EXPLORING PLAN AND ELEVATION GEOMETRY WITH PRODESKTOP

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Teachers tend to design worksheets to assist their students to develop their spatial skills. Many secondary schools students may not have sufficient concrete experiences to tackle abstract reasoning in geometrical concepts competently. In addition, students who are non-visual and spatial learners may have difficulties in learning geometrical topics. The aim of this study was to use the software, ProDesktop, to facilitate the teaching and learning of Plan and Elevation Geometry in a computer laboratory. A total of forty students from the Express stream of a neighborhood school in Singapore was selected to participate in the study. The results suggested that the use of ProDesktop had enhanced the learning of Plan and Elevation geometry both in terms of interest and proficiency of the topic.

INTRODUCTION

The topic, Plan and Elevation, was one of the most ancient branches of Mathematics originating in 2000 BC (Lanius, 1997). This topic had a long and continual history which could be attributed to the exceptional high usefulness of the subject where ancient Egyptians demonstrated a practical knowledge of geometry through survey and construction projects (Lanius, 1997). The secondary mathematics syllabus in Singapore included Plan and Elevation as one topic of geometry. This topic stressed the identification of a front elevation, a side elevation and a plan of a three dimensional

object. Students need to visualise the shape of three dimensional objects when seen from the front (Front Elevation), the side (Side Elevation) and the top (Plan) (See Figure 1 and Figure 2). In addition, students are required to use geometrical instruments to draw full-size elevations and plan of a three dimensional objects from labelled sketches.

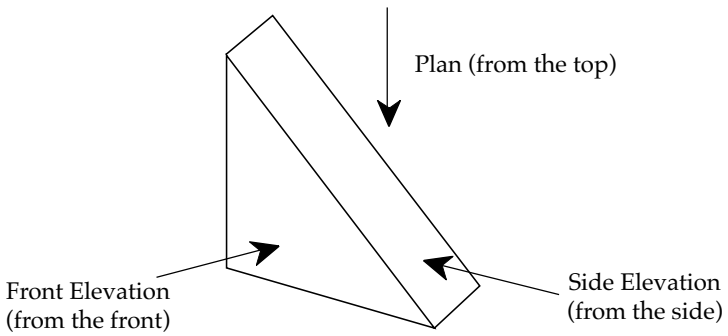

Figure 1: An example of a simple three dimensional object

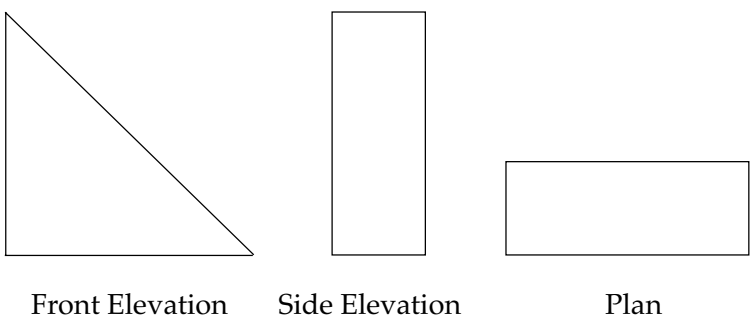

Figure 2: The front, side and top views of object shown in Figure 1

ProDesktop

Pro/Desktop, belongs to a category of software called *Computer Aided Design* (CAD) software, used primarily by designers for designing three dimensional objects (see Figure 3) (Industrial Technology and Design Teachers' Association of Queensland, 2002).

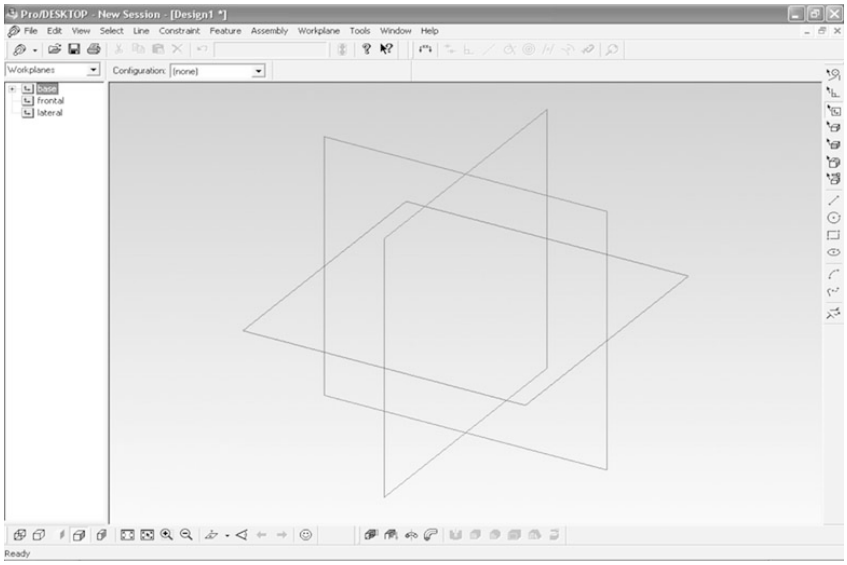

Figure 3: A screen shot of Pro/Desktop

ProDesktop enables the user to construct a virtual three dimensional model and interact with it. In other words, it is provided with the click-and-drag feature, and opportunities for students to elaborate on the attributes of the three dimensional object constructed. The software also enabled the user to carry out rotation, translation, enlargement, shear, and stretch of a given object. Figure 4 shows the object being rotated. Such interactivity implies students no longer need to perform abstract mental visioning to 'see' how an

object looks like from a particular perspective but instead they could view the actual rotation process taking place in virtual space.

The ProDesktop provided a powerful visualisation platform for educators to tap on and to assist students' spatial reasoning and hence understand the topic of Plan and Elevation better. However, other CAD software packages are rather costly as compared to ProDesktop. As ProDesktop was one of the most highly affordable ones till date, it could be an obvious choice amongst the various softwares.

Other benefits of this software included compatibility with major computer operating systems of today's such as Windows and Linux. The familiar windows graphical interface of this software and the availability of a wide knowledge base makes it easier for the user to acquaint with the software (see Figure 4). However, the act of bringing ProDesktop or any other computer software into the normal classroom setting would not guarantee a superior instructional environment.

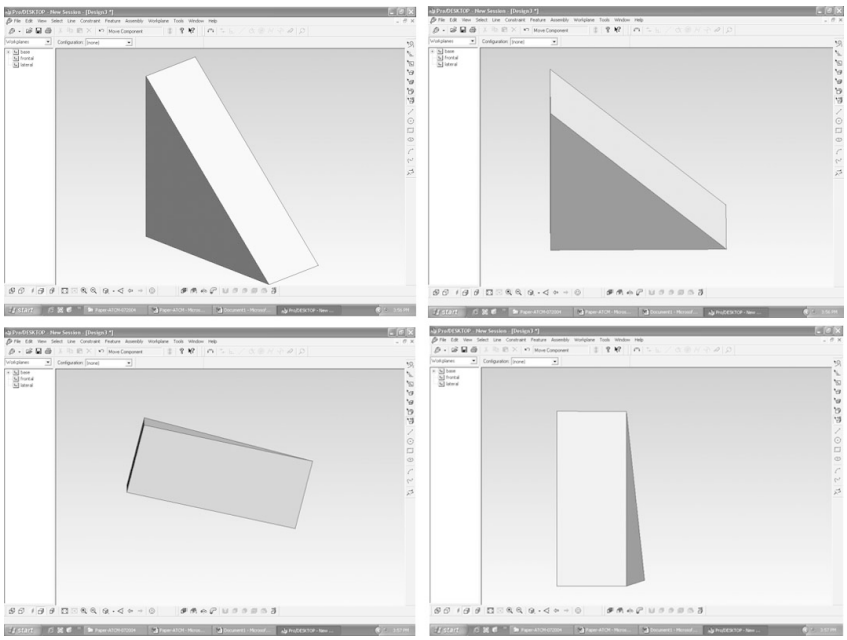

Figure 4: Literally 'grab' the object to rotate it around and thus view it from various perspectives.

RATIONALE

Since the objective of this topic entailed spatial visualisation, secondary school students might find it difficult to reconstruct visual representations of geometric objects as well as the manipulations and transformation of these visual representations. That is, the learner needs to perform a 'mental rotation'. Figure 5 illustrates how a pupil tries to visualise the Plan views of a triangular prism. Such cognitive activity tapped primarily on the students's spatial ability. This high degree of spatial skill was indeed a challenging task for some students as not all students are good visual learners

according to Howard Gardner's belief of Multiple Intelligences (Carvin, 1994). Moreover, many secondary schools students might not have sufficient concrete experience to tackle the visual-spatial reasoning in geometrical concepts competently. Furthermore, in the teaching of this topic, teachers tended to design worksheets to assist their students in developing their spatial skills. The usage of worksheets alone presents a planar perspective of the object and thus did not help either.

Numerous studies had shown that spatial ability could be improved by training (Bishop 1980, Ben-Chaim, Lappan & Houang, 1988). It would be of interest to educators to study how instructional programmes can be designed to assist students improved their visual representations. Nemirovosky and Noble (1997) argued that visual representations "in the mind" took place when using a tool which required the user to analyse external images. In addition, there was also a need to learn how computing technology could be used to enhance learning in the classroom (Herid & Baylor, 1993). In a visual topic like Plan and Elevations, it was believed that the use of computer software which assisted the visualisation process would have a positive effect on students' learning and attitude. Moreover, the authors' own experience in finding the topic typically challenging for students and teachers added further motivation to its choice. Therefore, the aim of the study was to explore the use of ProDesktop, to facilitate the teaching and learning of Plan and Elevation Geometry within the normal classroom setting. This provided leverage for non-visual learners and simultaneously enriched the lesson for the rest of the class.

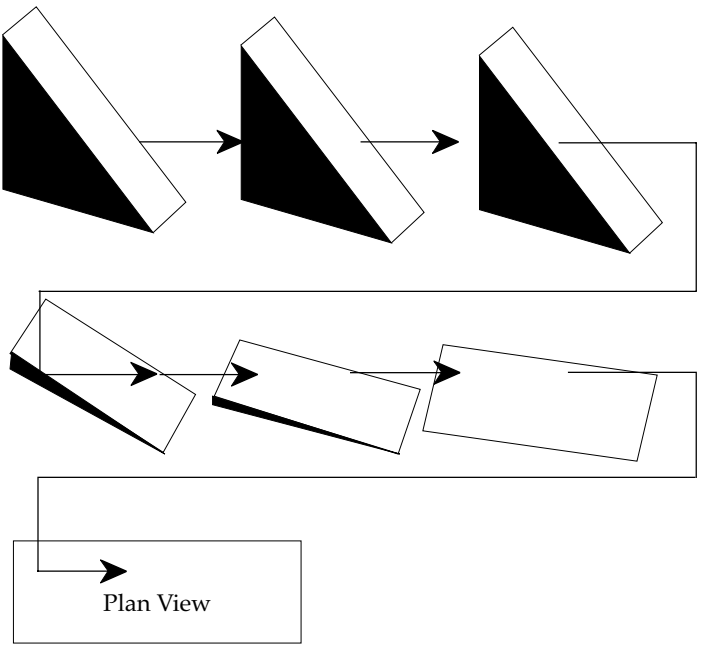

Figure 5: Visualisation process to derive the Plan view of a three dimensional object.

METHODOLOGY

Subjects

In Singapore, students who pass the Primary School Leaving Examination (PSLE), after six years of primary school, are streamed according to ability. The academically-able students follow a four-year programme in the Express stream. A total of forty students from two groups of Express stream of a neighborhood school in Singapore participated in the study. Twenty of these students were selected from the secondary one while another twenty students

came from secondary two. Although the students were from the Express stream, they were the lower end of the Express stream.

INSTRUMENTATION

The instrument used was a verbal-report survey where the students rated their agreement on statements pertaining to their reactions to the ProDesktop. Worksheet was designed to assess their proficiency in Plan and Elevation (see Appendix A). The verbal-report survey and worksheet provided an indication if the approach, and thus the software, has indeed been fruitful in terms of its receptiveness and effectiveness in teaching the topic, Plan and Elevation.

PROCEDURES

To study the effects of incorporating the software, ProDesktop in facilitating the teaching of Plan and Elevation, the students were first taught on the lesson on Plan and Elevation in a conventional approach using only the activity sheets created by the teacher. After one month, the same batch of students went into the topic again. This time round, the explanation of the concept of Plan and Elevation was facilitated by the software, ProDesktop. Besides ProDesktop, the same activity sheets was also used in the study as a basis for comparison. Students' work prior and after using Pro/Desktop on the same topic of Plan and Elevation could then be compared to determine if the software has any positive impact in the teaching and learning of the topic. Students were also encouraged to build their own three dimensional models and were handheld along by one of the author in their attempt to construct the model.

RESULTS AND DISCUSSIONS

Table 1 shows the percentages frequencies for the various statements responded by the forty students. Table 1 also indicated the verbal feedback obtained from the students on the usage of ProDesktop in teaching and learning of Plan and Elevation. The findings showed

that great majority of secondary two students found ProDesktop was easy to use while about half of Secondary One students agreed. This could be due to the fact that Secondary One students may have acquired only the basic computer skills. A high proportion of the students agreed that ProDesktop had helped them to visualise the three dimensional objects. This was encouraging as ProDesktop had served its intended function. All the students indicated that ProDesktop motivated and helped them to understand the topic, Plan and Elevation better. This could suggest that students were particularly attracted to the dynamic nature of the ProDesktop.

Table 1
Percentages of Responses in the two categories for statements on ProDesktop

		% Frequencies			
		Secondary One		Secondary Two	
	Statement	Yes	No	Yes	No
1	Is the software easy to use?	50	50	70	30
2	Does the software help you to visualize the objects given in the worksheet better?	80	20	80	20
3	Does the software motivate and help you understand the topic better?	100	0	100	0

Students often found it difficult to accept slant surfaces to be shorter and curved surfaces turned out to be rectangular when viewed from certain perspective (see Figure 6). From informal feedback, it seemed that all students were able to comprehend and visualise the three dimensional object features like slant surfaces, curved surfaces and hidden details much clearer (see Figure 6) after ProDesktop was incorporated in the lessons. These data and feedback suggested that the use of ProDesktop was able to enhance the learning of Plan and Elevation geometry both in terms of interest and proficiency of the topic.

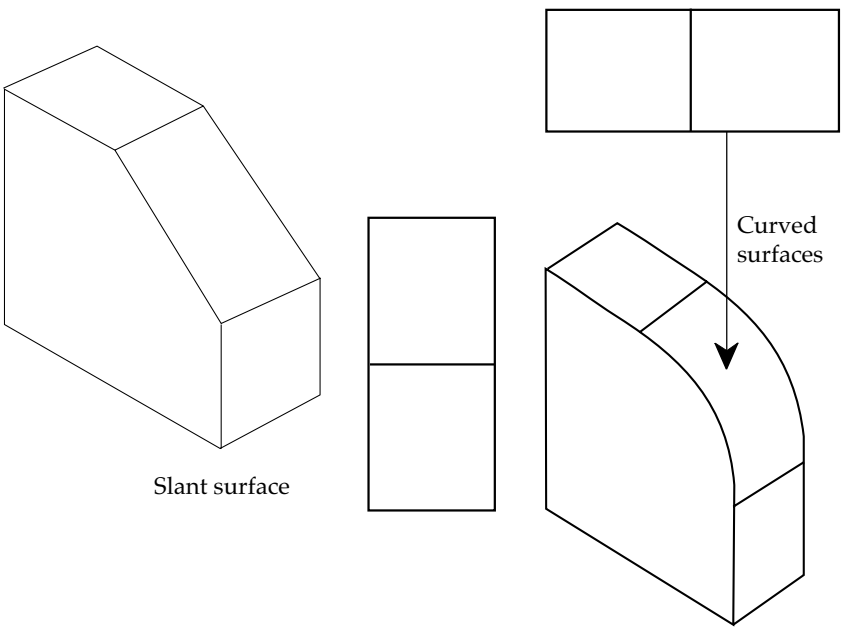

Figure 6: Typical abstract surfaces

The analysis of the students' responses in their activity sheets similarly point to consistently better answers. They indicated that these students have better developed concept-images characterised by an understanding of critical properties of each drawing and construction of figures. These mental representations were also more flexible and could be manipulated and evaluated. Fewer students demonstrated the same abilities.

LIMITATIONS

The results and findings are suggestive and should not be generalised to all the secondary Express stream students in Singapore. The results were also not conclusive due to the limited verbal survey in the study.

As in all studies, challenges and constraints were encountered along the way. These limitations included the requirements for the operating systems of the computers to be of version Windows 98 and above. Besides the requirement imposed on the operating system, some PCs installed with the software had experienced internal system conflict. This would render the program inexecutable but would not handicap the normal functioning of the computer. However, such cases were by far rare and few. Till date, feedback about such cases had not been more than five on the installed 100 seats.

When conducting such IT-based constructivist lessons where students were encouraged to explore and try out the ProDesktop, some students tended to get distracted by external influences such as the Internet and other programmes loaded into the computer terminals. Teachers would have to implement some ground rules so as to conduct the lessons successfully.

While the graphical user interface of the software was of high familiarity to the students, not all students were equally IT-savvy. This was clearly reflected in Table 1 where half of secondary one students indicated that the software was not as easy to use as we thought so initially. In fact, some could not even complete building the model and drawing the views of the object. It must be stressed here that the students' inaptness to complete the lessons in these cases were attributed more to a case of their unfamiliarity of using the software. It must be clearly established at this point that the ease of use of the software was a separate issue from whether the software was effective in facilitating the lesson of Plan and Elevation. In addition, we have to acknowledge the fact that all the students involved, regardless of their comfort level with the software, agreed that the software did aid them to better visualise the views of the object.

The authors acknowledged the insufficiency of a small sample in this study, to represent accurately the responses of the entire Secondary cohort in Singapore. Yet having such a small sample size study did have its merits in allowing the authors to understand the impact of the software from the viewpoint of a typical student for the purpose of preliminary study and discussions.

RECOMMENDATIONS

There are some recommendations which can be made concerning replication of this particular study. These recommendations are as follows:

- Pre-run the software on the installed seats prior the lessons to ensure that all seats are functioning effectively.
- Putting students through a fundamental course to orientate them to the software prior the lesson.
- Setting ground rules and restricting the students' access to the internet during the lessons so as to reduce students' distraction from the lessons.
- Increase the sample size and stratified the samples across various streams such as the Express stream to elicit accurately the responses of the students.

As ProDesktop was a relatively new tool used in Singapore classrooms, the potential of the software in enhancing geometric thinking and spatial reasoning should be an area of further research. These were some experiences the authors believed would benefit researchers should they desire to conduct further in-depth studies for the effects of using the software in similar educational context to elicit richer and more concrete findings.

CONCLUSIONS

Although this was a preliminary study, the results suggested that the software, ProDesktop, enhanced the motivation level of students and the competency of the topic, Plan and Elevation. By incorporating ProDesktop, the approach provided the benefits of nurturing IT-savvy students and an avenue for imparting the value of independent learning once students grasped the fundamentals of using the software. These coupled with the positive results as shown in the findings. It also provided substantial grounds for us to believe that incorporating the software had indeed been beneficial for the students in the learning of Plan and Elevation. The study also provided promise to teachers who desire to realise the theoretical ideals of a constructivist classroom environment without compromising on students' assessment results.

REFERENCES

Ben-Chaim, D., Lappan, G., & Houang, R. T. (1988). The effects of instructions on spatial visualisation skills of middle school boys and girls. *American Educational Research Journal, 25*(1), 51-71

Bishop, A. J. (1980). Spatial abilities and mathematics education – a review. *Educational Studies in Mathematics, 11*,257-269.

Herid, M. K., & Baylor, T. (1993). Computer Technology. In P. S. Wilson (Ed.), *Research ideas for the classroom – High school mathematics* (pp. 198-14). New York: Macmillan.

Lanius, C. (1997). History of Geometry, http://math.rice.edu/~lanius/Geom/his.html. Accessed 10 July 2004.

Carvin, A. (1994). Spatial Intelligence. http://www.edwebproject.org/edref.mi.th5.html. Accessed 10 July 2004.

Industrial Technology and Design Teachers' Association of Queensland (2002). INTAD Resources for PTC's Pro/Desktop. http://www.intad.asn.au/prod/default.asp#files. Accessed 10 July 2004.

Nemirovsky, R., & Noble, T. (1997). On mathematical visualization and the place where we live. *Educational Studies in Mathematics*, *33(2)*, 99-131.