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**Research Article**

# The Importance of Mathematics and Science Education in the Context of Digital Technology on Industrial Innovation

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**Abstract:** Mathematics and science are the foundations for various academic subjects and industrial applications. The purpose of this study is to allow students to apply derivative function formulas to make dynamic images and use the correlation between functions and derivative functions to observe the corresponding changes between functions and derivatives in the range of the functions. Students could use the production process to understand the meaning of applying mathematics and science, cultivate their visual thinking abilities and in turn extend their application to industry; thus motivating the ability for industry innovation.

**Keywords:** Application ability, digital learning, dynamic derivative function, mathematical management ability, problem-solving ability

## INTRODUCTION

Mathematics is the core of computer science and a foundation in mathematics directly influences the innovation and research ability of those with a computer-related background. Developments in computer science rely on research professionals, who thus need to consolidate basic knowledge in higher mathematics and enhance the ability to apply mathematics (Hsieh and Liu, 2007).

Mathematics ability is not only the ability to make numerical computations, but should also include spatial changes, relationship changes and uncertainty. Resolving these problems often requires using problem-solving techniques such as logic, analysis, thinking, understanding, model creation and hypotheses to reconstruct the problem contexts, in order to propose effective problem-solving methods and establish problem-solving procedures.

The problem-solving methods and techniques used in mathematics are similar to problem-solving abilities, which, in the increasingly complex modern industrial and commercial environment, are even more important. Improving industrial operations and creating industrial innovation are important issues that affect the survival and development of industries. Therefore, in planning and execution, it is necessary to be careful and precise for successful completion or processing. Such planning also relies on the problem-solving ability of the planners. Problem-solving ability is correlated to mathematics ability; thus, mathematics ability is the ability to analyze problem descriptions and develop precise problem-solving abilities, which allow individuals to see through the nature of a problem and fix it directly.

The problem-solving abilities and techniques used in mathematics are effective at inspiring the vitality of people's thinking. Optimal thinking vitality can inspire people to think about innovations, improvements and problem solving (Ichiro, 2006). Thus, mathematics ability is important for the industrial sector, which requires continuous innovation and advancement.

The Ministry of Education, Culture, Sports, Science and Technology's National Institute of Science and Technology Policy published The Forgotten Science-Mathematics (Hosotsubo *et al*., 2006; The Mathematical Society of Japan, 2006) published Suggestion-Elevating Our Nation's Mathematics Ability as Objective. On May 17, 2006, the Japan Academic Conference Mathematics Committee and the Mathematical Society of Japan sponsored the conference Foundational Knowledge: Mathematics-Mathematical Research and Collaboration with Scientific and Industrial Technique, to explore the connections between research in mathematics and science and other fields and industries.

Thus, it has been shown that mathematics ability is not only an important tool for competition in the workplace and for facing the rapidly changing international environment, industrial innovation and development further rely on mathematics literacy and high abilities in mathematics and science.

This study trained students who had already learned basic mathematical functions so that they could use the mathematics functions and formulas in computer code for production in practical courses on information technology, in order to make images for mathematical functions and to understand the meaning of these functions and images. Through practical work they could understand and control the operant meaning of functions and images, in order to enhance their data and image abilities through analyzing and managing functions. It was hoped that visual learning could enhance the students' abilities in mathematics and science and in turn promote corporate innovation and value creation.

## LITERATURE REVIEW

Education should train for responsive and flexible abilities, good communication know-how, the ability to apply information technology, innovation abilities and solid language, mathematics and science foundations, so that students can absorb new knowledge and adapt to new technology, be positioned in a knowledge environment to effectively resolve problems and connect to international society (Chen, 2007).

**The value of mathematics and science ability:** Mathematics has been defined by PISA (Programme for International Student Assessment) as amounts, spaces and shapes, change and relationships and uncertainty. The necessary techniques of mathematics are the understanding of mathematical language, model construction and the execution of problem-solving hypotheses, which are all related to problem-solving ability. Five problem contexts are defined in the PISA evaluation framework: personal, educational, occupational, public and scientific. The topics cover global warming, the greenhouse effect and population growth, floating oil in the ocean, acid rain, sports knowledge and life-related issues. These problems rely on people to use exploration and logic ability in mathematics and science to construct solutions (Taiwan PISA National Center, 2010).

In 2008 at the Science Council of Japan, the National Committee for Science Education (Science Council of Japan National Committee for Science Education, 2008) mentioned that, "Mathematics and sciences are the cross-sectional foundation for the scientific field and the accomplishments are diverse and widely applicable. It not only occupies a significant position in elementary school, middle school, high/vocational school and university, but is also applied to support diverse research. Learning mathematics can cultivate nuanced exploratory and logical thinking ability, which would greatly benefit school learning and the workplace. Abilities in mathematics and science stress using systematic courses to cultivate the logic and knowledge ability of learners" (Tsuneharo and Takahisa, 2006; College Entrance Examination Center, 2010). In addition, Japan's Meiji University will establish the School of Interdisciplinary Mathematics in 2013, which shows the importance of cultivating personnel with abilities in mathematics and science.

**Problem-solving ability:** Problem-solving ability is seen as the ability to use numbers, communication and responses for rational analysis, critical thinking and efficient methods to resolve problems (American Association for the Advancement of Science, 1993).

Many domestic and foreign scholars believe that problem solving is a process and that when learners encounter problems, they will try to use existing knowledge to resolve problems. When problems cannot be resolved, people will try to find new ways or assistance to resolve problems and this process requires efficient analysis and thinking (Su and Hsieh, 2006).

The mathematics and science testing provided by PISA primarily test to see whether the students can understand information and further flexibly integrate, evaluate and reflect the information, as well as construct answers for the problem contexts. The focus of evaluation is on whether young people can use knowledge techniques to resolve real-world problems, which refers to the problem-solving ability of students; this is a direction that should be developed in future education. Problem-solving ability is important for personal life, occupational applications, public fields, or innovative research and development; it not only demonstrates the quality of a nation's people, but is also the best evaluation indicator for national power (Taiwan PISA National Center, 2010).

**Industrial demand for mathematics and science ability:** In recent years, Ministry of Education, Culture, Sports, Science and Technology (2012) has actively promoted associated mathematics reform of mathematics, science and industry. It believes that using the knowledge and methods of mathematics and science to connect to the sciences can resolve and clarify various complex issues for the industries. Such mathematical and scientific knowledge will enhance new value for society. In 2007, the Japan Science and Technology Agency was active in mathematics research and industrial applications and the Ministry of Education, Culture, Sports, Science and Technology (2012) offered opportunities for university collaboration funding for joint research and development. Such unified acceleration has gradually produced research accomplishments leading to new directions. The Ministry of Education, Culture, Sports, Science and Technology's Research Promotion Bureau believes that this can contribute more to society.

Tseng (2009) proposed that industrial planning requires technique-centered concepts and that such techniques are the strength of mathematics and science personnel. Business Weekly (2011) reported that in the next four decades, the most popular industries will still be the financial and high-tech industries. Related occupations, such as securities analysts, futures analysts, semiconductor analysts, technological managers and engineers, are all people with high abilities in mathematics and science. This researcher believed that in the age of the knowledge economy, if a country does not enhance professional knowledge and techniques, problem-solving abilities and innovation abilities, its industrial competitiveness will fall behind that of other nations. The article titled Dialogue between Universities and Corporations Ministry of Education (2009) mentioned eight major abilities in corporate views for the employability of personnel in the future: a strong willingness to learn, high malleability, high stability and pressure-resistance, team cooperation, professional knowledge and techniques, problem-solving ability, international perspective and foreign language ability, innovation ability and synthesis ability. Thus, technological research and development also require personnel with innovation ability. For the technology industry to move from OEM to innovative research and development, as well as develop innovative manufacturing processes and products in response to domestic and foreign vendor needs, it needs research and development personnel to have stronger abilities in mathematics and science. These abilities are necessary for people to propose new models and construct mathematical models that can simulate results, in order to process the complex problems they encounter. Thus, industries need more people who can engage in mathematical and scientific activities.

**Training personnel with management ability in applying mathematics and science:** In recent years, China has placed great emphasis on talent policy (Ministry of Economic Affairs, 2009). In June 2010, it promulgated Guidelines for the Development and Planning of Talent in the Mid to Long Term for the State (2010-2020) as the basic standard for developing its talent development strategy (State Council of People's Republic of China, 2010). Talent refers to people who have a certain level of professional knowledge or professional capabilities and who conduct creative labor and contribute to society; they are laborers with higher ability and quality in human resources. Broadening their thinking methods and observational breadth (in other words, their imagination) can motivate creativity and innovative ability.

People are facing increasingly intense competition and workplaces can vary greatly. However, at school, learners cannot understand the pressure of competition in the workplace. If they lack training in relevant application ability, they will not be able to realize personal advantages and values. The sufficient realization of professional knowledge and potential, the quick response and comprehensive solution of problems (such as the optimal capacity and production schedule planning for products) and innovative research, are all demonstrations of mathematics and science abilities and their management. Thus, in facing the changes in the world, it is necessary to have professional abilities in managing and applying mathematics and science.

**Using digital information technology to assist instruction:** With the rapid development of digital information technology, instructional methods incorporating digital technology have also arisen. These instructional methods are more lively, interactive, challenging and interesting than traditional instructional methods and they more easily create learning environments that cannot be created using traditional instruction. For instance, researchers have used computers to create multimedia learning software about the subject of subsidence, so learners can personally see subsidence and experience subsidence, thus allowing them to convert the abstract concepts in books into concrete feelings (Lee, 2010).

Digital technology not only easily attracts the learners' attention; it can also be adjusted based on the learners' needs to make it individually suitable. Learners with special needs in particular require adjustments to the learning content and presentation to help them learn. Ju (2011) turned mathematics problem contexts into videos and the results of the implementation showed that this could successfully enhance the learning effects for students who are aurally challenged and have learning disabilities in mathematics.

The assistance of digital technology not only recreates the effects of actual experiences; it can improve upon student weaknesses and enhance student-learning achievements.

## MATERIALS AND METHODS

This study helped learners to use mathematical functions and derivative function formulas to create dynamic images, as well as experience the production of images and meaning to produce dynamic mages and then experience the produced images and meanings, to enhance thinking ability through visual learning. The learners applied mathematic formulas to form images and strengthened their knowledge and capabilities in applying programming languages. In How to Think, Phillips (2009) mentioned that people live in a visual age, where television screens, the Internet and published images quickly transmit various types of culture. More than half of the brain is correlated to visual function. The visual information received by the eyes is processed by the occipital cerebral cortex in the back of the brain and is then transmitted to the analysis areas in the rest of the brain. Many brain regions that are used to process what one sees are also used to reflect on what has been seen and to imagine the future. A major key to influencing visual ability is imagination. Individuals use their imagination to focus their spirit, calm their hearts, or elicit creativity. Thus, it is important to cultivate the ability of visual thinking. People rely on vision and are accustomed to appreciating impressive images. In order to attract others, regardless of whether it is through work briefings, the design of commercial concepts or the preparation of theses, it is necessary to grasp the basic

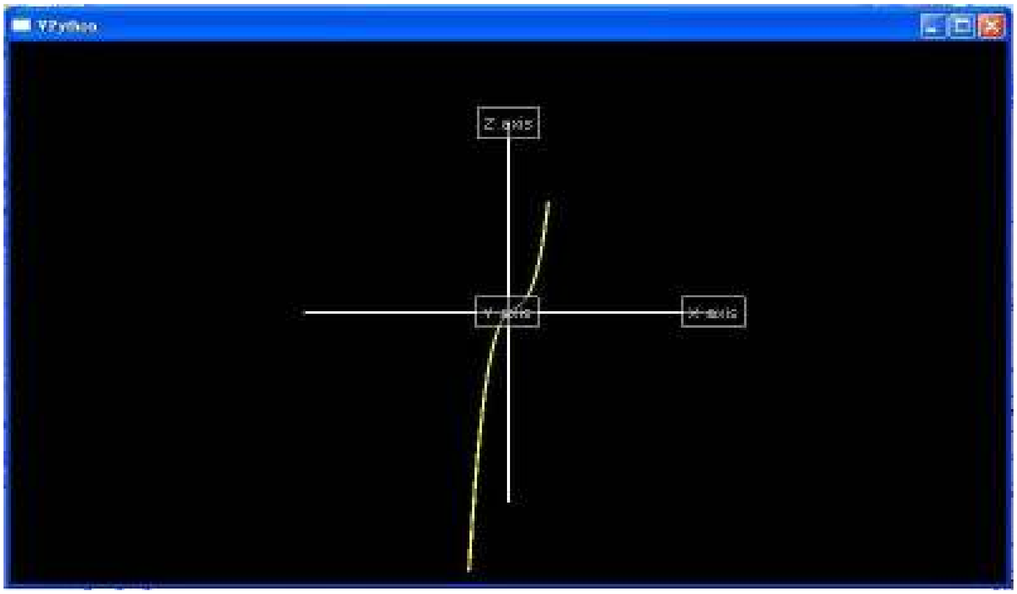



Fig. 1: Using the program to construct dynamic 3D curves from the function

principles of good visual sense. The researcher hoped to increase the visual focus, cultivate the visual memory of images and enhance the visual observation ability of learners.

Knowledge is the main asset for elevating the competitive advantages of organizations in the 21st century. Master of management Peter Drucker pointed out that future corporations will not use laborers, but rather, knowledge workers. Since knowledge workers have production tools and methods and they accumulate assets in the practical operations in the organization, organizations need to promote knowledge workers so they can share their knowledge and contribute wisdom. The founder of Japan's Matsushita Corporation, Konosuke Matsushita said, "now the business world is very complex; there is not only intense competition; there are also many dangers. The key to the sustainable operations of a company is whether the wisdom of all employees at the company are sufficiently emphasized and used" (Davenport and Gu, 1999). In Corporations that Create Knowledge, Knowledge management master Chang (2000) stated that in an uncertain economic system, the key to maintaining a competitive advantage lies in knowledge. Chang (2000) also pointed out that, "in a changing economic environment, the only thing to be certain of is that the environment is full of uncertain factors. In order to control competitive advantage, it is necessary to first control knowledge. In market changes, technology has continued to promote new things, there are more competitors and the product lifecycles keep getting shorter. In this environment, corporations that are successful are the ones that can continuously innovate knowledge, promote new knowledge in the organization and quickly absorb new technology and promote new products" (Liu *et al*., 2001). Enhancing the connection between knowledge and capabilities will result in productivity or creativity that far surpasses the value creation of capital and machines. The wisdom constructed by knowledge or capabilities will enhance the effects of corporations and organizations and will become the prime contributors to the growth of corporations and organizations. The corporations that can guide the 21st century will be those that have knowledge and capabilities as their primary production factors. The employees in these corporations will become the so-called knowledge plus capabilities workers.

Researchers have used practical examples that apply functions and derivative functions to construct images, which students can then simulate and manipulate. Examples include teaching learners to establish diagrams for the functions $f(x) = x^3 - x^2 + x$ and $g(x) = 3X^2 - 2X + 1$ (Fig. 1), using freeware to write evolutionary programs and constructing the functions and derivative functions shown in Fig. 1, so that learners can actually experience the images of derivative functions.

In programming code, learners understand the differences in color and number expression, as shown in the following example:

```
Color = color.yellow
f (x) = x**3 - x**2 + x
color = color.green
g (x) = 3*x**2 - 2*x + 1
```

where, $f'(x) = g(x)$ of the g function is the derivative function of the f function. In other words, $\int g(x)dx = f(x) + c$.

Derivatives themselves are the instant rate of change of the functions. They can calculate the slope of

Table 1: Original function and derivative function

| | Original function f (x) | Derivative functions f (x) |
|---|---|---|
| Economics | Profit function | Marginal profits |
| | Revenue function | Marginal revenue |
| | Cost | Marginal costs |
| Physics | Displacement function | Speed |
| | Speed | Acceleration |

the tangent line and smoothly convert the average change rate to the instantaneous change rate. The concept of the instantaneous change rate can be applied to marginal analysis in the functions of costs, income and profit, as in business management, marginal analysis, marginal revenue, or marginal profit are especially important.

During the instructional process, it is possible to teach learners to understand the correlation between image production and function change through 3D rotation functions and different viewing angles. The color differences produced by the values are used to discern the differences of images, which can reduce the cognitive load on the learners (Fig. 2).

The first derivative can be applied to marginal costs, marginal effects and marginal profits in economics. It can also be applied in engineering, physics and other fields, as follows (Table 1).

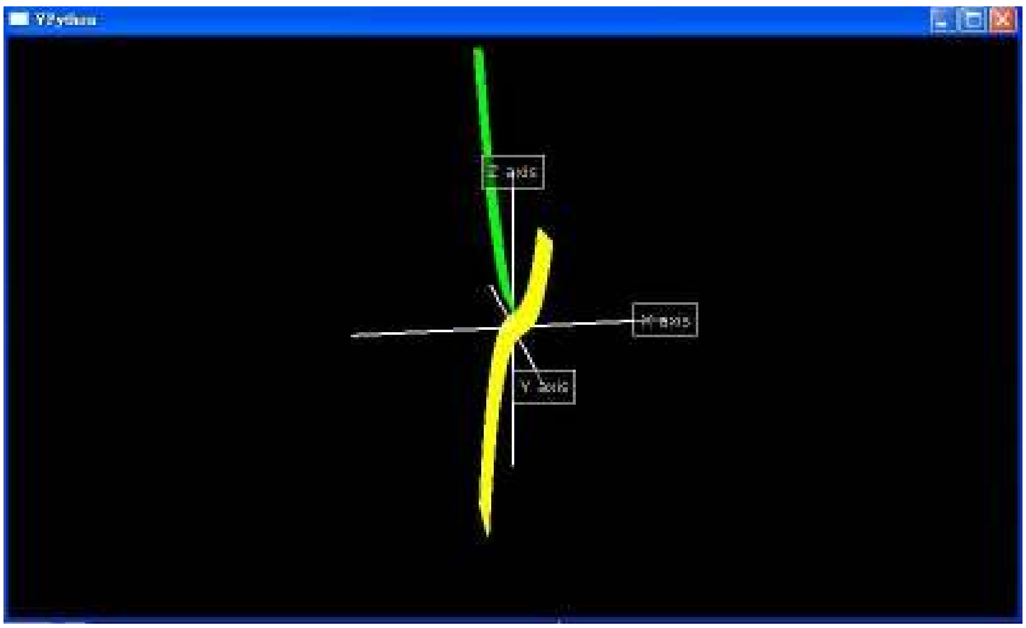
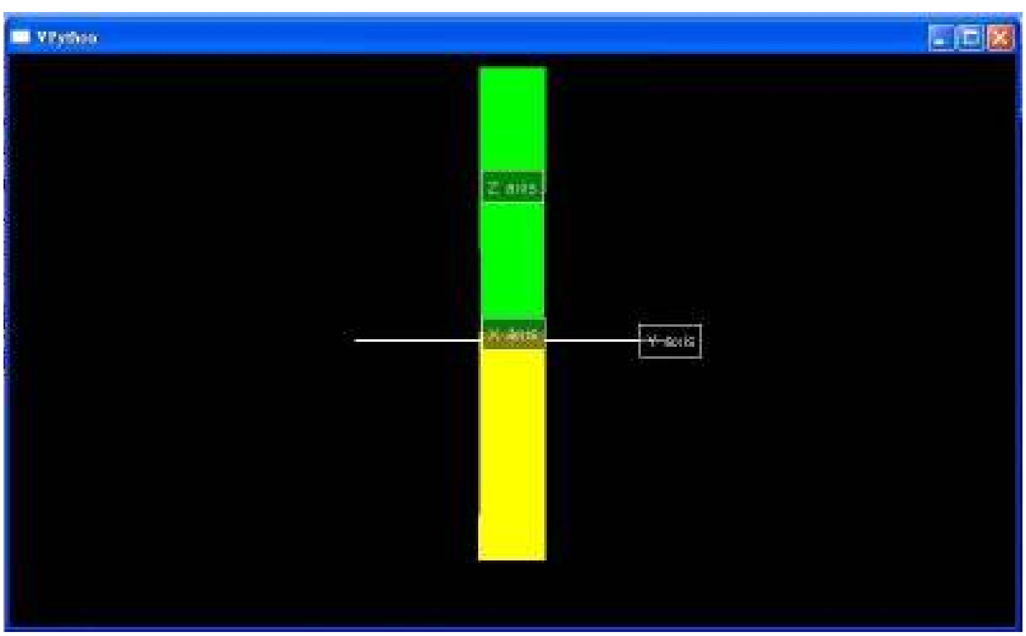
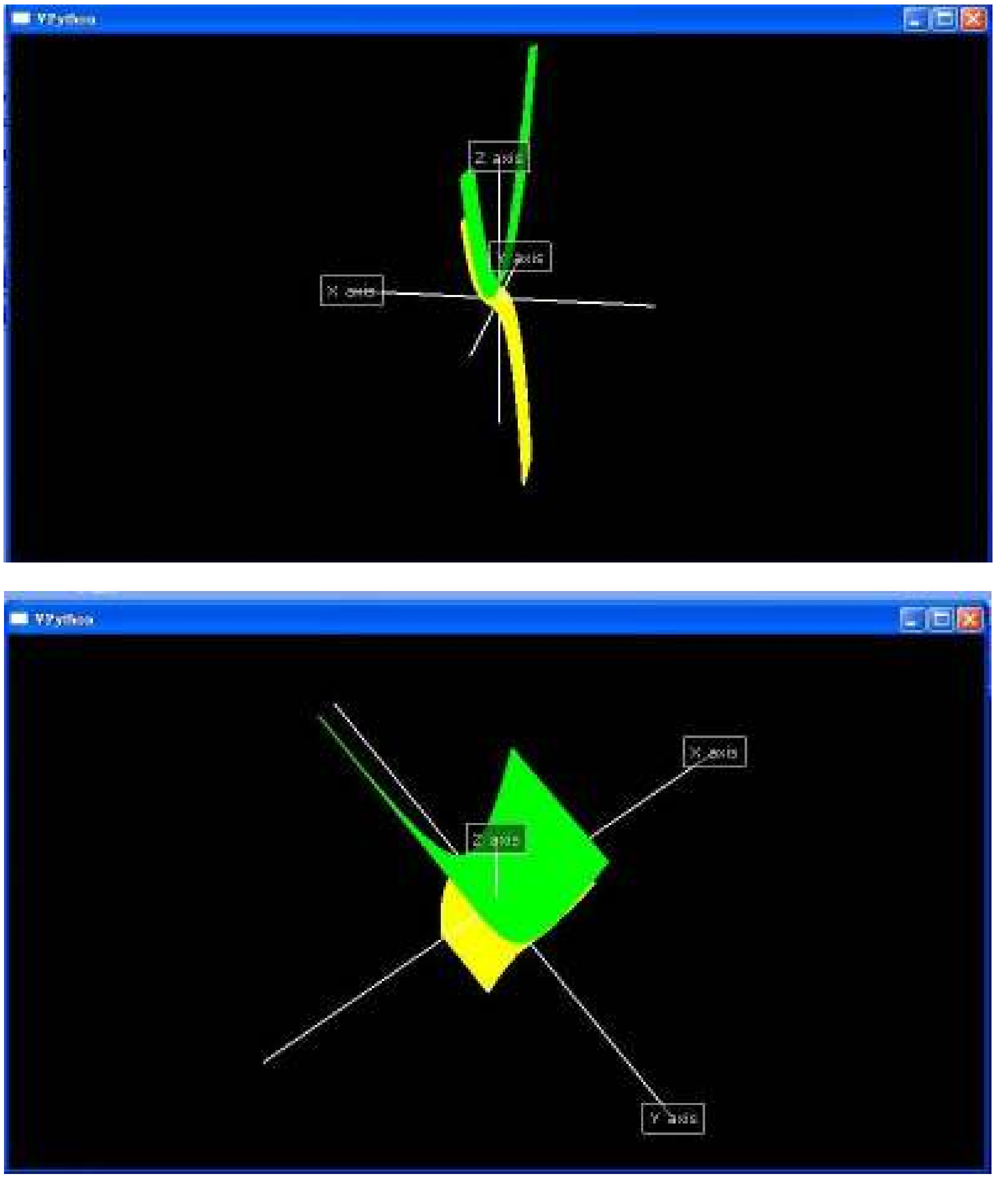


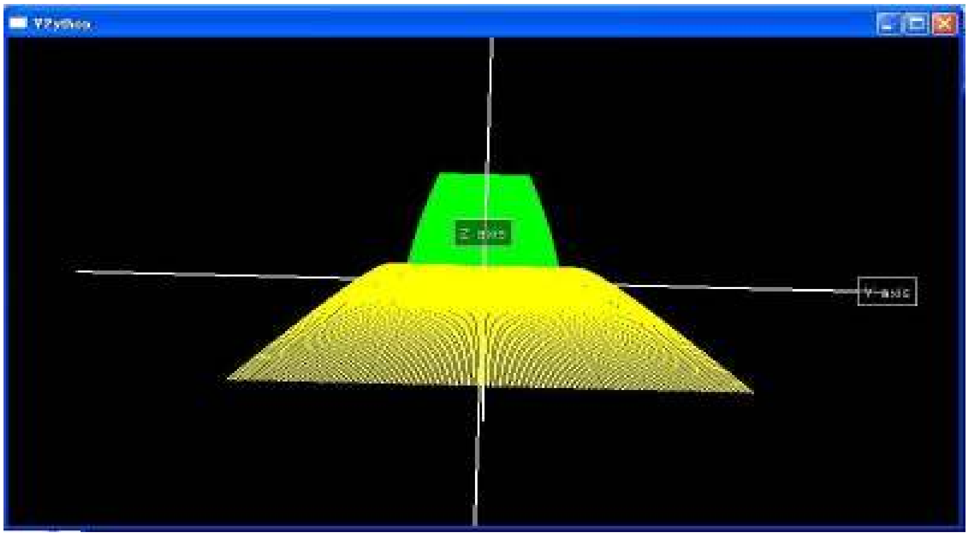

Fig. 2: The green image is the first derivative, or the original function



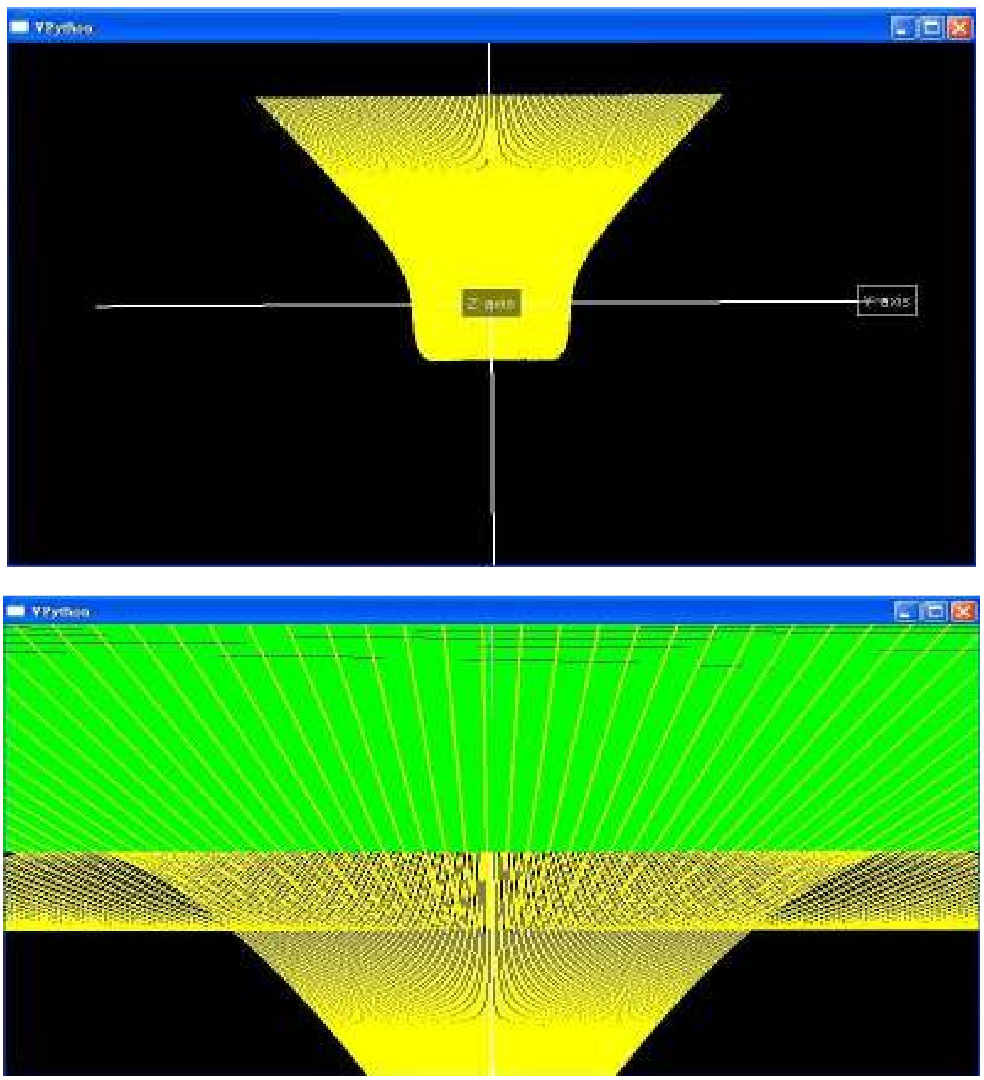
(a)



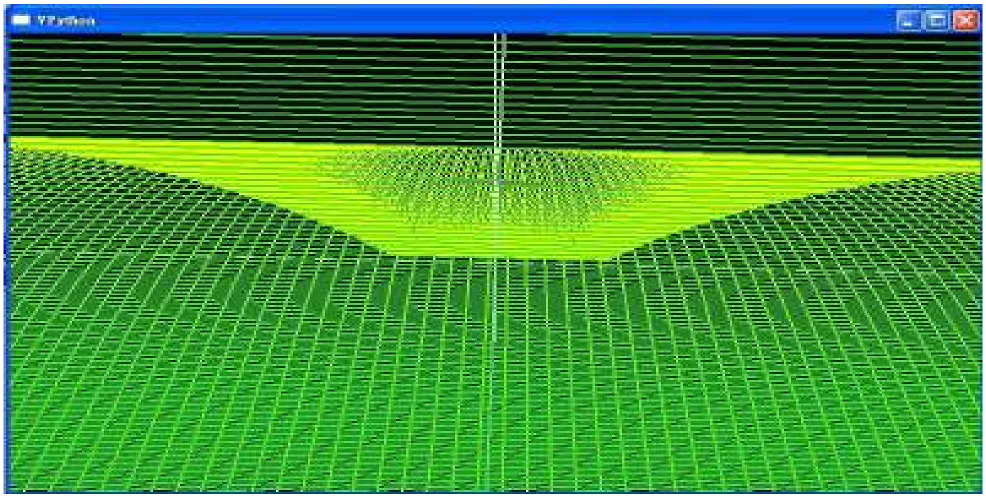

(b)




(c)




(d)



(e)

Fig. 3: Visual representations of the rotated faces

In addition, it can be applied in industrial craft and products designs, such as the images below (Fig. 3).

Modern corporations face an intensely competitive environment with numerous industrial changes. The upgrading of production techniques can be divided into cultivating existing fields and multilateral applications (Davenport and Gu, 1999). In this study, the learners simulated the programming codes developed by the researcher to execute the images, extended the multifaceted formulas and data to produce images and then observed changes in the images to form new ideas. In corporate culture, innovation, self-management, improvement, application and growth are used to obtain competitive advantages.

Based on the above described purpose of this study is that by teaching the use of culvert formula and apply to Python and other 3D software, research methods taught in the classroom students should have the derivation of the number of Han formula, Python and the use of 3D software, Finally, let the students to use these skills into dynamic graphics for its flexibility applied in different industries, the organization has many contributions.

## CONCLUSION

This study used digital technology to assist in learning mathematics and science abilities and to use the industrial perspective to explore the importance of these abilities. The learners used the mathematics formulas and images created by information technology to understand the formation of mathematical funtions and images for applied thinking.

Functions are suitable for application in industrial analysis and can be applied in instances such as production functions and product design, such as hooks. Important concepts in physics, geometry and economics can also be expressed in derivatives. Examples include using functions to find the number of sales of an item needed for maximum revenue or for achieving the production amount with the lowest average cost. It is also possible to measure consumer reactions to changes in prices. In terms of physics, a function correlation formula can be used to directly see particle kinematics; for instance, the position function formula for an object’s movement can be used to find the starting point, initial speed, instantaneous speed and acceleration. It can also express the geometric meaning of curves at the tangent slope at one point and at others. The proper expression of mathematics and science management ability lies in using these formulas properly for analysis, discovering problems and then designing solutions.

In the learning process, students must use the Python construct 3D objects, while training students the ability to enhance the students to problem solving.

In subsequent research, it is suggested that the connections between different formulas and image compositions, learning achievements and problem-solving abilities, as well as quick responsiveness, thinking about problems and problem-solving determination can also be explored.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## REFERENCES


American Association for the Advancement of Science, 1993. Benchmarks for Science Literacy. The United States, Oxford University Press, New York, 1993.

Business Weekly, 2011. 7 Most Popular Industries in the Next 40 Years. No. 1224, Business Weekly, Taipei.

Chang (trans.), N.I., 2000. Corporations that Create Knowledge. Tianxia Wenhua, Taiwan, Taipei, pp: 24-48.

Chen, J.J., 2007. Coping with industry demands in the new century, accelerating reform in occupational education---strategies in developing intricate occupational education. Tech. Occupation Bimonthly, 71: 68-73.

College Entrance Examination Center, 2010. Treasure Box for Learning Groups, Vol. 185.

Davenport, T.H. and L.P. Gu (trans.), 1999. Working Knowledge, Taiwan, Taichung. China Productivity Center, pp: 48-49.

Hosotsubo, M., Y. Ito and T. Kuwahara, 2006. The Forgotten Science-mathematics, Ministry of Education, Culture, Sports, Science and Technology National Institute of Science and Technology Policy. Science and Technology Research Center, Online Searching Data. Retrieved form: http://www.nistep.go.jp/achiev/results01.html. (Accessed on: May 31, 2006).

Hsieh, M.C. and H.C. Liu, 2007. Considering mathematics in the cultivation of research personnel in computer fields. J. Inner Mongolia Normal Univ., Educ. Sci., 1: 96-98.

Ichiro, S., 2006. Living Room Mathematics. Seibunshinsha Publishing Co., Ltd, Tokyo.

Ju, J.M., 2011. Effect of Schematic Videos and Animations in Assisting Students with Mathematics Difficulty and Deafness in Solving Word Problems with Unknown Original Numbers. National Science Council: NSC 99-2511-S-468-007, 2011.

Lee, H.L., 2010. Instructional effects of context experience strategy applied to incorporate in environmental education in elementary school-incorporation of “migratory multimedia instructional materials” into the unit on subsidence (I). National Science Council: NSC98-2410-H-024-005, 2010.

Liu, P.L., S.F. Yang and W.C. Chen, 2001. The study of the implementation of knowledge management and its effects on increasing the competition. Chung Hua J. Manage., 2(1): 59-74.

Ministry of Economic Affairs, 2009. Ministry of Economic Affairs Program for Developing and Promoting Professional Talent, pp: 1-341.

Ministry of Education, 2009. Dialogue between universities and corporations. Higher Educ. Tech. Vocational Newsletter, 30: 1-24.

Ministry of Education, Culture, Sports, Science and Technology, 2012. Promotion of Mathematics, Sciences and Association with Industry in Mathematics Reform. Ministry of Education, Culture, Sports, Science and Technology, Research Promotion Bureau, Foundational Research Promotion Section.

Phillips, C., 2009. How to Think: 50 Puzzles for Visual Thinking. Connections, England, London, pp: 1-96.

Science Council of Japan National Committee for Science Education, 2008. Science Council of Japan-current Conditions and Issues in Research and Cultivating Youths in Mathematics and Sciences, pp: 1-61.

Su, H.L. and H.Y. Hsieh, 2006. Incorporation of science games in problem-solving ability of children in the science subject in elementary school. Nat. Univ., Tainan J. Sci. Technol. Stud., 40(1): 47-68.

State Council of People’s Republic of China, 2010. Guidelines for the Development and Planning of Talent in the Mid to Long Term for the State (2010-2020) pp:1-28.

Taiwan PISA National Center, 2010. PISA the Programe for International Student Assessment, Retrieved form: http://pisa.nutn.edu.tw/pisa_tw.htm. (Accessed on: June 25, 2011).

The Mathematical Society of Japan, 2006. Toward the Improvement of Our Country’s Mathematics Ability. The Mathematical Society of Japan, September 15, 2006.

Tseng, C.C., 2009. Future Focus Industries in Taiwan, National Policy Foundation National Policy Analysis. Retrieved form: http://www.npf.org.tw/post/3/5566 (Accessed on: June 26, 2010).

Tsuneharo, O. and M. Takahisa, 2006. Mathematical Brain-Increasing Insight Ability from Doing Simple Diagrams. Nippon Jitsugyo Publishing Co., Ltd., Tokyo.