Implementing Stop Motion in Learning Quadratic Functions to Develop Mathematical and Global Competence for Students in Vietnam for the Sustainable Development Goals

Chi Ton Le, To Van On High School, Vietnam

The Asian Conference on Education & International Development 2023
Official Conference Proceedings

Abstract
In this research, 10th - grade students at To Van On high school in Vietnam participated in a Project Based Learning (PBL) with three stages. In the first stage, the students collaborated together to do some research on quadratic functions and Stop Motion technique as well. In the second stage, the students studied the local social problems focusing on the environment and discussed the suitable solution for the problems. In the last stage, the students used the application Stop Motion Studio combined with their own knowledge of the quadratic functions to create videos which conveyed things such as "Climate Action", "Life below Water", and "Life on Land". They are three of seventeen goals of the Global Goals, were adopted by the United Nationals in 2015. From the research process, we knew that the students were not only demonstrating their understanding about mathematical knowledge but also giving their standpoints and helping raise community awareness on the mentioned goals of Sustainable Development Goals. Participating in the project helped the students develop mathematical modeling skills, enhance digital skills as well as thrive global competence. This research can be seen as an interesting reference for teachers, who want to implement digital technology and global competence in their own practices.

Keywords: Digital Technology, Global Competence, Quadratic Functions, Stop Motion, Sustainable Development Goals

Introduction

The context of global education of the 21st century demands to educate our next generation students to become global citizens associated with developing global competence and digital skills. The Asia society determines that global competence articulates the knowledge and skills students need in the contemporary world which consists of four following domains:

Investigate the world: Students investigate the world beyond their immediate environment.
Recognize perspectives: Students recognize their own and others' perspectives.
Communicate ideas: Students communicate their ideas effectively with diverse audience.
Take action: Students translate their ideas into appropriate action to improve conditions.

(Asia Society 2005, p. 13)

Figure 1: Global Competence by Asia Society 2005.

Global competence helps connect students' learning process with real world experiences and in addition well equip students with the necessary skills such as: cross-communication, critical thinking, problem solving, collaboration and team work skills. "Global competence thus supports the Sustainable Development Goals both by proving the vision of education the SDSs advocate for, and by encouraging young people to act in the general interest of collective-wellbeing and sustainable development that the SDGs embody." (OECD, PISA 2018, para. 2).

Moreover, we are living in the digital era. Understanding digital technology therefore is a significantly vital purpose in training global citizens and global workforce. This leads to teaching and learning digital skills is an inevitable educational trend in an ever-changing world. "The changes have highlighted the need for school to ensure that all students are prepared for the contemporary digital world. The need to provide digital skills for all students means that digital technology can no longer be taught only as a specialist subject area but rather needs to be embedded in all subjects across the curriculum." (Parsons, MacCallum, Schofield, and Johnstone, 2020).

This very need has required that "Teachers and students will need to work together in new forms of "partnering" in which students do what they do best - for example, using technology, find information, and create products that demonstrate their understanding." (Marc Prensky, 2011).

In terms of teaching mathematics at secondary levels, implementing Stop Motion Studio Application to depict an animate picture of a graph of a function allows the two learning

processes “learning is relearning” (Kolb, 1984, p. 30) and “learning by making” (Papert and Harel, 1991) to be happened simultaneously. Moreover, “each step in creating an animation is important to learning the underpinning science as each activity explores the same concept but in a different mode. This creates a cumulative semiotic progression with meaning building from one representation to the next to promote learning” (Wishart, 2017).

Additionally, “When learners generate an animation about a science concept, they experience the process of clarifying, checking and refining their understanding.” (Hoban, Nielsen and Carceller, 2010’s). Therefore, using stop motion technique in teaching quadratic functions not only motivates students access digital technique and apply it in their own learning, but also maximizes their understanding of the properties and graph of the functions. Furthermore, in this research, Stop Motion Studio is also an actually effective tool which was creatively used by students to convey their messages about the sustainable development goals to other people.

Reference Theories

In this research we used the anthropological theory of didactics by Yves Chevallard in order to determine praxeologies associated with knowledge object quadratic functions in the mathematics curriculum for 10^{th} grades in Vietnam from 2007-2022. We also applied the concept of didactic engineering of Michele Artigue to construct a didactic project which is a PBL focused on developing mathematical modeling, digital, and global competencies for students whilst they learn quadratic functions. Besides that, Eight Big Ideas Behind the Constructionist Learning Lab of Seymour Papert, Asia Society’s Global competency framework, and Solution plan for modelling tasks of Blum and Ferri are used as reference theories.

Praxeologies Associated with Quadratic Functions in the Mathematics Curriculum for 10^{th} Grades in Vietnam from 2007 to 2022

In this period, the concept of quadratic functions in the algebraic curriculum for 10^{th} grades in Vietnam was displayed completely in mathematical context. Integrating digital skills and developing global competence for students has not been appeared in textbooks and in references used by teachers for planning lessons, constructing tests to evaluate students’ abilities.

Through a research process based on *Algebra 10 Textbook*, *Algebra 10 Teacher-book*, and *Algebra 10 Workbook* which were used to teach Vietnamese students nationally in this time, we found that there are five praxeologies relating to quadratic function.

Task T_1: “Finding the vertex I of a given quadratic function.”

Technique τ_1: Student implements the formula of the vertex $I\left(-\frac{b}{2a};-\frac{\Delta}{4a}\right)$.

Task T_2: “Finding the y-axis and x-axis (if any) of a given quadratic function.”

Technique $\tau_{2.1}$: Student implements the formula of the y-axis is $A(0;\mathrm{c})$ to find the y-axis.

Technique $\tau_{2.2}$: Student solves the quadratic equation $ax^2+bx+c=0$ to find the x-axis.

Task T_3: “Finding the values of a,b,c in the parabola $y=ax^2+bx+c$, which is suitable some given conditions.”

Technique τ_3: Student solves for $a, b,$ and/or c the simultaneous linear functions.

Task T_4: "Creating a table illustrating the monotonicity properties and sketching the graph of a given quadratic function."

Technique τ_4: Student follows the process: First, is to determine sign of a. Second is to draw a monotone indicating table (illustrated in Algebra 10 Textbook, page 45). Third is to state increasing and decreasing open intervals of the function. Fourth is to determine the coordinate of the vertex I. Fifth is to sketch the axis of symmetry $x = -\frac{b}{2a}$. Sixth is determine the y-intercept and x-intercept (if any), and other points belonging to the graph. And last is sketching the parabola passing through the determined points.

Empirical Research

Project

We constructed and studied a PBL because "PBL is an active student-centered form of instruction which is characterised by students' autonomy, constructive investigations, goalsetting, collaboration, communication and reflection within real-world practices." (Kokotsaki, Menzies, and Wiggins, 2016). The project was expected to pave the way for the emergence and development of knowledge, competencies and skills "through invention and reinvention, through the restless, impatient, continuing, hopeful inquiry men pursue in the world, with the world, and with each other" (Paulo Friere, 1974). More specifically, our research focuses on developing students' understanding on quadratic functions. Also students use these insights to create videos that convey the sustainability goals. Participating in the project helps students develop two core competencies of the 21st century education as digital literacy and global competence.

PBL's opened question: "***What realistic movements orbiting a parabola can convey messages about the United Nations' Sustainable Development Goals (SDGs)?***"

Introductions for students:

> **Stage 1:** Students implement process of re-learning the knowledge of quadratic functions and learning how to create video using the Stop Motion Studio application.
> **Stage 2:** Students undertake research on the Seventeen SDGs, followed by observing the outside world to seek parabolic movements associated with the SDGs. After that they use the knowledge learned to build a mathematical design for the selected motion.
> **Stage 3:** Students use the Stop Motion Studio app to produce a short video and write a short essay to voice their standpoints and raise public awareness on the ongoing issues. Students then take practical actions to improve the issues.

The output of the PBL is uploaded to the Padlet at https://padlet.com/lctonc3tvon/i4wroln-fdk9eayv. Students organize discussions on their products via Google Meet to collaborate to correct mathematically and share their messages and visions. During these discussions we are observers and coordinators.

A Priory Analysis

In terms of developing mathematical modelling competence

Strategy S_{GtoF}: Students follow the four steps to solve a modeling task suggested by Blum and Ferri.

"Step 1. **Understanding task**: Read the text precisely and imagine the situation clearly; Make a sketch." Students study the project question and discover parabolic movement in the real world which is suitable to the requirement of the question. They then partially do the task T_4 depicting a chosen movement on paper with Oxy plane.

"Step 2**. Establishing model**: Look for the data you need. If necessary: make assumptions; Look for mathematical relations." Students note down general form of parabola $y = ax^2 + bx + c$.

"Step 3. **Using mathematics**: Use appropriate procedures; Write down your mathematical result." In this step students completely practice the task T_4 combined with the tasks: T_1, T_2, and T_3 in order to determine correctly the values of the parameters a, b, and c.

"Step 4. **Explaining result**: Students round off and link the result to the task. If necessary, go back to step first; Write down your final answer." With the equation found in the previous step, students re-do the task T_4 and display the solution of the task as their mathematical design of the movement. Also, they compare the graph to the real orbit to understand necessity to constrain the values of x on a closed interval which helps their established mathematical model illustrate the orbit more appropriately. Nevertheless, solving quadratic inequalities will be taught in the next semester, hence determining a suitable function without restraint on the values of x is still considered as a valid answer.

This is an optimal strategy expected to happen; however, students are anticipated to face challenges in Step 3. This is able to lead to the appearance of a suboptimal strategy S_{FtoG}.

Strategy S_{FtoG}: Students do Step 1 and Step 2 of the modelling process, and at the end of Step 2 they decide to write a specific quadratic function and skip Step 3. They after that do Step 4 by solving the task T_4. With S_{FtoG}, the chosen function could not illustrate effectively the real movement; however, it will be able to appear with higher proportion compared to S_{GtoF}.

In terms of developing digital skills

Students actively access the Internet to explore the Stop Motion Studio App and install the app on their smartphone. To make a short film using this application, students experience a four phase process of "Planning, storyboarding, construction, and reconstruction" (The Mind Lap, 2020). As a matter of fact, students work together in the environment of paper and pen to construct a movie background that focuses on the movement of object with the parabolic orbit whose graph is designed earlier. They then place the object at different positions on the graph following the direction of motion. At each position, students take a photo by Stop Motion Studio application. Last, in the environment of Stop Motion Studio, they create and

edit their video. The whole process poses challenges for students by virtue of high requirements for the smoothness of video and accuracy of movement. This is a comprehensive process of expressing and re-expressing students' knowledge in practical environment.

In terms of developing global competence

In the question of the PBL we highlight the aim of the didactic project is to convey messages about the United Nations' Sustainable Development Goals via realistic movements whose orbit are parabolas. This stimulates students to study the goals on the Internet and investigate the local or regional issues vis-à-vis their chosen goals. The goals: "Climate Action", "Life below Water", and "Life on Land" are looked ahead to be targeted by many students. Additionally, they initially exchange and recognize perspectives about these problems together. Furthermore, they communicate proactively their standpoints to others and act positively to improve the current issues.

A Posteriori Analysis

This PBL was conducted in November 2021, in the context of COVID 19 pandemic and in Vietnam, students had to learn online. The project had participation of 40 students in grade 10A11 at To Van On high school located at an under-resourced community. The students have diverse backgrounds and many of them with low achievement and motivation in math. The teacher's instructions were delivered via email and Google Meet.

In terms of developing mathematical modelling competence

Based on the provided drafts and students' presentations in the discussions there were seven group chose and succeeded with the strategy S_{GtoF}. The strategy S_{FtoG} was picked by the remaining groups. Although six of them initially selected S_{GtoF}, the difficulties expected earlier in Step 3 forced members of the groups to abandon this strategy. This result was obviously evident that mathematical modelling competence was established and the students implemented it to build successfully mathematical design for parabolic orbits. Accompanying with thriving mathematical modelling competence, our experiment created opportunities for students to develop other skills such as creative thinking skills, problem solving skills, and scientific debate skills.

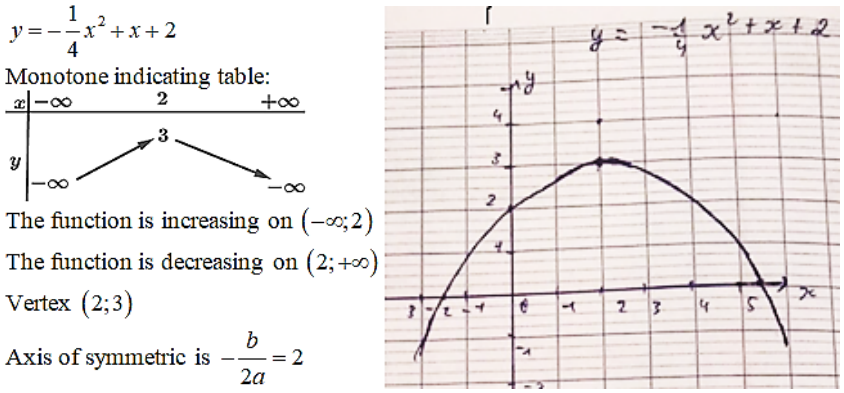

Figure 2: A mathematical design completed by a group with the strategy S_{GtoF}.

In terms of developing digital skills

The filmmaking process of students showed that this is an interesting process in which students actually experienced and implemented at least seven of eight ideas suggested in the work **Eight Big Ideas Behind the Constructionist Learning Lab**. Those ideas are: "learning by doing", "technology as building material", "hard fun", "learning to learn", "taking time – the proper time for the job", "you can't get it right without getting it wrong", and "we are entering a digital world where knowing about digital technology is as important as reading and writing". Not only does the project aim to develop digital skills for students, but it also aims to take advantage of the Stop Motion Studio app as an effective tool to comprehend quadratic functions as well as convey the necessary messages to other audiences.

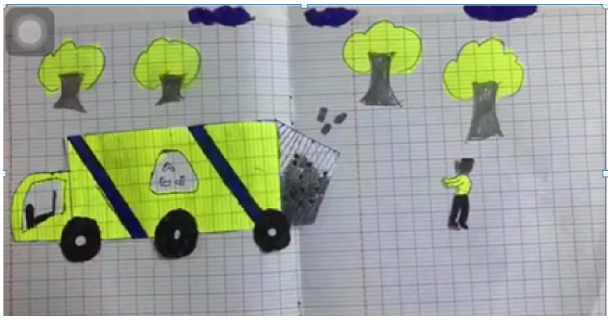

Figure 3: A screen capture of students' video depicting the collection of garbage that belongs to the goal "Climate Action."

Figure 4: A screen capture of students' video picturing dolphins jumping out of the water that belongs to the goal "Life below Water."

In terms of developing global competence

The number of groups choosing the goals "Climate Action", "Life below Water", and "Life on Land" were twelve, three, and five respectively.

Investigate the world: Students have really studied practical issues such as environmental pollution, the effects of climate change with their lens, understanding, and responsibility. Students were well aware that this is not just a local or national problem, but a global problem for which each individual and organization must be responsible.

Recognize perspectives: Students understood and critically absorbed positive and negative viewpoints on their chosen issues and communicated their viewpoints.

Communicate ideas: In each group, individuals contributed, collaborated and critiqued ideas from which to implement the project. In the classroom, students shared and commented on

ideas and messages from the groups' products. At home, students called for responsibility among members for the issues they were interested in and chosen.

Take action: In addition to conveying the message through videos and short essays with diverse viewers, students participating in the project ran an environmentally friendly campaign with the slogan "*Each student one green tree"*. They were also pioneers in planting and taking care for trees.

Message one: "*Let's dispose of garbage in the right place to protect the environment and also protect human health. The environment is our place to live. Protecting the environment is protecting life. It is the duty of every citizen to fulfill."*

Message two: "*Please protect the marine environment because the sea is a very rich and diverse place in terms of resources, full of potential for diverse economic development. Not only that, the sea is also an easy place to develop tourism and develop the aquaculture industry. Let's join hands to prevent marine pollution; you will see its inherent potentials."*

Conclusions

We notice that undertaking a PBL in order to help students in grade 10^{th} in Vietnam to develop mathematical modeling competence, global competence and digital skills while teaching and learning the concept of quadratic function is achievable.

The project can foster productively differentiated and student-centered activities. Moreover, it also assisted students in developing critical thinking, creative thinking, problem solving, communicating and collaborating skills.

Students expressed themselves in the roles of designers, directors, art creators, and makers of products oriented towards sustainable development goals.

PBL and Stop Motion technique are able to create opportunities for teaching mathematical knowledge in both online and face-to-face teaching contexts such as: Vectors, Functions, Coordinate Geometry.

References

Asia Society 2005. *What is Global Competence*? Retrieved from https://doi.org/10.1787/978926-4289024-en

David A. Kolb (1984). *Experiential Learning: Experience as the Source of Learning and Development*. ResearchGate.

David Parsons, Kathryn MacCallum, Lynley Schofield, and Anna Johnstone (2020). Next-Generation Digital Curricula for Future Teaching and Learning. *Emerging Techologies and Pedagogies in the Curriculum*, 3-19.

Deymour Papert (1999). Eight Big Ideas Behind the Constructionist Learning Lab.

Dimitra Kokotsaki, Victoria Menzies and Andy Wiggins (2016). Project-based learning: A Review of the Literature. *SAGE journals*.

Garry Hoban, Wendy Nielsen, and Charles Carceller (2010). Articulating Constructionism: Learning Science through Designing and Making "Slowmations" (Student-genrated animations). *Conference of the Australasian Society Computers in Learning in Tertiary Education*.

Jocelyn Wishart (2017). *Exploring How Creating Stop-Motion Animations Supports Students Teachers in Learning to Teach Science*. Journal of Research on Techology in Education.

Marc Prensky (2011). From Digital Natives to Digital Wisdom Introduction. *From Digital Natives to Digital Wisdom: Hopeful Essays for 21st Century Education.* Corwin Press 2012.

Michele Artigue (1990). Ingéniérie didactique, Recherche en didactique des mathématiques. *Vol. 9.3, p. 218-307, La Pensée Sauvage*. Grenoble.

The Mind Lab (2020). *Teaching Digial Skills for Sustainable Education*.

OECD. PISA 2018. *Global Competence*. Retrieved from https://www.oecd.org/pisa/innovatio-n/global-competence/

Paulo Friere (1974). *Education for Critical Consciousness*. Bloomsbury.

Tran Van Hao, Vu Tuan, Doan Minh Cuong, Do Manh Hung, Nguyen Tien Tai (2016). *Algebra 10 Textbook*. Vietnam Education Publishing House Limited Company.

Tran Van Hao, Vu Tuan, Doan Minh Cuong, Do Manh Hung, Nguyen Tien Tai (2016). *Algebra 10-Teacher-book*, Vietnam Education Publishing House Limited Company.

Vu Tuan, Doan Minh Cuong, Tran Van Hao, Do Manh Hung, Pham Phu, Nguyen Tien Tai (2016). *Algebra 10-Workbook*. Vietnam Education Publishing House Limited Company.

Werner Blum, Rita B. Ferri (2009). Mathematical Modelling: Can it Taught and Learnt? *Journal of Mathematical Modelling and Application*, Vol. 1, No 1, p. 45-58.

Yves Chevallard (1999). L'analyse des pratiques enseignantes en théorie anthropolo-gique du didactique. *Recherches En Didactique Des Mathématiques 19*(2), p. 221-266.

Contact email: tonmath87@gmail.com