A Conceptual Structure for Mathematical Presentation Systems

Ming-Jang Chen

Center for General Education, National Chiao Tung University
Hsinchu 300, Taiwan
mjchen@mail.nctu.edu.tw

Abstract

The key role in promoting educational technology in class is usually played by teachers in class; on the other hand, the teachers always face the barriers such as digital differences and high cost for popularizing for that task. In this paper, a solution of raising the willingness of teachers for using technology by reducing those barriers is proposed. As a teaching based environment for mathematics in class, a new conceptual structure for mathematical presentation systems is introduced, its implementation on PowerPoint is also included for illustration purpose.

The three features of the conceptual structure behind the system include the functions in the presentation system, the add-in functions, and the algorithmic operations for editing mathematical elements and complex structures. Making good use of human perceptions, mathematical operation strength, and some operating algorithms, some functions of MathPS are added to this presentation system for better performances, they work together like a mathematical courseware. Contents preparations, teaching strategy, and the evaluation of effects under this environment will continuously be the focus of our further study. All works, available in a CD-ROM on request, included in this paper were done in PowerPoint.

Keywords: presentation system, digital difference, courseware, center-based duplication, line-based duplication

1. Introduction

How to integrate educational technology into teaching as well as in learning has been a long term project over the past twenty years. It has been always concluded that one of the key role in promoting educational technology around campus is always played by the teachers in class; on the other hand, the teachers always face some barriers such as digital difference and high cost of popularizing for that task. A solution of raising the willingness of teachers' using in class by reducing those barriers will be studied in this paper; a new conceptual structure for presentation systems is introduced, and an implementation on PowerPoint is included for illustration purpose.

The environment that teachers need for preparing mathematics contents and the suitable software as tool are the two main concerns we must deal with. Preparing mathematics contents and teaching them in class interactively with the assistance of educational technology are the two basic tasks we face. Since the ways of presenting teaching mathematics contents are diverse, it is not possible for teachers to prepare those contents from a unique resource and hence teaches always take time to

learn many tools before they can handle them skillfully. It is both time and energy consuming, and hence is the main reason that teachers are not willing to use educational technology in class. A handy tool is needed badly for teachers to put those mathematics contents together, to modify them, and to present them in class no matter how they were produced and or how they were collected. In order to remove obstacles and to decrease the loading of learning new tools, we need a platform which can be used to carry diverse contents, to accumulate the experience of human-computer interaction. Therefore, popularizing and teaching are the main concerns when we develop educational technology.

Presentation system is one of the most popular software, which provides people the ability to present information of various types. Indeed, people learn to use such presentation system when they were in primary schools. However, Presentation system is a general-purpose system for presentation [1, 2, 5], but not designed specialized for mathematical teaching in class. It indeed provides most functions needed for teaching mathematics in class; however, functions of drawings are limited, complex structures and mathematical objects can not be processes friendly either, and even worse that it has no function in supporting class interactivities either. Due to its popularity, presentation system has been chosen to serve as the platform of this system. Three features of the conceptual structure behind the system are the functions in the presentation system, the add-in functions, and the algorithmic operations for editing mathematical elements and complex structures. Some new functions are added for improving its performance, so they work together like a mathematical courseware in the hope to lower the barriers for mathematics teaching. Our purpose is to propose an environment for teacher to prepare mathematics contents and to teach mathematic in classroom interactively. Making good use of human perceptions, mathematical operation strength, and some operating algorithms, some functions of MathPS are added to this presentation system. Contents preparations, teaching strategy, and the evaluation of effects under this environment will continuously be the focus of our further study.

2. The Structures of the System

The conceptual structure behind the systems consists of the following three features: functions in the presentation system, add-in functions, and algorithmic operations for editing mathematical elements and complex structures. The first one is the functions in presentation systems. Various presentation systems [1, 2, 5] may vary slightly in their functions while dealing with similar objects, there are certainly some common functions used for text, figures, tables, and charts, for carrying images, multimedia, and equations. However, it turns out that not all of the objects can be edited directly by functions in a presentation system; some are edited by other software. Presentation systems has had supported animation for objects for sometime. Animations for objects are provided when entering a slide, when being notified, and when leaving. Furthermore, object can be moved from one location to another in a slide. A sequence of animations can be triggered by many ways, they may be triggered by clicking mouse only once, then objects can be animated manually or automatically by clicking. Objects can be animated in either a sequential or in a parallel way.

The meaning of interactive presenting to presentation systems is "to create a hyperlink to a web site", "to create series of hyperlinks accessible from a summary slide" or "to create hyperlink to other resources." Adaptive environments, programming languages, functions to record the operating procedures as macro are among those functions provided by various (presentation) systems; for example, programming languages for controlling objects for AutoCAD, Flash, and MS Office; both

recording functions and programming language for users for PowerPoint, Open Office presentation. Some add-in functions in the system include *Viewer*, *Constructor*, *Converter*, *Geometer*, *Structure*, *Measurement*, and *Animation*. More precisely,

Viewer: functions that for querying the attributions of objects or for setting preferences.

Constructor: functions for constructing basic structures, for example, regular polygon, circles on a circle, path, curve, loop, circuit, and segment, etc.

Converter: functions that convert an object to another form;

Geometer: functions for constructing *geometric* shapes and for *geometric* positioning;

Structure: functions for constructing basic *structures*, for example, grid, squares, or for processing complex structures;

Measurement: functions for constructing 1-D or 2-D coordinates; and for *measuring* the length of a segments and the area of a region;

In order to help teacher to design interactive material for classroom teaching, the system provides "On-Off", "Sequencing", and "Layers" for animation purpose, these three functions are simple enough to provide the interactive environment between teacher and students;

Figure1:
The system structure of MathPS.

3. Methodology

Guidelines and standards are needed for evaluating whether a function meets the requirements. For editing complex and various figures, we need not only handy functions but also algorithm to edit a figure elegantly. From the algorithmic viewpoint, the conceptual system provides the functions for *positioning*, *duplicating* and for *deconstructing*. More specifically, positioning is used to locate an object precisely by fuzzy operations; duplication rule works for processing large quantity of mathematical objects. Instead, "add and then accumulation" to construct a teaching materials, "deconstruction rule" works for constructing complex structures by *"deconstruction and deleting"*.

A simple function collocates with a good algorithm; some very creative and special figures can be made in a few seconds.

3.1 The Positioning Rule

MathPS is a positioning system, with a positioning rule used for locating an object precisely simply by fuzzy operations. It helps users to position objects in certain locations or layout the presentation by mouse friendly. In particular, the "duplication rule" helps users to locate objects in a complex structure interactively and recursively.

Vertex: a fundamental mathematical element; is used to locate positions for lines, regions, etc. In the presentation system, there is concept of vertex but vertex can not exist independently.

We design a vertex with a very small circle in a visible circle. The inside circle is used to attract mouse pointer and the outside one is used to help user to see the location by eyes. Once the mouse drag an object and move into a outside circle, the inside one will attract mouse pointer, both of them works together to help users to use eye to locate, use mouse to move object to certain position correctly and easily.

Line: a fundamental mathematical element and also is a basic element of drawing. Line is not only used to connect two objects, but also use to layout a figure.

The information in a line contains orientation, magnitude of line, and locations of two ends. In the line-based duplication, we used it as base line, recurrent line and objective structure. Polygonal line is a group of connected segments. Each vertex on a polygonal line has magnetism.

Region: The boundary of a region includes polygonal lines or curves. There are connectors at both ends of segments and lots of connector along the curves. Connectors have magnetism.

Connector: a part of object, can not exist independently; a connector, there is magnetism.

Object: there are 8 connectors in the placeholder of any object. Each connector has magnetism.

Grid: a coordinate system and a positioning system as well; providing grid to help users to locate objects precisely; in addition to built in grid for covering whole slide in the edit mode, (but it disappears in the presentation mode), a user-defined grid is provided by simply drawing a rectangle, and keying in the numbers of rows and columns.

Relative positioning: refer to center-based duplication and line-based duplication below.

3.2 The Duplication Rule

Operations for constructing a figure include the steps such as selecting an object, moving the mouse to certain location, deciding the size and tuning the orientation. The functions in various presentation systems are capable to process simple figures without difficulty. However, additional functions must be required if elements in a figure require mathematical positioning or if a large quantity of objects in a slide to be processed. Duplication rule works for processing large quantity of mathematical objects. Three duplication functions - original position duplication, center-based duplication, line-based duplication - will be provided to overcome the difficulty of operations. Based on recurrent substitution, some fractals can be created simply by repeated using duplication rule manually. We explain the three duplication functions in the following:

Under presentation system, when pasting a object from the clipboard, the new object is pasted either at some distance from original location where we can distinct both of them, or at original location.

Sometimes, we want to paste objects at the original position, if the presentation system does not works this way, *original position duplication* provides another option, it paste the new object at the original position. Center-based duplication is used to duplicate object to the center location specified by selected objective object. The first step is to copy selected object to clipboard as model, then select objects as objective objects, and then use center-based duplication to pastes a new copy to the center of each target object with the same width, height and orientation as the target object. Using this function we can duplicate objects to predeterminied locations, with predetermined orientation and size. Based on recurrent substitution [4], we can design some selft-similary fractals can be made in this way as shown Figures 2-4.

| pattern 1 | initial | 1st iteration | 2nd iteration | 3rd iteration |
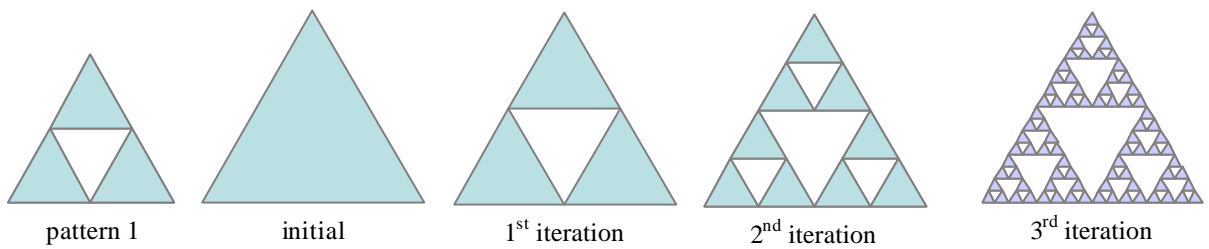
Figure 2:
Sierpinski Sieve

| pattern 2 | initial | 1st iteration | 2nd iteration | 3rd iteration |
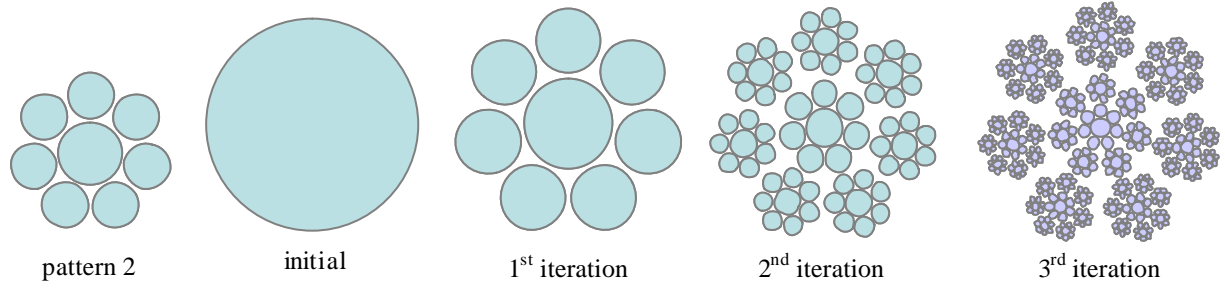
Figure 3:
One more example for center-based duplication

| pattern 3 | Replace picture in 2nd iteration of Figure 2 with patter 3 | pattern 4 | replace picture in 1st iteration of Figure 2 with patter 4 |
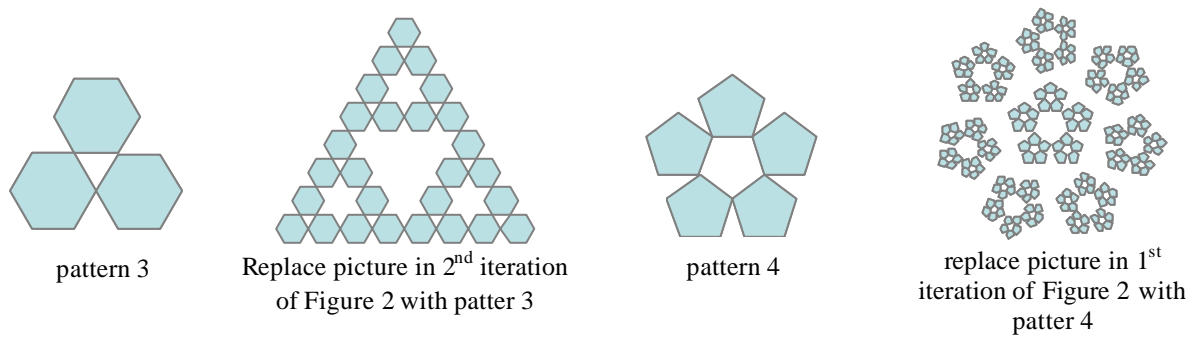
Figure 4:
Center-based duplication with multiple patterns

Line-based duplication, based on the relative relation between Base line and Pattern, replaces each segment in objective structure with pattern with the size of the ratio of "Base line" and each segment in objective structure. Objective structure is a group of predetermined segments. This is a method to duplicate similar object with different size and different orientations, refer to Figure 5.

Basse line and arc · Objective structure · Arcs are at predetermined location by *line positioning duplication*
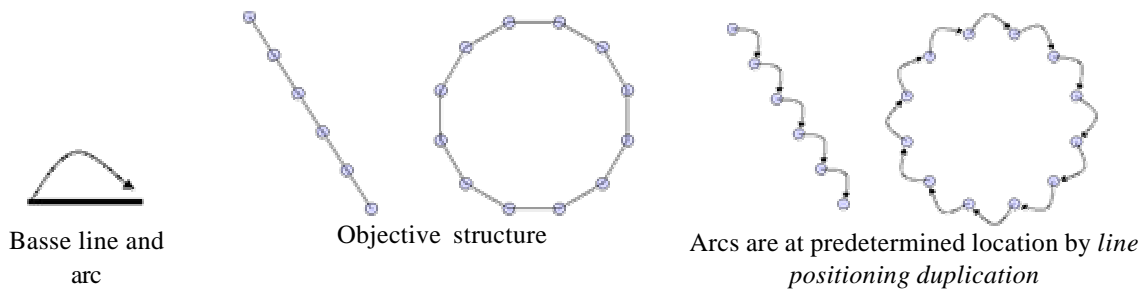
Figure 5:
Uniform arcs by line-based duplication

Based on recurrent substitution [4], segments are added to the pattern as recurrent lines, and then the recurrent lines will become the new objective structure after duplication. Fractal grows manually with repeated executions in terms of the examples of Pythagorean trees, Bamboo, Seaweeds in details as shown in Figures 6-8. A few more are included in Figure 9 for illustration purpose.

Pythagorean trees:
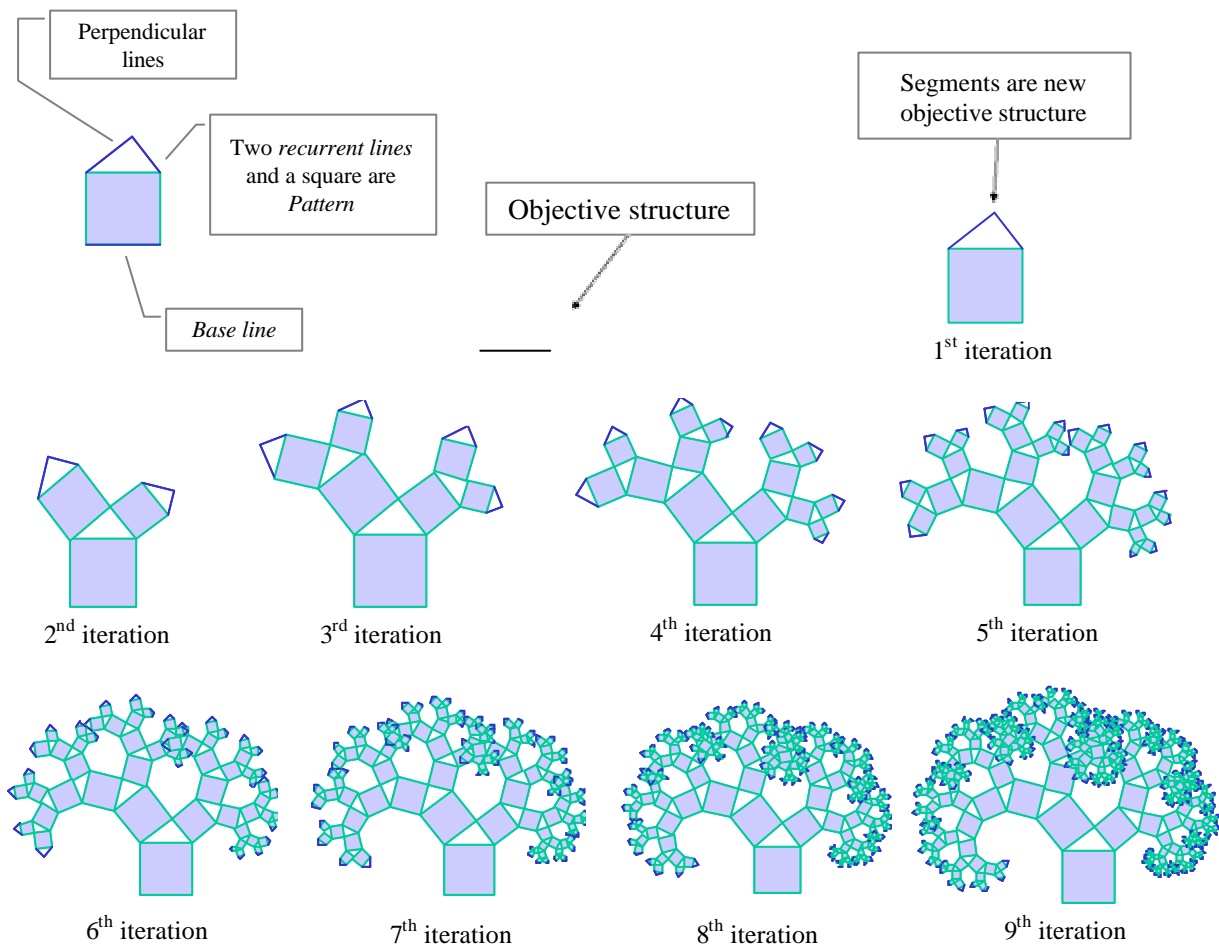
Figure 6:
The processes for creating a Pythagorean tree

Bamboo and Seaweeds:

| Pattern and bas line | Objective structure | 1st iteration | 2nd iteration | 3rd iteration | 4th iteration |
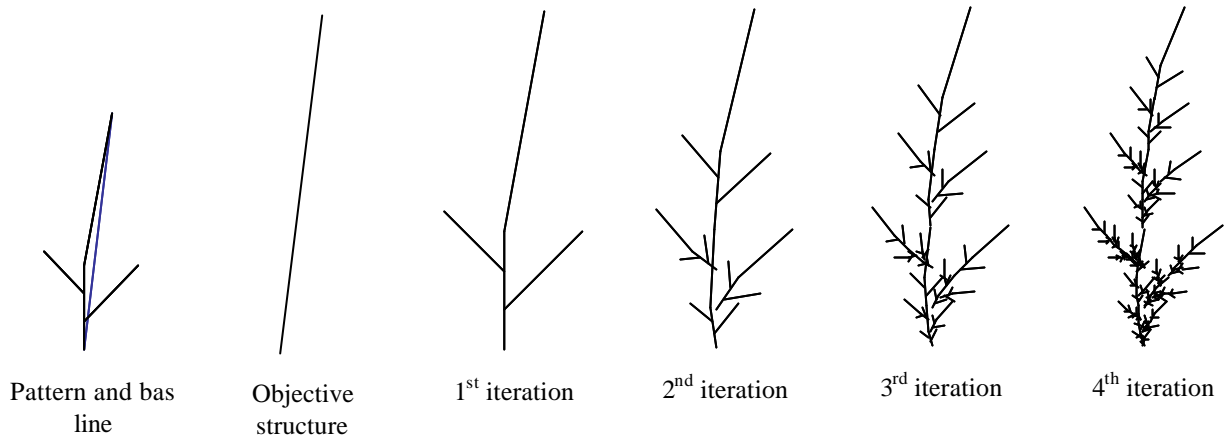
Figure 7:
The processes for creating a bamboo

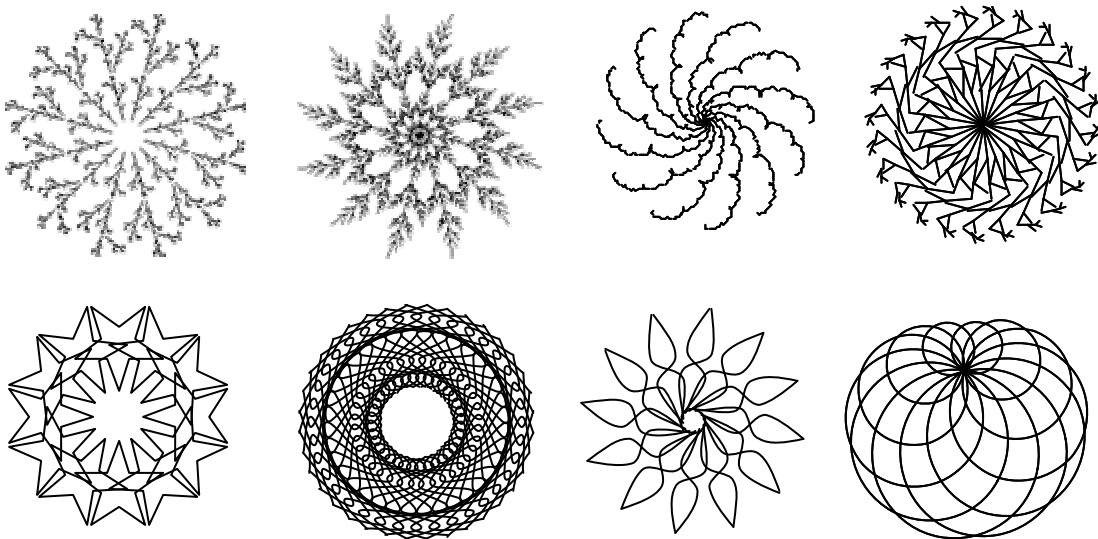| Pattern and bas line | Objective structure | 1st iteration | 2nd iteration | 3rd iteration | 4th iteration |
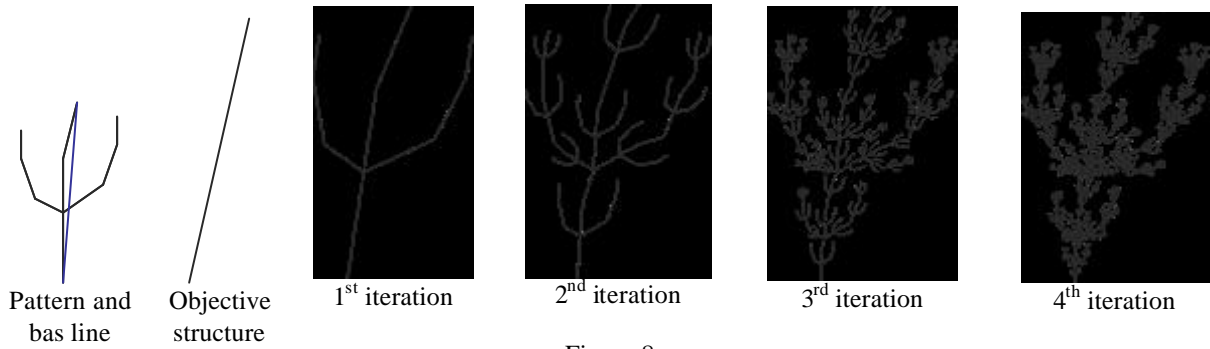
Figure 8:
The processes for creating seaweed

Some other works for illustration:
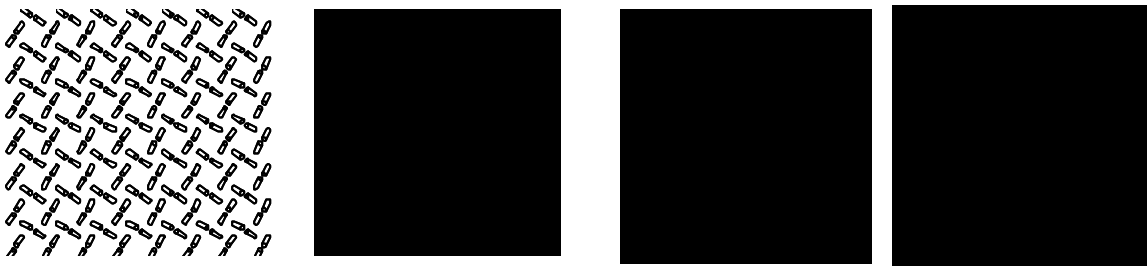
Figure 9:
Decorative designs in a second

3.3. The Deconstruction Rule

Instead, "add and then accumulation" to construct a teaching materials, deconstruction rule works for constructing complex structures by *"deconstruction and deleting"*. Since the representation of mathematics is diverse, it is not possible to design simple function for different but similar figures. Instead of designing many functions for those figures, we present simple function which present full figure, and then user deletes those needless portions. To construct a figure by deleting unnecessary elements is easier than to construct a figure by adding elements step by step.

4. Complex Structures and Contents for Interactive Teaching

Some basic geometric patterns together with some functions for converting objects to various forms are provided for dealing with complex objects. Moreover, to create a hyperlink to a web site, to create series of hyperlinks accessed from a summary slide or to create hyperlink to other resources will provide an interactive presentation in presentation system.

4.1 Complex Structures and Figures

For constructing various complex figures, some basic geometric patterns together with some other functions for converting objects to various forms are provided in this section. Those basic geometric units include divisions on a line, regular polygon, circles on a circle, circles on an arc, r-partite complete graph, grid and squares as shown in Figures 10-12. Some functions for converting objects to various forms are provided:

(1)   covert a polygonal line to segments and vice versa;
(2)   covert a curve to a polygonal line and vice versa;
(3)   reverse the direction of a line; and
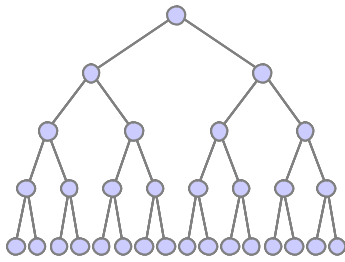(4)   divide a line into segments of equal length.
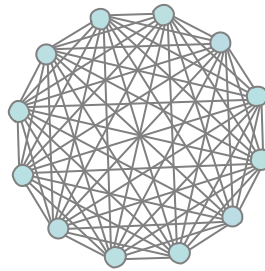
Figure 10:

A binary tree
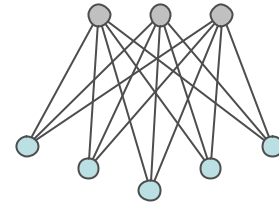

Figure 11:

A complete graph

Figure 12:

A complete bipartite graph

To locate segments at predetermined location is easier than to locate an object directly. In order to avoid the uncertainty of manual driven, the objective structures are layout in segments first, then we use line-based duplication to bring patterns to objective structure. In order to modify a complex figure, we provide "Save location" to save to the location of each individual object first, and then user can start necessary modification, move objects, delete object, change text, etc. After modification, instead moving objects back to their original locations one by one manually, we just need to press "Home", and then all objects are moved to their original location automatically.

4.2 Interactive teaching material

The functions *On-Off*, *Sequencing*, and *Layers*" are provided for user to create interactive buttons, to provide the interactive environment between teacher and students. The predefined animated objects will be displayed one by one sequentially simply by pressing the buttons. Several buttons are designed in one slide; each button controls different sequence of animated objects. In the PowerPoint, for example, there are two types of animated sequence [6], one is main sequence, and the other is interactive sequence. Each slide has only one "main sequence", click mouse and then animated sequences are displayed one by one; otherwise "interactive sequence" is a sequence of animated objects started by pressing a button. Each slide can have many interactive sequences.

Based on these functions, Several interactive classroom teaching materials, for example, interactive chesses, magic squares, multiplication tables and two types of Pascal's triangles were developed and shown in Figures 13-17 respectively.
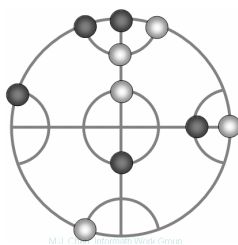

Figure 13:

Interactive chess

Figure 14:

Interactive magic square

Figure 15:

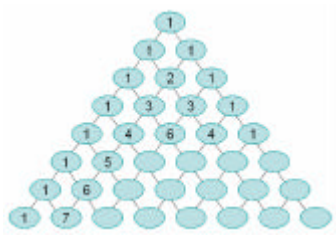Interactive multiplication table
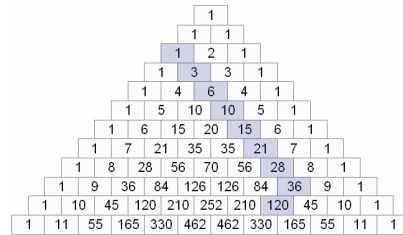
Figure 16:

Interactive Pascal's triangle

Figure 17:

Interactive Pascal's triangle, highlight version

5. Conclusion

Various Different presentation systems [1, 2, 5] may vary minor in their functions. Make good use of human perception shortage, mathematical operation strength, and operating algorithm, a conceptual structure of teacher-based environment is presented for presenting mathematical material and for teaching interactively in class. A set of add-in functions (MathPS) was developed to fulfill this conceptual structure on PowerPoint as example. According to a preliminary experiment, we have had the following feed back:

MathPS is handy; to prepare mathematical material for presentation is easy.
Based on PowerPoint's popularity, to popularize MathPS will not be difficult.
MathPS will not be another new "digital difference".
The interactive activities in the classroom are getting more fun.

Material designs, teaching strategy, and the effects on teaching under the environment proposed by this conceptual structure will be the focus for further study.

Reference

1. Ed Bott & Carl Siechert. (2001). Microsoft Windows XP Inside Out, Microsoft Press.
2. Erik Holsinger (2003). Presenting Keynote: The Insider's Guide to Creating Great Presentations. Sybex.
3. MathPS user's guide (unpublished)
4. PeiTgen, Jürgens and Saupe. (1992). Chaos and Fractals - New Frontiers of Science. Springer-Verlag.
5. Solveig Haugland & Floyd Jones. (2003.). OpenOffice.Org 1.0 Resource Kit, Prentice Hall PTR, 20 February, 2003.
6. The Microsoft Developer Network (MSDN), http://msdn.microsoft.com/
7. Open Office Developers Guide, http://api.openoffice.org/DevelopersGuide/DevelopersGuide. html