student is to construct and understand, these concepts cannot be transmitted from the teacher to the student simply through "telling" via the usual lecture method familiar in many universities. Knowledge cannot be passively received if understanding is to result, with the emphasis on learning, rather than teaching.

3.3   The Use of Computer Based Tools

With the availability of good graphic based computer software, project planning tools have become much more attractive to use. However, the temptation to use such fully-featured, complex tools as MSProject needs careful consideration, as their capabilities have become very comprehensive. The techniques that students need to support their learning may be buried in the complexity of the package. The danger is that the focus moves towards teaching of the software itself, rather than facilitating and integrating the students' learning of concepts.

What was needed was a simple, specialist computer based tool that removed the emphasis from the tool, by allowing specific learning concepts to be targeted whilst addressing the learning needs of students. The aim was to allow the focus to be on the problem domain; not the software being used. It is in this context that the "PERT" software was developed.

4.   THE "PERT" SOFTWARE

Careful consideration was given to the design with the following factors being considered essential features:
♦ a user interface matching software commonly used by students,
♦ a short learning curve for effective operation,
♦ the ease with which complex project information could be stated,
♦ the graphical presentation of the planning results,
♦ the speed and ease with which project details could be changed, and
♦ the speedy feedback of the results of such changes.

An early consideration was the input interface, and the benefit of a short learning curve for users. The creation of specialist software was rejected in favour of a system integrating with Excel - software that students would be familiar with. An interface based on Excel made for ease of data entry, and allowed standard "cut and paste" operations. The result is software that can deal with complex project management situations, and enables the student to concentrate on the interaction of a few manageable parameters. Built-in macros calculate tasks' start and finish times, float, and the critical path.

4.1   The Input Interface

The software is based on the Activity-on-Arrow approach, and once the project task has been structured, often through the creation of a PERT network, a minimum of input information needs to be entered. Emphasis is on only those items of information - task duration, dependencies, and resources - necessary to specify the project. This minimalist approach was designed to reinforce the concentration on the project planning process being considered - task dependencies and resource planning.

Input_Code | Code

Title of Project

Create | Adjust | Help on

Resources ======>

Code	Start	End	Description	Time	Delay	DR+	D+	ENG+	E+	P+	L+	Cost	
A	1	2	Design equipment	2			4					1.0	2.0
B	2	15	Design building	4		6		4				5.0	20.0
C	15	11	Construct building 1	6				1	4	4	8	25.0	150.0
D	11	14	Construct building 2	6				1	6	6	4	14.2	85.0
E	2	13	Procure long-lead equipment items	10			2					6.0	60.0
F	2	11	Procure ancillary equipment	9			2					6.0	54.0
G	2	4	Remove existing equipment	2				1			6	2.5	5.0
H	4	11	Prepare site	4				1	2	4		5.0	20.0
I	3	4	Design equipment installation	2			2					0.5	1.0
J	2	3	Detail equipment	3		6						1.8	5.4
K	4	5	Fabricate equipment (shop)	3			1					5.0	16.0
L	5	11	Assemble equipment (shop)	1			1					10.0	10.0
M	11	13	Install - Phase 1	3				1	2	4		4.0	12.0
N	2	6	Design controls	4				1				0.4	1.6
O	6	7	Select controls supplier	3				1				0.4	1.2
P	7	13	Fabricate and assemble controls	10				1				2.5	25.0
Q	13	14	Install - Phase 2	2				1	2	4		4.0	8.0
R	14	16	Debug equipment	1				1	2	4		3.0	3.0
S	2	9	Develop operating procedures	2				2				1.0	2.0
T	9	14	Select and train personnel	3				2				1.0	3.0

Input / Output / Resources /

Figure 1. Entry screen with sample project data.

Output Details - tasks in reverse order

Code	Start	End	Description	Time	Delay	Start-Times Earliest	Latest	End-Times Earliest	Latest	Float	Total Float
E	7	10	Ship stock to distributors	6	0	23	23	29	29	critical	
H	6	7	Sell to distributors	6	0	17	17	23	23	critical	
D	3	7	Package stock	6	0	13	17	23	23	4	4
M	9	10	Conduct advertising campaign	10	0	12	19	29	29	7	7
J	5	6	Train sales personnel	7	0	10	10	17	17	critical	
L	8	9	Plan advertising campaign	4	0	8	15	12	19	7	7
K	4	8	Select advertising agency	2	0	6	6	8	15	7	7
I	4	5	Hire sales personnel	4	0	6	6	10	10	critical	
G	4	6	Select distributors	9	0	6	6	17	17	2	2
B	2	3	Set up packaging facility	10	0	2	7	13	17	5	5
C	1	3	Order stock	13	0	0	0	13	17	4	4
F	1	4	Organise sales office	6	0	0	0	6	6	critical	
A	1	2	Design package	2	0	0	0	2	7	6	6

Input / Output / Resources / Gantt /

Figure 2: Results of Critical Path Calculations

Resource Details

Period Resources ----->

Period	DR	D	ENG	E	P	L	Cost
1		4					1
2		4					1
3	12	4	8			6	22
4	12	4	8			6	22
5	12	4	7				20
6	6	6	7				18
7		6	4	4	4	8	38
8		5	3	6	8	8	47
9		5	3	6	8	8	47
10		5	3	6	8	8	49
11		5	3	6	8	8	54
12		2	2	4	4	0	33
13			3	8	10	4	20
14			3	8	10	4	20
15			3	8	10	4	20
16			2	6	6	4	16
17			2	6	6	4	16
18			2	6	6	4	16
19			1				2
20			1	2	4		4
21			1	2	4		4
22			1	2	4		3

Figure 3: Resource Allocations over Life of Project
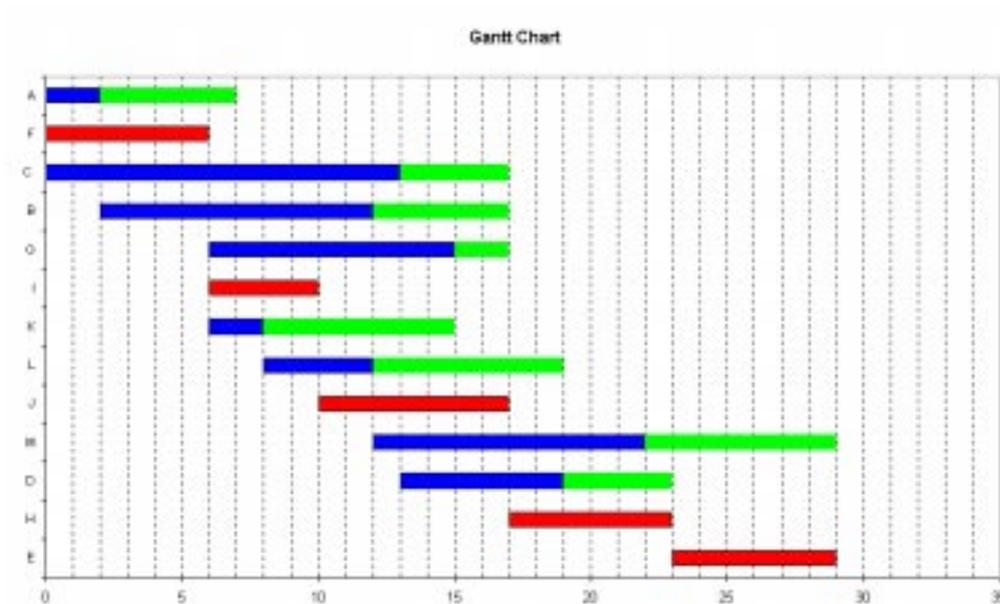
Figure 4: Project GANTT Chart Created by the Software

Ease of use is exemplified by the choice of only two "Operational" buttons. The [CREATE] button is used to calculate the project details and create the GANTT and resource charts. This is used initially after the project details have been entered, or when major changes have been made to the project plan, such as:

♦ adding or removing tasks, or

♦ adding or removing resources.

The [UPDATE] button is used to re-calculate project details when only relatively minor adjustment are made to the project plan, such as:

♦ changing task parameters, such as task length, resources, etc,

♦ delaying one or more tasks, thus using float, or

♦ adjusting the relationship between one task and another by rearranging the nodes which define each task.

To aid the student, the [HELP] button is available to display simple instructions on how each column is used.

4.2   The Output Interface
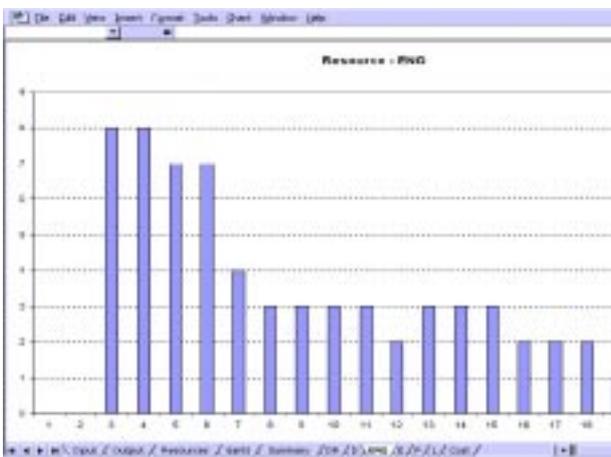
Figure 5. Details of one resource.

All output screens are self explanatory, with both numeric and graphic forms of output available to the student. The [Output] sheet contains automatically calculated details of the critical tasks and float for non-critical tasks, with the [Resources] sheet containing details of resource allocations over the life of the project.

From a learning point of view the most important displays are those that show project and resource information graphically. The software automatically creates the GANTT chart, see Figure.4, that clearly presents critical tasks, non-critical tasks, and float.

Where tasks are delayed, float will appear either side of the task bar.

The software displays the details of each resource over the life of the project, shown in Figure 5. The details of selected resources may be combined onto one summary screen. From this the student may see the balance between the allocation of one resource with another. Selection of a resource for inclusion on this summary sheet is by appending a "+" onto the resource name on the input sheet.

4.3   Additional Features

Because the software becomes an integral part of Excel, all the features of Excel still are available. Items of input data need not be scalar quantities, but could be calculated from values based in formulae in other cells. For example, unit costs for tasks can be calculated from total task cost and task duration; or task durations may be calculated from optimistic, most likely, and pessimistic times contained in other areas of the spreadsheet.

With problems requiring more complex management decisions, other Excel features may be drawn upon to calculate input data. For example, features such as [Solver] may be used where the value of any task parameter needed to be constrained.

5.   THE STUDENT ASSIGNMENT

Students were presented with a complex project planning scenario and asked to set their own planning objectives, attempt to meet those objectives, and discuss the reasons why some were not achievable. The PERT software was explained and demonstrated in a lecture using sample data similar to that of the assessment. It was intended that the software would replace the mechanical processing aspects of project planning as well as provide students with a tool that would help in constructing their own knowledge.

6.   METHOD OF SURVEY EVALUATION

Forty-three students (21 female and 22 male) enrolled in a second year degree course completed a survey seeking information on their computing experiences, their opinions on the PERT software and their views on how they constructed their knowledge.
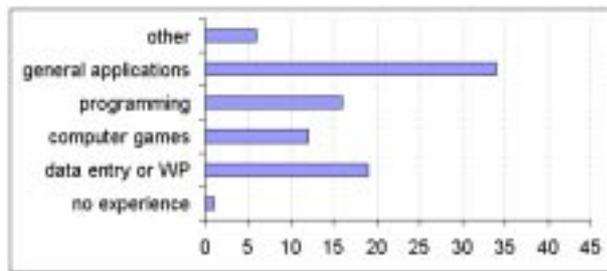
Figure 6. Students' computer experience.

A qualitative method was chosen because it gave the students freedom to express their own views on how they felt they constructed their learning and whether the software proved of value to them. Careful attention was paid to frequency of occurrence of the "yes/no" responses as well as of the coded themes and discrepant instances (Erickson, 1998). Results were recorded on a spreadsheet.

7. RESULTS AND DISCUSSION

Results and analysis of responses to the questionnaire are discussed below.

7.1 Computer Experience

There was no significant difference between male and female computing experience in any of the categories shown in Figure 6 with all but one male student reporting some experience with computers. This result was not unexpected as all students should have completed a first year computer applications course.

7.2 Use of Software

All 43 students responded "yes" to the question "Did you find the software helpful in coping with the assignment?" and forty-two answered the question "Did you like using the software?" with 39 replying "yes", two responding "yes and no" and one "no". There was no significant difference between male and female views of how helpful the software was or whether they liked it. The majority of students provided reasons relating to the themes shown in Figure 7. Most comments were positive and related to ease of use, the ability of the software to speedily provide a visual representation of changes, do the calculations and show the impact of resource leveling. Sixteen percent of comments referred to students recognising that the software helped their understanding
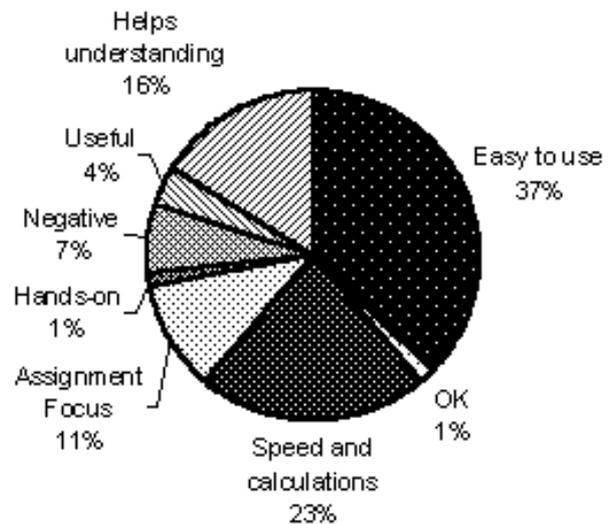

Figure 7. Reasons for students liking and finding the software helpful.

with 11 percent student responses noting the software focused on assignment objectives. The few negative comments included reference to the software not being "sufficiently flexible ...", being "fiddly having to constantly flick between worksheets", and "tended to waste time by playing around just to see effects".

7.3 Understanding

Question 8 stated "The software provided an immediate response when you changed your plan. Please comment on whether this feature gave you a better understanding of how these changes impacted on the project "as a whole". Twenty-eight students responded, the majority commenting positively. A selection of student comments relating to the theme "increased understanding" are:

♦ Yes, because it showed what tasks became critical

♦ It gave me a better understanding because I was able to look at the graphs to see where the changes had occurred

♦ Most important were the changes to the Gantt chart after alterations were made. It was essential to see these changes immediately, so the effect on time and critical tasks could be examined and therefore their effect on the project as a whole.

♦ Direct feedback was important. I was more likely to try more combinations.

Figure 8 charts the positive responses and the themes of confusion, limitations and no effect ("having used project management software before there was no impact"). The majority of students found that the responsiveness of the software to their changes helped with understanding the multiple concepts. However for some, the changes proved confusing as indicated by comments such as "I could not work out why some tasks were affected more than others", "it became confusing... as there was a compounding effect" and "the immediate response often got me confused as to why these tasks were dependent on each other". Six students perceived limitations with their use of the software, the ability of it to enhance understanding, the lack of features such as a zoom button and the need to use output with a network diagram.
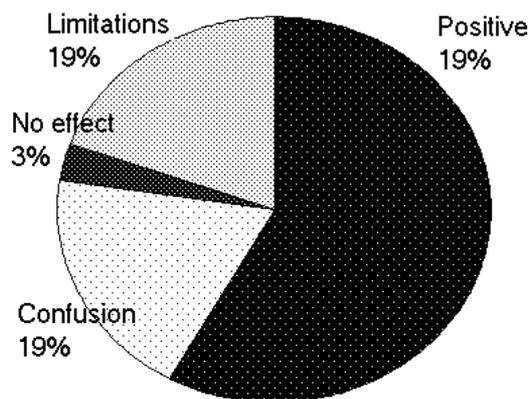
Figure 8. How the immediate response of the software affected understanding.

7.4   Collaboration and Group Work

Despite any formal facilitation of students into groups, 35 said they had discussed and collaborated with others during the assignment. Two females and five males chose to work on their own and one did not reply. The majority considered this way of learning positively with only two commenting "I would rather talk to the lecturer" and "Not much, everyone was in limbo, not knowing how to approach it". Table 1 shows some comments relating to the positive themes. Twenty-eight students gave reasons for how they believed this informal group work and discussion had helped their learning and understanding. The responses are categorised by themes of understanding, brainstorming, assurance and negative (Figure 9). The 29 percent of student responses relating to "assurance" and 29 percent to "brainstorming" reveal the importance of self-efficacy in a learner's knowledge construction (Ng, 1998).
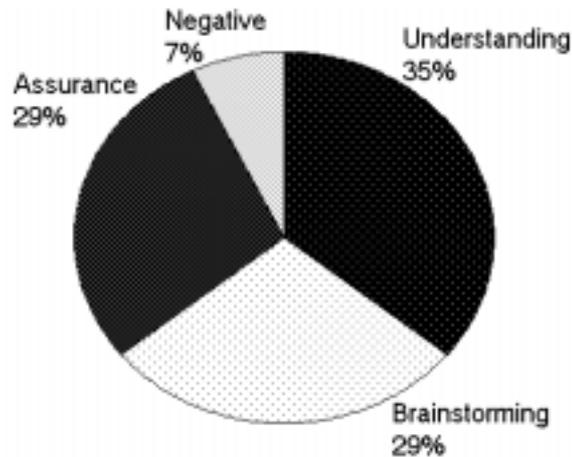

Figure 9. Responses to how collaboration and group work helped learning.

Table 1: Comments for understanding/brainstorming/ assurance:

♦ Helped me understand the complexities/Made me realise each person took a different angle/Approval of my opinion.

♦ Discussions helped with my understanding of how the project worked and what to look for/Helped to know what approaches other people were taking/We all had similar experiences; it was good to reinforce ideas.

♦ My own understanding and learning becomes 'wider'/ Definitely helped being able to bounce ideas off others/Good to know I am not the only person having problems.(2 students).

The informal group-work that the majority of students enjoyed was facilitated by the immediate feedback made possible by the software. Group learning is recognised as being helpful in knowledge construction (Dewey, 1920; Piaget, 1970; Vygotsky, 1986) but it is not a panacea for all learning. It can over-simplify important issues concerning the social structures of groups, the goals of individuals in groups and the diverse nature of knowledge construction (Linn & Burbules, 1993). For this reason no formal group allocations were made but the students were provided with a learning environment which was conducive to enculturation (Roth, 1993) into the practices of project management. They became actively involved in a meaningful and authentic manner and participated consciously in the culture of the subject, experiencing a community with shared goals, skills and values. This type of experience is central to problem solving and for developing student understanding.

7.5 Understanding Project Management Concepts

A number of questions sought students' views on how the software helped their understanding of project management concepts. Well over 60% of the group considered that the software increased their understanding of the "nature of the critical path", the "smoothing of resources", and the "use of slack". Over 50% considered that their understanding of the "interaction between tasks" had been improved. The concept least improved in understanding was that of "project objectives". (See Figure 10). Based on student perceptions the software had gone some way to improving understanding of the concepts.
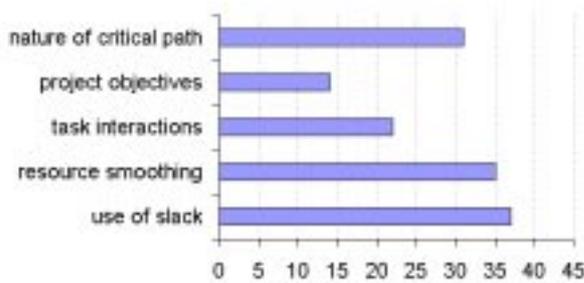
Figure 10. Project Management concept better understood.

7.6 Software Evaluation

One a scale of 1 (very good) to 5 (very poor), students were asked to give a rating for various aspects of the software. Figure 11 through Figure 13 show the ratings for the software's overall design and use, the design of the input screen, and the design of the output screens. Overall the results are very pleasing with students indicating a strongly positive view of the software.
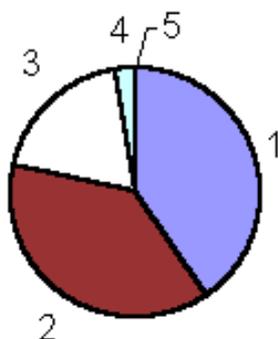

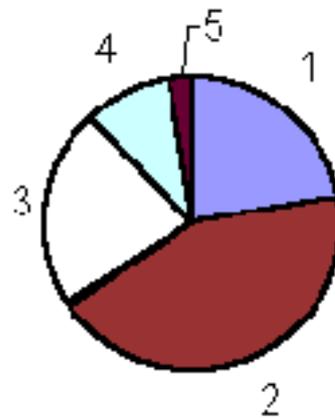**Figure 11. Rating the design of the software overall.**

Figure 12. Rating the design of the input screen.
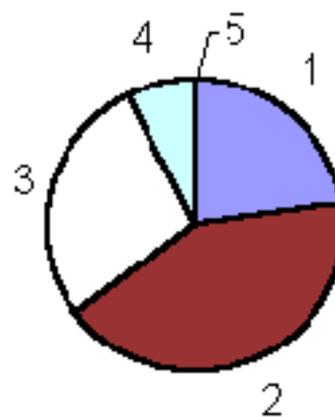

Figure 13. Rating the design of the output screens.

Figure 14 indicates how much time was spent using the software. One response of 25 hours was not included in the results as it was felt that this was unusual and not representative of the group as a whole. The results shows that there are two distinct peaks of use, one of approximately 4 to 5 hours, and the other of approximately 10 hours. These two areas of time do not appear to have any correlation with other information collected as part of the survey (for example, sex or experience). The amount of time spent on using the software may have some bearing on the final grade for the assignment, or the paper, but as the survey was anonymous there is no way of linking individual outcomes with the results of the survey.
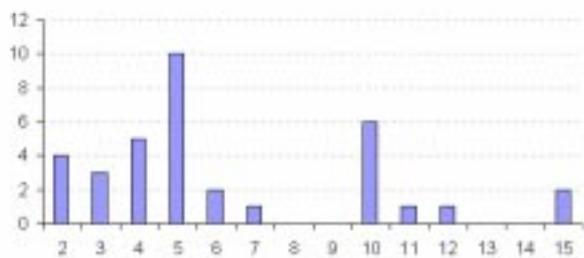
Figure 14. Time spent on using the software.

8. CONCLUSION

The software, used within a constructivist framework provided the students with a collaborative, supportive learning environment and changed the role of the educator from one of being "the fountain of information" to one of facilitator, a pointer to information, a discussant, a motivator and an encourager. The majority of students reported positively on the design and use of the software and on how they perceived it affected their learning. Students were more readily able to structure learning around "big ideas" or primary concepts, their points of view could be expressed and valued and assessment of their learning was done in the context of teaching. The survey highlights limitations of the software, providing a basis for further development and improvement. The software did not replace the traditional lecture or tutorial based approach, but was used as an adjunct, thereby providing another avenue for students to construct their knowledge.

9. REFERENCES

Azemi, A. (1995). Teaching computer programming courses in a computer laboratory environment. Proceedings - Frontiers in Education Conference .

Dewey, J. (1920). The child and the curriculum. Chicago: University of Chicago Press.

Erickson, F. (1998). 10.2 Qualitative research methods for science education. In B. J. Fraser & K. G. Tobin (Eds.), International Handbook of Science Education, Part Two (pp.1155-1173), The Netherlands: Kluwer Academic Publishers.

Linn, M. C., & Burbules, N. C. (1993). Construction of knowledge and group learning. New Jersey: Lawrence Erlbaum Associates, Inc.

Maor, D., & Fraser, B. J. (1993). Use of classroom environment perceptions in evaluating inquiry-based computer learning. In D.L. Fisher (Ed.), A study of learning environments: volume 7 . Perth: Curtin University of Technology.

Ng, A. H. (1998). Asian business students: Influence of self-efficacy and fear on learning approaches. Paper presented at the ANZAM Conference, Adelaide, Australia..

Piaget, J. (1954). Construction of reality in the child. New York: Basic Books.

Piaget, J. (1970). Science of education and the psychology of the child. New York: Orion Press.

Prawat, R. S. (1993). The value of ideas: Problems versus possibilities in learning. Educational Researcher, 22(6), 5-12.

Rochlin, G. I. (1997). Trapped in the net: The unanticipated consequences of computerization. Princeton: Princeton University Press.

Roth, W. (1993). Construction sites: Science labs and classrooms. In K Tobin (Ed.), The practice of constructivism in science education . New Jersey: Lawrence Erlbum Associates, Inc.

Taylor, P. C. S. (1993). Collaborating to reconstruct teaching: The influence of researcher beliefs. In K. Tobin (Ed.), The practice of constructivism in science education . New Jersey: Lawrence Erlbum Associates, Inc.

Treagust, D. F., Duit, R., & Fraser, B. J. (1996). Overview: Research on students' preinstructional conceptions - the driving force for improving teaching and learning in science and mathematics. In D.F. Treagust, R. Duit & B.J. Fraser (Eds.), Improving Teaching and Learning in Science and Mathematics . New York: Teachers College Press.

von Glasersfeld, E. (1993). Questions and answers about radical constructivism. The practice of constructivism in science education (pp. 23-38). Washington, D.C.: American Association for the Advancement of Science.

von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. D. Steffe & J. Gale (Eds.) Constructivism in Education (pp. 3-16). New Jersey: Lawrence Erlbaum Associates.

Vygotsky, L. S. (1986). Language and thought. Cambridge, MA.: MIT Press.