International Journal of Education and Practice
2021 Vol. 9, No. 4, pp. 656-669.
ISSN(e): 2310-3868
ISSN(p): 2311-6897
DOI: 10.18488/journal.61.2021.94.656.669

TEACHING MATHEMATICS THROUGH INTERDISCIPLINARY PROJECTS: A CASE STUDY OF VIETNAM

Nguyen Phuong Chi

Department of Mathematics Education, Hanoi National University of Education, Hanoi, Vietnam.
Email: chinp@hnue.edu.vn Tel: 0084-944584339

Article History
Received: 3 March 2021
Revised: 17 September 2021
Accepted: 19 October 2021
Published: 8 November 2021

Keywords
Integrated curriculum
Integrated teaching
Interdisciplinary mathematics project/education
Project–based learning
STEM education.

ABSTRACT

Integrated or interdisciplinary teaching is an approach that encourages students to synthesize knowledge from more than one discipline in order to solve problems. It focuses on students' interests, a connection of subjects, use of authentic situations and problem solving techniques. This study aimed to make clear the concept of interdisciplinary teaching, by identifying how different subjects could be integrated in a curriculum and how interdisciplinary work could be developed and organized in mathematics classrooms. By reviewing various literature of the research on the topic of interdisciplinary education, the study synthesized ideas, concepts and models in interdisciplinary teaching. Then the study discussed how to apply the explored theory of interdisciplinary teaching in the Vietnamese mathematics situation. It was found out that projects should be used for interdisciplinary mathematics education. A four-step process to design an interdisciplinary project for Vietnamese mathematics classrooms was proposed. This process proved to be a useful guideline for mathematics teachers to design interdisciplinary projects. Two interdisciplinary projects for Mathematics involving Biology as the second subject were introduced in this study. These are examples of how to construct an interdisciplinary project based on the four-step process. Through these projects, students could know how to integrate skills and knowledge of the two subjects Mathematics and Biology to solve a real life problem.

Contribution/Originality: This study made clear the concept of interdisciplinary teaching, identified how different subjects can be integrated in a curriculum and how interdisciplinary work can be developed and organized in mathematics classrooms. This is a unique research study to combine interdisciplinary teaching and project based learning in teaching mathematics, for the situation of Vietnam.

1. INTRODUCTION

Mathematics is one of the most important subjects within the school curriculum because mathematical knowledge and skills are often used within other school subjects. However, the subject "mathematics" is always taught separately, without any connection to other subjects. Consequently, after leaving school, students face difficulty in applying mathematical knowledge to solve real life problems. In order to solve such problems, students need to use not only their mathematical knowledge but also knowledge of other subjects. Therefore, teachers need to present mathematics in a wider context and encourage students to synthesize knowledge of mathematics and other curriculum subjects to solve problems. This is an integrated approach in teaching mathematics.

Integrated or interdisciplinary teaching has received considerable attention in recent years. As Drake (1998) mentioned: "The world we are living in is changing and education must change with it. If we live in an interconnected and interdependent world, it only makes sense that knowledge be presented as interconnected and interdependent" (Drake, 1998). Research has shown that students in an integrated curriculum demonstrate academic performance equal to or better than students in a discipline–based program (Drake & Reid, 2010). There is a strong belief among those who support curriculum integration that schools must look at education as a process for developing abilities required for life in the 21st century, rather than as discrete, departmentalized subject matter (Connolly & Vilardi, 1989).

Recently many countries around the world have become concerned regarding the need for interdisciplinary education. Since 2007, in the English National Curriculum (QCA, 2007), interdisciplinary education has explicitly been mentioning in the context of mathematics program that teachers should provide opportunities for students to "work on problems that arise in other subjects and in contexts beyond the school" (Item 4d, p.147 and p.163). In Germany, since 2000 the benefits of interdisciplinary teaching and learning in schools have been emphasized, mostly in the form of problem-based and cross-disciplinary teaching that is organized in projects (Labudde, 2014; Moegling, 2010). A special case of interdisciplinary education is STEM (Science, Technology, Engineering and Mathematics), which originates from America. This is now being considered worldwide as many countries see STEM education as fundamental to a successful industrial base (Banks & Barlex, 2014; Williams et al., 2016). In 2018, the new general curriculum in Vietnam ensured that STEM education was an educational trend and should be appropriately considered as a Vietnamese educational innovation. Interdisciplinary education is also mentioned as a goal of teaching mathematics: "Mathematics education establishes connections between mathematical ideas, between mathematics and real life, between mathematics and other school subjects and other educational activities, especially the connections between mathematics and the subjects Science, Natural Science, Physics, Chemistry, Biology, Technology and Informatics to perform STEM education" (MOET (Vietnam Ministry of Education and Training), 2018).

Although recognizing the advantages of interdisciplinary teaching, the Vietnam Ministry of Education and Training (MOET) still has difficulties in introducing it. While the school curriculum is innovative, the teachers still do not know how to integrate school subjects in the teaching process (Krause et al., 2020). The survey in the project *"Teaching mathematics at the high school level in an integrated way through interdisciplinary projects"* shows that high school mathematics teachers understand the necessary of interdisciplinary teaching but they find difficulties in applying it because of the limitation of teaching time, the lack of instructive documents and the lack of knowledge of other subjects (Nguyen & Nguyen, 2019). This paper aims to show that using interdisciplinary projects is a suitable way to achieve the purpose of interdisciplinary education. To provide instructions for interdisciplinary mathematics education, the author proposes the process to design interdisciplinary project work for the mathematics classroom and illustrates this via examples.

2. METHODOLOGY AND RESEARCH QUESTIONS

There are various opinions regarding the interdisciplinary approach in teaching. The critical questions are about what various forms of inter-disciplinary and curriculum integration mean, why they are being encouraged and how they should be understood. There is a need to first understand the concept of interdisciplinary teaching and the related concepts. This was the first step of the present work. In the next step a literature review of the research on the topic of interdisciplinary teaching was carried out in order to know what was already available and to synthesize the whole field to identify further work based on the goal of this article. The purpose was to identify what different subjects can be integrated in a curriculum and how such interdisciplinary work can be developed and organized in classroom. Finally, it was necessary to identify how to apply the explored theory of interdisciplinary teaching to the situation of Vietnam mathematics education. Many researchers have suggested that project work is appropriate to interdisciplinary approach but few explained why. This study aimed to provide scientific and logical reasons why project work should be used for interdisciplinary education. Furthermore, how to undertake this "educational practice" also needed to be highlighted. It was therefore required to show how to design and implement interdisciplinary projects in Vietnamese mathematics classroom.

To illustrate this idea, Biology was chosen one of the STEM subjects, to integrate with Mathematics. The questions needed to be discussed, pondered and examined in this study included: What does interdisciplinary teaching mean? How to integrate different subjects in a curriculum? How to apply the theory of interdisciplinary teaching to the situation of Vietnam mathematics education? Why should project work be used in interdisciplinary teaching? How to design interdisciplinary projects for the mathematics classroom in Vietnam?

3. LITERATURE REVIEW

3.1. Various Terms and Definitions Related to Interdisciplinary Teaching

The idea of combining two or more disciplines, pedagogical approaches, groups of people, or skills first appeared in curricular contexts in 1920s under the title 'core,' interdisciplinary and integrated curriculum. These have been widely associated with the progressive education movement (Clair & Hough, 1992; Mathison & Freeman, 1997; Oberholzer, 1937; Vars, 1991). Besides the term "integrated curriculum" or "interdisciplinary curriculum", researchers have also used other terms such as integrated teaching, interdisciplinary teaching, integrated approach, interdisciplinary approach, and integrated study.

Humphreys, Post, and Ellis (1981) defined "integrated study" as "one in which children broadly explore knowledge in various subjects related to certain aspects of their environment". With this definition, links among various school subjects were examined to find how knowledge and skills can be developed and applied in more than one area of study (Connolly & Vilardi, 1989).

Shoemaker (1989) defined "integrated curriculum" as "education that is organized in such a way that it cuts across subject-matter lines, bringing together various aspects of the curriculum into meaningful association to focus upon broad areas of study. It views learning and teaching in a holistic way and reflects the real world, which is interactive".

Jacobs (1989) defined "interdisciplinary curriculum" as "a knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience". Jacob's definition implies that in an interdisciplinary curriculum there is a combination of knowledge from different subjects to solve a central problem.

Savage (2011) used the term "cross-curricular approach" instead of "interdisciplinary approach" and defined that "A cross-curricular approach to teaching is characterized by sensitivity towards, and a synthesis of knowledge, skills and understandings from various subject areas. These inform an enrich pedagogy which promotes an approach to leaning with embraces and explores this wider sensitivity through various methods". Savage's definition expresses that an interdisciplinary approach can be recognized not simply through an overlap in content but through associated changes in both the teacher's pedagogy and the students' learning experience (Ward-Penny, 2011).

Methods of teaching, the role of teachers and motivation possibilities of interdisciplinary approaches were emphasized by Yager, Hofstein, and Lunetta (1981); Hartzler (2000) and ASCD (2014). According to Yager et al. (1981), in integrated approaches, the pedagogy is issues-oriented and the teacher is someone who is aware "of the needs, problems, and interests of the community and the society where he or she lives and teaches". Hartzler (2000) has the same opinion through the affirmation that "the integrated curriculum provides the context for learning, however, instructional practices must make these connections explicit". The Association for Supervision and Curriculum Development (ASCD) also declares that integrated curriculum encompasses different approaches but remains "a way of teaching and learning that does not depend on division of knowledge into separate subjects. Topics are studied because they are interesting and valued by teachers and students concerned, not because they appear in a required course of study" (ASCD, 2014).

Despite a multiplicity of terms, most of the definitions of interdisciplinary teaching have the following common ideas:

- Content from more than one discipline is presented.
- Knowledge and skills of more than one subject areas are connected/synthesized.
- Applications and authentic learning are focused.
- Student – centered methods and problem – based methods are encouraged.
- Motivations of teachers and students are considered.

Through these definitions, the benefits of interdisciplinary teaching are explored. In interdisciplinary teaching, students have opportunities to solve problems in reality through *authentic activities*. Thus, integrated teaching can help to familiarize students with the idea of applying mathematics in context, encouraging them to develop the skills of selecting appropriate mathematics, applying it and critically evaluating its use against real concerns and limitations (Ward-Penny, 2011). Because an integrated study is a reflection of the real world, students become more *interested* and *motivated* in their learning (Fogarty, 1991). In integrated teaching, students often work in groups to solve problems. Therefore, they have opportunities to *develop integrated skills* such as collaborative skills, presentative skills, technology skills, reflective skills. (Ward-Penny, 2011). The definitions also support the view that integrated curriculum is an educational approach that meets the many demands of the 21st century, especially the demand to *develop problem solving competence for students* and *prepare them for lifelong learning*.

3.2. Integrated Models

In attempts to help teachers understand curriculum integration, various authors have presented their models of integrated curriculum (Drake & Burns, 2004; Fogarty, 1991; Gresnigt, Taconis, van Keulen, Gravemeijer, & Baartman, 2014; Jacobs, 1989; Vars, 1991). There are similarities and differences between authors' models and approaches of integration but in general, all of them try to describe different methods and degrees of integration as guidelines for educators and teachers to implement in the curriculum and apply in the teaching process.

Vars (1991) presented three options for curriculum integration. The simplest approach is *correlation* where teachers of different subjects' deal with aspects of one topic at the same time. *Fusion* takes integration a step further by combining the content of two or more subjects into a new course with a new name. The *core curriculum* is a full and important step beyond either correlation or fusion. In core, the curriculum design begins with the students and the society in which they live. Needs, problems, and concerns of a particular group of students are identified, and skills and subject matter from any pertinent subject are brought in to help students deal with those matters. Staff members may identify a cluster of student concerns or needs that are typical of the age group and design units of study that promise to be relevant to students.

Vars (1991) approaches differentiate clearly the degrees of integration, however, methods of integration are still not recognized. It seems that Vars' models are concerned with the position of the subjects: whether the subjects are still separated or they are combined into a new subject, whether the subject content is taught in regular order or in a new order for integration purpose. In other words, Vars' models concentrate on the organizational structure of the curriculum and are less focused on how the curriculum is taught.

To guide teachers more clearly about methods of integrating curriculum, Drake and Burns (2004) proposed three approaches of integration as follows:

- *Multidisciplinary integration:* Multidisciplinary approaches focus primarily on the disciplines. Teachers who use this approach organize standards from the disciplines around a theme. The disciplines are taught separately but they are connected through a common theme. In this approach, teachers do not need to change the content of the disciplines too much.
- *Interdisciplinary integration: In* this approach to integration, teachers organize the curriculum around common learnings across disciplines. They combine together the common learnings embedded in the disciplines to emphasize interdisciplinary skills and concepts. The disciplines are identifiable, but they assume less importance than in the multidisciplinary approach.
- *Transdisciplinary integration:* In the transdisciplinary approach to integration, teachers organize curriculum around student questions and concerns. Students develop life skills as they apply interdisciplinary and disciplinary skills in a real-life context (Drake & Burns, 2004).

The three approaches of Drake & Burns have some differences in the degree, method and intent of integration. The multidisciplinary approach uses a common theme to connect the disciplines, while the interdisciplinary approach is based on common interdisciplinary skills and concepts to connect the disciplines, and the transdisciplinary approach connects the disciplines through real life contexts. However, all the three approaches are standard–based approaches, which are very effective in designing the process of teaching.

Fogarty (1991) helps teachers to understand more about methods and degree of integration by proposing ten models for integration. These models are divided into three forms as presented in Table 1, Table 2, and Table 3.

Table-1. Form 1 Within a single discipline.

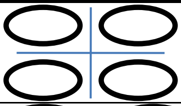
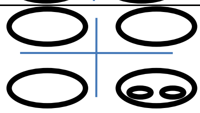
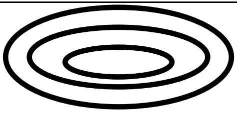
Name	Model	Description
Fragment		This is a traditional curriculum which separates topics and courses into distinct disciplines.
Connected		Two small circles are two areas inside a subject which are connected together to create a common theme (the outside circle). This is integration within an individual discipline.
Nested		Overlapped circles express that knowledge of subjects are nested in the teaching process. The purpose of this model is to develop specific skills such as social skills or thinking skills.

Table-2. Form 2 Across the disciplines.

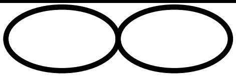
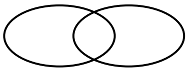
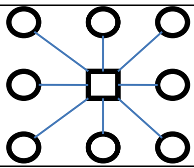
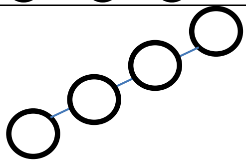
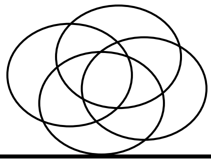
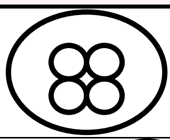
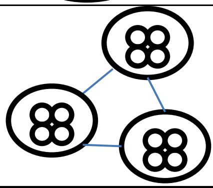
Name	Model	Description
Sequenced		Topics and units are taught independently, but they are arranged and sequenced to provide a framework for related concepts.
Shared		Two disciplines focus on shared concepts and skills. Knowledge of the two disciplines are connected through a common topic.
Webbed		The squared is a broad theme based on knowledge of many disciplines. The disciplines are taught separately but lean to the common theme.
Threaded		The line goes through the circles expresses a skill that needs to be developed through some disciplines. The content of the disciplines is only a tool to develop the skill (social skills, thinking skills, technology …)
Integrated		The intersection of all the circles expresses the most considered goals that all disciplines lean to (develop competencies, skills, attitude…). Teachers of all disciplines need to discuss and define this common goal or propose a common theme.

Table-3. Form 3 Within and across learners.

Name	Model	Description
Immersed		Learners integrate by viewing all learning through a perspective of one area of interest.
Networked		Learners direct the integration process through selections of a network of experts.

Some models of Fogarty are similar to models of Vars or models of Drake & Burns. For example, the *webbed* model of Fogarty is similar to the *multidisciplinary integration* approach of Drake & Burns and the *correlation* model of Vars; the *threaded* model of Fogarty is similar to the *interdisciplinary integration* approach of Drake & Burns. However, differing from Vars and Drake & Burns, Fogarty focused on not only the disciplines but also the learners in her models of integration. Fogarty's approaches show different levels of integration in each form and there are more choices of integration in the models of Fogarty than in the models of Vars or of Drake & Burns. Moreover, Fogarty' models guide clearly show how to connect the disciplines, either by topics, by skills, or by goals.

In addition to the integrated models of Vars, Fogarty and Drake & Burns, other methods and degrees of integration are also mentioned. Jacobs (1989), for instance, established 5 levels of integration, which are *parallel* *disciplines*, *multidisciplinary*, *interdisciplinary*, *integrated day*, and *complete integration*. Gresnigt et al. (2014) distinguished six approaches to integration with the increasing degree of integration, which are: *isolated*, *connected*, *nested*, *multidisciplinary*, *interdisciplinary*, and *transdisciplinary*.

The above-mentioned approaches and models of integration have some differences but all share the following:

- Emphasis on students' needs/interests.
- Connection between subjects.
- Use of authentic situations.
- Emphasis on long life learning.
- Focus on synthesizing knowledge and skills.
- Emphasis on projects.

The above properties are useful guidelines for teachers to integrate school subjects in the teaching process.

4. APPLICATION OF INTERDISCIPLINARY TEACHING IN VIETNAMESE MATHEMATICS EDUCATION

4.1. How to Integrate Mathematics with Other School Subjects in the Teaching Process?

The principle of integrating mathematics with other school subjects is that teachers need to:

- choose suitable methods and degrees of integration.
- choose suitable content in mathematics and other school subjects to integrate.
- choose a suitable process of organizing integrated teaching.

4.1.1. Methods and Degrees of Integration

Many studies have emphasized that projects should be used in interdisciplinary teaching (Banks & Barlex, 2014; Drake & Burns, 2004; Roth, 2014). The reason is that projects can help students to develop problem solving competence and develop integrated skills and knowledge from a variety of sources in the process of developing useful outcomes (Banks & Barlex, 2014). Project are also based on real world problems and engage students in authentic practices. All the above-mentioned benefits of projects namely "authenticity", "develop integrated skills and knowledge" and "develop problem solving competence" are also parts of the rationale of interdisciplinary teaching. Moreover, interdisciplinary projects tend to cross the traditional boundaries between academic disciplines (Roth, 2014). Therefore, using interdisciplinary projects is an effective choice for interdisciplinary teaching. Here it is understood that "interdisciplinary projects" are projects which require knowledge and skills of two or more school subjects in a problem-solving process.

Vietnam has a centralized curriculum, which means that there is a unique and obligated curriculum for students in the whole country. The Vietnamese mathematics curriculum is almost fixed. It is not flexible enough to use the transdisciplinary models of Drake & Burns or the integrated model of Fogarty. Based on this situation, this study explored the possibility to combine the multidisciplinary and interdisciplinary approaches of Drake and Burns (2004) and the shared or webbed models of Fogarty (1991). It means mathematics and other subjects can be taught separately but lean to a common theme/topic based on expected knowledge and skills of mathematics and other disciplines. Teachers can help students synthesize these knowledge and skills to solve problems arising from the common topic.

In summary, to apply the chosen models and the method of using interdisciplinary projects for the situation of Vietnam, there is a need for teachers to do the following:

- Organize integrated teaching process through an interdisciplinary project.
- Choose the project topic as a common topic based on theories of mathematics and other subjects.
- Try to construct a topic which starts from real life contexts.
- Organize and guide students to synthesize knowledge and skills of various areas to solve problems arising from the project topic.

To explain more clearly about the above-mentioned tasks of teachers, the author next presents how to design interdisciplinary projects for a mathematics classroom.

4.1.2. The Process of Designing Interdisciplinary Projects for Mathematics Classroom

Drake and Reid (2010) presented seven steps for designing an integrated curriculum:

1. *Scan and cluster*: Scan the subjects' curricula to find the similarities and important knowledge and skills. Cluster expectations into meaningful groups that describe the conceptual content (Know), skills (Do), and attitudes/belief (Be) or the KDB.
2. *Issue/theme:* Choose an appropriate issue or theme for study.
3. *Concept web*: Brainstorm possible activities based on expectations. Create a concept web as an organizing graphic.

4. *Know/do/be (KDB):* Finalize the KDB to act as an umbrella for the unit.
5. *Culminating activity:* Create a rich assessment task for a culminating activity. Align this task with the KDB and curriculum expectations.
6. *Big questions:* Create two or three big questions. Organize daily instruction around them.
7. *Daily instruction/assessment:* Create daily instructional activities that address the big questions to ensure that students acquire the knowledge, skills and attitudes they need in order to demonstrate the KDB.

Based on the above seven steps of Drake & Reid and considering the Vietnamese mathematics education scenario, following four steps are proposed to design interdisciplinary projects for mathematics classrooms:

Step 1: Choose a project topic:

To define a topic for the project, teachers need to have a look at the mathematics curriculum and other subjects, and identify such knowledge and skill standards that can integrate the teaching content. Subsequently, the teaching content can be connected to the problems of real life.

Teacher should also raise questions such as:

- Which content can be integrated? Why?
- Does the topic include a complex task?
- Does the topic involve a genuine transfer and integration of knowledge, skills and understanding of mathematics and other school subjects?
- Is it suitable to learners' interests?
- Does it have real meaning?
- Does it result in an enhanced experience for the learner?

Step 2: Identify necessary knowledge and skills

In this step, teachers need to:

- Check which knowledge needs to be achieved and which skills need to be consolidated in each subject.
- Identify which interdisciplinary skills can be trained through the projects.

Step 3: Prepare questions, tasks and learning activities

In this step, teachers need to do the following:

- Identify such orientation questions to help students in investigating problems and accumulating necessary interdisciplinary knowledge.
- Based on the orientation questions, design learning activities that students need to perform in the project. For each activity, teachers need to consider the aims of the activity, construct the content of the activity, prepare the tasks for students, and make a plan for organizing the activity.

Step 4: Define assessment tools

In this step, the following should be notified:

- Teacher should design assessment tools for each task so that teacher can adjust the result of the task.
- Teacher should encourage students to participate in the assessment and self-assessment process.

Some assessment tools can be:

- *Individual assessment sheets:* given to students at the beginning of the project and collected at the end of the project. These sheets will help students to assess their competencies themselves and know their changes before and after the project.
- *Cooperative assessment sheet:* given to all students in a group. Each student uses this sheet to assess the cooperative ability of other members in the group.
- *Project book*: given to students at the beginning of the project. This book helps the teacher to assess the performing process of students. The project book includes initial ideas, performance plan, work division sheets, information, pictures, group discussion sheets, and assessment tables.

4.2. Sampling of Interdisciplinary Projects

To illustrate the proposed four steps of the process of designing interdisciplinary projects for mathematics classroom, we chose to integrate mathematics and biology –STEM subjects- in the teaching process. The two interdisciplinary projects designed for integrating mathematics and biology at high school level are presented below:

a) Project 1: Genetic diseases in real life

Project Title: Genetic Diseases in Real Life

<u>Step 1:</u> Choose the project topic

- Probability is an important content in mathematics which has many applications in real life and in other disciplines.
- In genetics as a topic in Biology, students can apply probability to predict genetic diseases passed from parent to offspring. Therefore, they can find the way to avoid and overcome effects of these genetic diseases.
- Thus, the knowledge of probability in Mathematics and the knowledge of genetics in Biology are integrated through a common theme. Eventually, this project was constructed as Mathematics – Biology interdisciplinary project named *"Genetic diseases in real life"!*

<u>Step 2:</u> Identify necessary knowledge and skills

- The interdisciplinary knowledge needs to be consolidated:

- *In Biology:* Genetic research methods, the laws of Mendel, genetic diseases and ways to avoid or overcome effects of these genetic diseases (Grade 9).
- *In Mathematics:* Event, probability of an event, rules to calculate probabilities (Grade 11).

- The interdisciplinary skills need to be achieved:

- Students should know how to apply probability (mathematics) to solve genetic (biology) problems.

<u>Step 3:</u> Prepare questions, tasks and learning activities

To help students investigate problems and interdisciplinary knowledge, teachers can organize the following activities:

Activity 1: Teacher raises the following questions:

1. What is **albinism**?
2. Why is **albinism** dangerous?

To answer the above questions, students have to find the information about albinism on their own (through internet, newspapers, books…):

1.What is albinism?

Suggested answer:

- Albinism is a congenital disorder characterized by the complete or partial absence of pigment in the skin, hair and eyes
- Albinism results from inheritance of recessive gene alleles and is known to affect all vertebrates, including humans.

2.Why is albinism dangerous?

Suggested answer:

- Albinism is associated with a number of vision defects, such as photophobia, nystagmus, and amblyopia. Lack of skin pigmentation makes for more susceptibility to sunburn and skin cancers in humans. It is a congenital disorder characterized by the complete or partial absence of pigment in the skin, hair and eyes.

Activity 2: Teacher raises a question:

- If parents are not albinos, can we conclude that their children are not albinos?

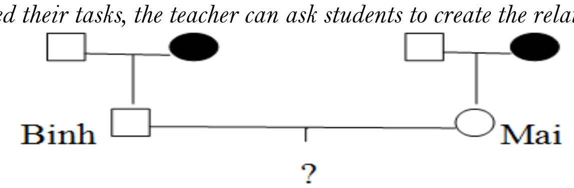
To answer the above question, we should consider the following problem:

Binh and Mai are not albinos but both of them have albinotic mothers. Both their parents have no albinotic gene. If Binh marries Mai, what is the probability that they have two children which are not albinos?

To solve the above problem, the teacher divides students into 4 groups and assigns them the following tasks:

- Group 1: Review the laws of Mendel (Biology 9);
- Group 2: Review how to create and explain a genetic diagram (Biology 9);
- Group 3: Review knowledge of event, probability of an event, independent events, rules to calculate probabilities (Algebra & Analysis 11)
- Group 4: Search information and study about some specific genetic diseases.

After group 1 and 2 have presented their tasks, the teacher can ask students to create the relation diagram of the family:



albinotic male   albinotic female   non-albinotic male   non-albinotic female

Activity 3: Create the genetic diagram of the family in the problem and identify gene types

Suppose A: normal gene

a: albinotic gene

aa: albino
AA, Aa: not albino

Where, gene types of Binh's mother, Mai's mother: aa
Gene types of Binh's father, Mai's father: AA
Gene types of Binh, Mai: Aa
If Binh marries Mai, the genetic diagram of this family is:

P:	Aa	x	Aa
G:	½ A: ½ a		½ A: ½ a
F:	¼ AA: ½ Aa: ¼ aa		
Ratio	¾ normal: ¼ albino		

Thus, gene types ratio of the children of Binh and Mai is ¾ normal: ¼ albino.

Activity 4: Apply probability.
After the group 3 had summarized knowledge of event, probability of an event, independent events rules to calculate probabilities (the additional rule and the multiple rule), the teacher asks students to apply this knowledge to find the probability that Binh and Mai have two normal children and explain the results. Students have to show the following answer:

- Since the gene types ratio of the children of Binh and Mai is ¾ normal: ¼ albino, the probability between each albino child of Binh and Mai to not albino is ¾.
- Suppose that A is an event that the first child of Binh and Mai is not albino and B is the event that the second child of Binh and Mai is not albino. Then AB is the event that the two children of Binh and Mai are not albino.

Where P(A) = P(B) = ¾ and A and B are two independent events.
Thus, by applying the multiple rule we have:
P (AB) = P(A)×P(B) = ¾×¾ = 9/16. It means that the probability between the two children of Binh and Mai of being not albino is 9/16.

After solving this problem, the students can recognize that normal parents still can have genetic diseased children. Then they can raise a question such as: "How people can avoid and overcome effects of genetic diseases?"

Activity 5: Some specific genetic diseases and ways to avoid or overcome effects of these diseases (Group 4 presents its task and then all students discuss) Some genetic diseases are: down syndrome, turner syndrome, albinism, deaf and dumb (caused by radioactivity or noxious chemicals), born with a cleft palate, hands without fingers, and so on
Ways to avoid:

- Fight against manufacturing and the use of nuclear and chemical weapons
- Do not destroy the environment.
- Avoid marriages between people with diseased gene types or restrict them from having babies.

Step 4: Define assessment tools

The assessment tools can be *individual assessment sheets*, *cooperative assessment sheets* and *project books*. Based on the project topic, orientation questions and tasks, a few questions and criteria were proposed like the *individual assessment sheets* (Table 4), *cooperative assessment sheets* (Table 5), and *project books* (Table 6):

Table-4. Questions for the *individual assessment sheets.*

No	Questions
1	Have you learnt the topic "probability" in mathematics?
2	Do you know any application of probability in real life? If yes, please present it.
3	Do you know any application of probability in Biology? If yes, please present it.
4	Can you list some genetic diseases in real life?
5	Do you think that normal parents still can have genetic diseased children? Why?
6	Can you give an example to illustrate your answer in the question 5?
7	Do you know how to avoid genetic diseases?

Table-5. Criteria table for the *cooperative assessment sheets.*

Criteria	Point (100)
1. Actively collect information related to the group task	20
2. Complete individual work, do not affect the progress of the project	20
3. Assist other members in the group to complete their work	20
4. Actively discuss and give valuable ideas	20
5. Actively assess individual work and task solutions	20

Table-6. Criteria table for assessing the *project books.*

Criteria	Point (100)
1. Identify clearly the task of the group	10
2. The plan to perform the task is clear, logical and scientific.	10
3. Divide reasonable work for each member of the group	10
4. All member actively participate in the group discussion	10
5. Find related information which is exact and useful	10
6. The solution of the task is correct and clear	20
7. The way to present the solution is attractive and reasonable	10
8. Answer correctly questions of other groups	20

b) Project 2: Mitosis – fundamental base for reproduction:
Project Title: Mitosis – Fundamental Base for Reproduction
Step 1: Choose a project topic

Looking at the mathematics and biology curricula at high school level, it is revealed that:

- In Mathematics, "geometric progression" is an important topic in upper-secondary level because it has many applications in real life and in other disciplines.
- In Biology, "geometric progression" can be applied to find the number of cells reproduced in mitosis processes.

Thus, we can integrate the knowledge of "geometric progression" in Mathematics and the knowledge of "mitosis" in Biology through a common theme. Therefore, a Mathematics – Biology interdisciplinary project named "Mitosis – fundamental base for reproduction" was constructed.

Step 2: Identify necessary knowledge and skills

- The knowledge needs to be consolidated:

In Biology: Mitosis or *E-coli* (Grade 10).
In Mathematics: Geometric progression and its properties (Grade 11).

The interdisciplinary skill needs to be achieved:

- Students should know how to apply the general term formula of a geometric progression to find the number of cells reproduced in mitosis processes.

Step 3: Prepare questions, tasks and learning activities

Introduce the topic:

Suggested answer:

E. coli is a type of bacteria that normally lives in the intestines of people and animals. *E. coli* can also appear in food products and water resources. The appearance of *E. coli* in water resources is also a criterion to measure how clean the water source is. Most varieties of *E. coli* are harmless or cause relatively brief diarrhea but a few particularly nasty strains can cause severe abdominal cramps, bloody diarrhea and vomiting. Can you imagine how fast *E. coli* reproduce? What people should do to avoid diseases caused by *E. coli*?

To help students investigate problems and interdisciplinary knowledge, teachers can give them the following oriented questions:

Question 1: The reproduction of *E. coli* is called "mitosis". Thus, what is mitosis?

Question 2: Can you search information of the time that an *E. coli* cell needs for one cycle of mitosis?

Question 3: To know how fast *E. coli* reproduces, please investigate that after one day, how many *E. coli* cells are reproduced from one *E. coli* cell? Find out which mathematics principle should be used to answer this question?

Question 4: What should people do to avoid diseases caused by *E. coli*?

Based on the above orientation questions, teachers can plan to divide students in 3 groups and give these groups the following tasks:

Task 1 (for Group 1): Read the Biology textbook of grade 10 to review the concept of "Mitosis".

Task 2 (for Group 2): Search information of the duration that an E. coli cell needs for one cycle of mitosis.

Task 3 (for Group 3): Read the Algebra and Analysis Textbook of grade 11 to review the concept of "geometric progression" and its properties.

To help students investigate problems and interdisciplinary knowledge, teachers can organize the following activities:

Activity 1: *Teacher raises question 1:*

The reproduction of *E. coli* is called "mitosis". Thus, what is mitosis?

Group 1 presents their answer that they have summarized in the Biology textbook, grade 10. The expected answer is:

Mitosis is the usual method of cell division, characterized typically by resolving of the chromatin of the nucleus into a threadlike form, which condenses into chromosomes, each of which separates longitudinally into two parts, one part of each chromosome being retained in each of two new cells resulting from the original cell.

Activity 2: *Teacher raises question 2:*

Can you search information of the duration that an *E. coli* cell needs for one cycle of mitosis?

Group 2 presents the information that they have prepared. The suggested answer is:

If *E. coli* is appropriately grown, after each 20 minutes, one *E. coli* cell divides into two new E. coli cells. This information can be found in the Vietnamese mathematics textbook: Algebra and Analysis, grade 11 (p.100).

Activity 3: *Teacher raises question 3:*

To know how fast *E. coli* reproduces, please investigate that after one day, how many *E. coli* cells are reproduced from one *E. coli* cell? Find out which mathematics principle should be used to answer this question?

After the group 3 had reviewed the concept of a "geometric progression" and its properties, the teacher asked all the three groups to find out the number of E. coli cells reproduced after one day. The expected answer wass:

From the result of task 2, we know that:

After 20 minutes, the number of E. coli cells is 2.

After the next 20 minutes, the number of *E. coli* cells is $2.2 = 2^2 = 4$.

After the next 20 minutes, the number of *E. coli* cells is $4.2 = 2^2.2 = 2^3 = 8$.

After the next 20 minutes, the number of *E. coli* cells is $8.2 = 2^3.2 = 2^4 = 16$.

…

It was realized that the above numbers of *E. coli* cells formed a geometric progression 1, 2, 4, 8, 16… with the common ratio 2. Thus, the formula of the general term of a geometric progression was applied to find the number of E. coli cells after 1 day:

1 day = 24 hours = 72 cells. (@20 minutes each cell).

Then the number of *E. coli* cells after 1 day is the 73^{th} term of the geometric progression, it is equal to 2^{72} cells.

Hence, after 1 day, the number of *E. coli* cells become a very large number.

Activity 4: *Teacher raises the question 4:*

What people should do to avoid diseases caused by *E. coli*? All the three groups discussed the above question. Students were required to find the information themselves through internet, newspapers, and books. The expected answer was: Most strains of *E. coli* are harmless. Some strains however, such as Shiga toxin-producing *E. coli* (STEC), can cause severe foodborne diseases. It is transmitted to humans primarily through consumption of contaminated foods, such as raw or undercooked ground meat products, raw milk, and contaminated raw vegetables and sprouts. To avoid diseases caused by *E. coli*, people should control measures at all stages of the food chain, from agricultural production on the farm to processing, manufacturing and preparation of foods in both commercial establishments and household kitchens. In addition, people should not eat raw food, nor drink raw milk and check carefully the water resource before moving to live in a new area. (source: https://www.who.int/news-room/fact-sheets/detail/e-coli)

Step 4: Define assessment tools

The assessment tools can be *individual assessment sheets*, *cooperative assessment sheets* and *project books*. Based on the project topic, oriented questioned and tasks, we propose the questions and criteria for the *individual assessment sheets*, (Table 7), *cooperative assessment sheets* (Table 8), and *project books* (Table 9), *as* follows:

Table-7. Questions for the *individual assessment sheets*.

No	Questions
1	Have you learnt the topic "geometric progression" in mathematics?
2	Do you know any application of geometric progression in real life? If yes, please present it.
3	Do you know any application of geometric progression in Biology? If yes, please present it.
4	Do you know about the mitosis in Biology?
5	Do you know about the *E. coli* bacteria? Is it harmful or meaningful to human living?
6	Do you know how fast an *E.coli* cell reproduce?
7	Do you know how to avoid diseases caused by *E.coli*?

Table-8. Criteria table for the *cooperative assessment sheets*.

Criteria	Point (100)
1. Actively collect information related to the group task	20
2. Complete individual work, do not affect the progress of the project	20
3. Assist other members in the group to complete their work	20
4. Actively discuss and give valuable ideas	20
5. Actively assess individual work and task solutions	20

Table-9. Criteria table for assessing the *project books*.

Criteria	Point (100)
1. Identify clearly the task of the group	10
2. The plan to perform the task is clear, logical and scientific.	10
3. Divide reasonable work for each member of the group	10
4. All member actively participate in the group discussion	10
5. Find related information which is exact and useful	10
6. The solution of the task is correct and clear	20
7. The way to present the solution is attractive and reasonable	10
8. Answer correctly questions of other groups	20

5. CONCLUSION

Interdisciplinary teaching should be applied in mathematics education because it helps students to integrate skills and knowledge of mathematics and other school subjects to solve problems. Furthermore, it helps students to understand how mathematics inter-relates with other school subjects and with the real life. In this paper, the author explained ideas, concepts and models in interdisciplinary teaching. The author discussed how to apply the theory of interdisciplinary teaching in the Vietnam mathematics education. More specifically, a four-step process to construct an interdisciplinary project for mathematics classrooms was proposed. This four-step process proved to be a useful guideline for mathematics teachers to design interdisciplinary projects. Two projects "Genetic diseases in real life" and the "Mitosis– fundamental base for reproduction" were introduced in this study. These are examples of how to construct an interdisciplinary project based on the four-step process. Through these projects, students could know how to synthesize skills and knowledge of the two subjects Mathematics and Biology to solve a real life problem.

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

REFERENCES

ASCD. (2014). A lexicon of learning: What educators mean when they say. Retrieved from http://www.ascd.org/Publications/Lexicon-of-Learning/S.aspx. [Accessed 2.14.2014].

Banks, F., & Barlex, D. (2014). *Teaching STEM in the secondary school: Helping teachers meetthe challenge*. Abingdon: Routledge.

Clair, B. S., & Hough, D. L. (1992). Interdisciplinary teaching: A review of the literature. Springfield, MO: Southwest Missouri State University. ERIC Document Reproduction Service No.ED 373 056.

Connolly, P., & Vilardi, T. (1989). *Integrating curriculum: Writing to learn Mathematics and science*. USA: Teachers College Press.

Drake, S. M. (1998). *Creating integrated curriculum: Proven ways to increase student learning*. Thousand Oaks, CA: Corwin Press.

Drake, S. M., & Burns, R. C. (2004). *Meeting standards through integrated curriculum*. USA: The Association for Supervision and Curriculum Development (ASCD).

Drake, S., & Reid, J. (2010). Integrated curriculum: Increasing relevance while maintaining accountability. What Works? Research into practice (A research-into-practice series produced by a partnership between the Literacy and Numeracy Secretariat and the Ontario Association of Deans of Education. *Research Monograph*, *28*, 1-4.

Fogarty, R. (1991). *The mindful school: How to integrate the curriculum*. Pallantine: Skyline Publishing.

Gresnigt, R., Taconis, R., van Keulen, H., Gravemeijer, K., & Baartman, L. (2014). Promoting science and technology in primary education: A review of integrated curricula. *Studies in Science Education*, *50*(1), 47-84.Available at: https://doi.org/10.1080/03057267.2013.877694.

Hartzler, D. S. (2000). *A meta-analysis of studies conducted on integrated curriculum programs and their effects on student achievement*. Dissertation, in Partial Fulfillment of the Requirements for Doctor of Education, School of Education, Indiana University.

Humphreys, A., Post, T., & Ellis, A. (1981). *Interdisciplinary methods: A thematic approach*. Santa Monica, CA: Goodyear Publishing Company.

Jacobs, H. H. (1989). *Interdisciplinary curriculum: Design and implementation*. Alexandria, VA: Association for Supervision and Curriculum Development.

Krause, E., Dilling, F., Kraus, S. F., Chi, N. P., Chat, T. N., & Van Bien, N. (2020). elevant content for a scientific collaboration in mathematics and physics education research – a comparative content analysis of handbooks and Conference Proceedings in Germany and Vietnam. . *REURASIA Journal of Mathematics, Science and Technology Education*, *16*(4), em1836.Available at: https://doi.org/10.29333/ejmste/114097.

Labudde, P. (2014). Interdisciplinary science lessons - myths, definitions, facts. *Journal for Didactics of Natural Sciences*, *20*(1), 11-19.

Mathison, S., & Freeman, M. (1997). *The logic of interdisciplinary studies*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago ERIC Document Reproduction Service No.ED 418 434.

Moegling, K. (2010). *Competency development in interdisciplinary teaching: promoting networked thinking and complex action; Didactic fundamentals, models and teaching examples for the secondary levels I and II. Series* (Vol. 2). Immenhausen Bei Kassel: Prolog-Verl.

MOET (Vietnam Ministry of Education and Training). (2018). School educational curriculum: The general curriculum. Retrieved from https://data.moet.gov.vn/index.php/s/LETzPhj5sGGnDii#pdfviewer. [Accessed 13 May 2019].

Nguyen, P. C., & Nguyen, T. H. P. (2019). *Teaching mathematics at the high school level in an integrated way through interdisciplinary projects (Project report)*. Vietnam: Hanoi National University of Education.

Oberholzer, E. E. (1937). *An integrated curriculum in practice*. New York: AMS Press.

QCA. (2007). *The national curiculum 2007: Statustory requirements for key stage 3 and 4*. London: QCA.

Roth, W. M. (2014). Interdisciplinary approaches in mathematics education. In S. Lerman (Ed.), Encyclopedia of mathematics education (pp. 647-650). Berlin, Heidelberg: Springer.

Savage, J. (2011). *Cross-curricular teaching and learning in the secondary school*. Abingdon: Routledge.

Shoemaker, B. J. E. (1989). Integrative education: A curriculum for the twenty-first century. *OSSC Bulletin, 33*(2), 1-46.

Vars, G. F. (1991). Integrated curriculum in historical perspective. *Educational Leadership, 49*(2), 14-15.

Ward-Penny, R. (2011). *Cross-curricular teaching and learning in the secondary school: Mathematics*. Abingdon: Routledge.

Williams, J., Roth, W. M., Swanson, D., Doig, B., Groves, S., Omuvwie, M., & Mousoulides, N. (2016). *Interdisciplinary mathematics education, ICME–13 topical surveys*. Switzerland: Springer.

Yager, R. E., Hofstein, A., & Lunetta, V. N. (1981). Science education attuned to social issues: Challenge for the'80s. *The Science Teacher, 48*(9), 12-14.