TOOLS AND AFFORDANCE OF DYNAMIC GEOMETRY SOFTWARE: THE CASE OF GEOGEBRA

Vinh Nguyen

Deparment of Engineering

The University of Auckland

Upi : vngu014

Abstract

This paper will discuss the design of construction tools in Dynamic Geometry Sofware (DGS) and how such design has a certain impact on the affordance of a program, later it will briefly discuss the most featured affordance of GeoGebra: double representation of mathematical object i.e. algebraically and geometrically.

Keywords: Dynamic Geometry interaction, affordance, GeoGebra

Introduction

The use of Dynamic Geometry Softwares in teaching Mathematics has somehow enhanced the students' ability of learning mathematics. They provide students a great way of visualising mathematical objects and encourage them to carry out tasks to interact with such objects and add to support of their learning. Appropriate tools of such DGS will enhance the affordance of a program hence would increase the ability to perceive of learners.

GoeGebra , a free open source DGS, originated by Hohenwarter , 2002 as his master thesis at the University of Salzburg, has now evolved in many countries as a computer mathematical education program also has great affordance feature which will be discussed later.

Construction tools

One of the most important designs of the functionalities of the DGS is the tools that the DGS will provide; such tools that allow users to carry out the desire operations (for example tool to draw a circle of Geogebra). A tool will take some forms of inputs and produce outputs, distinct tools will have different types of input, selection processes or different types of outputs and have the same functionality if they produce the same outputs when given the same inputs[2].

Multiple functionalities can be encapsulated into a tool in the case those different types of inputs within that tool will produce different types of outputs (e.g. conic tool of GoeGebra has four functionalities: Eclipse, Hyperbola, Parabola and Conic through five points). A tool is called to have atomic functionality if it produces outputs when given the inputs in a way which cannot be done by any other tool or sequence of tool which do not have the same functionality as the original tool [2]. A tool is called to have molecular functionality if its outputs can be achieved from the given inputs by an operation or series of operations of tool with atomic functionality. Tools with atomic functionality likely associate with compass or ruler tools with molecular functionality may involve measurements that require calculation and may be equipped within the program or can be customized created by the user. Figure below shows the circle tool of GeoGebra that encapsulates different circle creation functionalities where the first (Circle with Center through Point) and the third (Compass) are atomic.

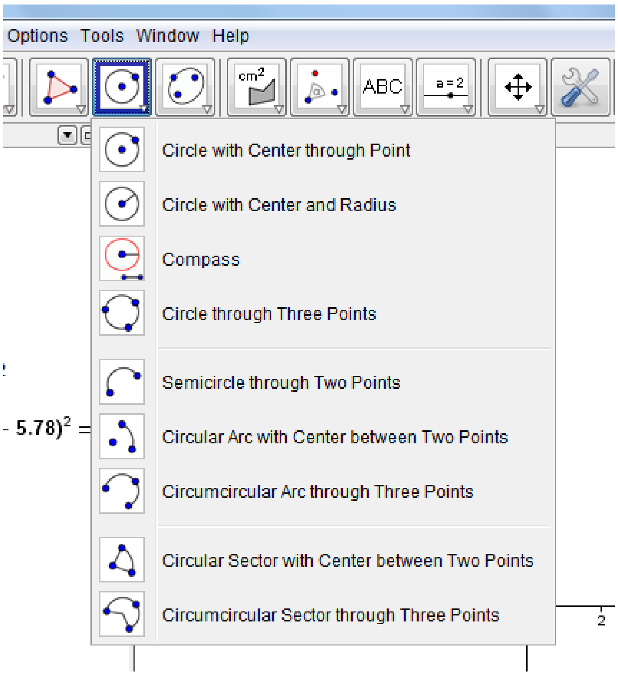

Figure 1: Drop down menu of circle tool in GeoGebra.

The choice of including tools with molecular functionalities has a large impact a program. They can somehow reduce complexity of performing an operation when that operation in a series of atomic tools is having high level of complexity. For example, to calculate the area of a triangle, one may first construct and measuring the height, and then multiplying this by the base length, but this requires a number of constructions and also knowledge of the formula triangle area formula. Hence a given tool to calculate the area is included in GeoGebra.

More tools and functionalities will increase the complexity of the software itself [4]. Using molecular tools may omit fundamental relationships and constructions, for example in GeoGebra a tool to find midpoint of a segment can be custom made but this can also be done using the Perpendicular Bisector tool hence the relationship and construction of the bisector line is omitted, but however the molecular tools give more speed up construction, leave out distracting details, thus one can focus on the main context. However in pedagogical sense, limiting the molecular tools is necessary as to encourage learner to explore the fundamental relationship between objects and build their own tools once they have mastered the concept.

Affordances

One of the important factors that designer of a software needs to pay attention to is the affordance of a program. The affordance factor refers to the ability of advertising the possibilities of interaction [1], that is the interface cues that help users know what can be done and how it can be done. Real affordance is what interaction is possible within a program and perceived affordance is the possible interaction that users perceive. Affordance is also a factor that affects the users' learning and cognitive process such as reasoning, interpreting, evaluating and understanding.

In the scope of carrying out tasks in order to accomplish a goal in DGS, tools with new atomic functionality help increasing the affordance of a program [2] however tools with new molecular functionality do not affect the affordance of a program. As tools with atomic functionality will result outputs which cannot achieved by other tool, making itself distinguished from other tools hence increase the real affordance and more perceivable thus enhance the perceived affordance and make users attend to the interactions that are possible.

One of the advantage affordance of GeoGebra is that it allows the manipulation on double representations of objects, provides a closer connection between the symbolic visualisation of Computer Agebra System (CAS) and the dynamic changeability of DGS [3]. Users can not only works with algebra objects such as line, circle eclipse equations on algebra window but also their presentation on geometry window. They can also fully manipulate on one window and observe the corresponding change on the other windows, for example one can drag the circle on the geometry window to change its radius with the mouse and observe the change of its equation and area on algebra window or one can change the equation of the circle directly and observe the change in the geometry window. This feature also adds to supporting users' cognitive activities by making mathematical objects, concepts and relationships, ready to be perceived [6].

Kllogjeri and Shyti [5] address the double representation as the bidirectional combination of geometry and algebra (the way of representing an object in both algebraically and geometrically). One advantage of this is the ease of teaching and learning for example changing the formula in the algebra window will lead to the corresponding change in the geometry window. This feature is an advantage to teachers who want to demonstrate the multiple views to students. Another advantage of double presentation of GeoGebra is that it provides quick and correct grasping of the concept, since the change resulted from manipulation happens within a short time one can make conjecture of the relationship of two objects or somehow draw some conclusion. This feature would help the students to grasp concepts instantly and is one step advantage compared with other mathematical software.

Conclusion and future work

Tools with atomic functionalities add to the perceived affordance of a program. The limiting the molecular tools is necessary as to encourage learner to explore the fundamental relationship between objects and build their own tools once they have mastered the concept.

GeoGebra has the great affordance in the way that manipulation on mathematical objects on either algebra window or geometry window and observe the correspondent change encourages usrers' conjectures.

Future work may include the analysis of how visual learning of DGS supports users' cognitive process.

Reference

[1] Sedig, K., and Liang, N. Interactivity of visual mathematical representations: Factors affecting learning and cognitive processes. *Journal of Interactive Learning Research*, (2006), 17(2), 179–212.

[2] Mackrell, K. Design decisions in interactive geometry software. *ZDM Mathematics Education* (2011) *Volume* 43, *Number* 3, 373-387

[3] Hohenwarter, M., and Jones, K. Ways of linking geometry and algebra: the case of GeoGebra. In *Proceedings of the British Society for Research into Learning Mathematics*. (2007), 126-131.

[4] Kortenkamp, U., and Dohrmann, C. User interface design for dynamic geometry software. *Acta Didactica Napocensia*, (2010), 59–66

[5] Kllogjeri, P., and Shyti, B. GeoGebra: a global platform for teaching and learning math together and using the synergy of mathematicians. *International Journal of Teaching and Case Studies* 2010 - Vol. 2, No.3/4 , 225-236

[6]Karadag, Z., and McDougll, D. GeoGebra as a cognitive tool. *Modeling and Simulations for Learning and Instruction*, (2011), *Volume* 6, 169-181