THE DEVELOPMENT OF PRINCIPLE-BASED LEARNING ON ETHICS IN A SCIENCE CLASSROOM

A DISSERTATION

BY

WASHIRASORN SAENGSUWAN

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DOCTOR OF EDUCATION DEGREE IN SCIENCE EDUCATION

AT SRINAKHARINWIROT UNIVERSITY

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AN ABSTRACT

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Washirasorn Saengsuwan. (2011). *The Development of Principle-Based Learning on Ethics in a Science Classroom.* Dissertation, Ed.D. (Science Education). Bangkok: Graduate School, Srinakharinwirot University. Advisor Committee: Acting Sub Lt. Dr. Manat Boonprakob, Assoc. Prof. Dr. Somson Wongyounoi, Asst. Prof. Dr.Sirinoot Teanrungroj.

The main purpose of this study was to develop a principle-based learning course on ethics in a science classroom in Thailand. This was a mixed-method research design with two phases of study. The first phase was a survey study and the second one was an experiment that implemented the results from the survey to an actual classroom. The objectives of this study were as follows: 1) To promote, develop and assess students' understanding of key ethical, concepts and principles in science. 2) To promote, develop and assess students' analytical, creative, practical and ethical thinking skills along with communicative skills in learning ethics in science. 3) To determine students' opinions on learning ethics in science. 4) To evaluate the effectiveness of a hybrid learning approach of ethics in science.

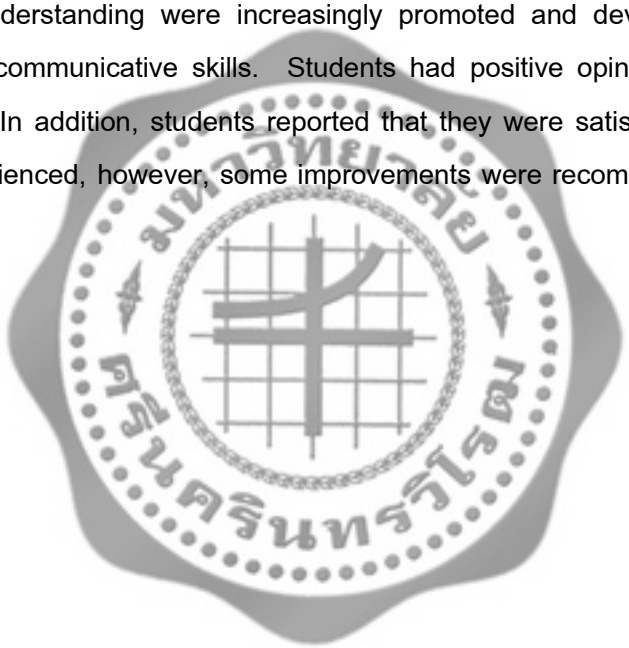
A researcher-designed survey was developed and used to collect quantitative and qualitative data from 288 science students and 107 science teachers of Mahidol Wittayanusorn School and 12 Princess Chulabhorn's Colleges during the second semester of the 2007 academic year. In the second phase, the researcher developed principle-based learning course on ethics in science based on the preliminary results by using hybrid learning (the combination of face-to-face and web-based learning). The developed hybrid learning was implemented in a chemistry class of 24 grade 10 students at Mahidol Wittayanusorn School during May – September, the first semester of 2009 academic year. The research instruments were 1) Questionnaires on science teachers' and students' opinions on ethics in a science classroom 2) A questionnaire on the students' opinions on learning ethics in science, 3) The test on understanding of ethics in science, 4) Evaluation form of thinking skills and 5) Interviews questions for students. The employed statistics for quantitative data of this study were the 1) mean and 2) standard deviations. A content analysis was used for the qualitative data.

The findings of this study are as follows:

1. In the survey study, it was found that 37.9 percent of students rated their level of understanding of ethics in science as high or very high. In addition, 66.3 percent

of them thought that they were interested in studying ethics in science. More importantly, the study of ethics in science was essential for science students was rated high or very high by 92.7 percent. A total of 61.2 percent of the teachers and 55.1 percent of the students indicated that scientific ethics should be taught to science students by incorporating its' principles into a regular science class, rather than as an elective class. Students' thinking skills and communicative skills should also be promoted. Additionally, 62.6 percent of the teachers and 64.6 percent of the students thought that hybrid learning is an appropriate pedagogical method of learning ethics in science.

2. In the second phase of the study, it was found that the students' awareness and understanding were increasingly promoted and developed as well as their thinking and communicative skills. Students had positive opinions about learning ethics in science. In addition, students reported that they were satisfied with the hybrid learning they experienced, however, some improvements were recommended.



การพัฒนาการเรียนรู้ที่ใช้หลักการเป็นฐาน เรื่องจริยธรรมในชั้นเรียนวิทยาศาสตร์

บทคัดย่อ

ของ

วชิรศรณ์ แสงสุวรรณ

เสนอต่อบัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ เพื่อเป็นส่วนหนึ่งของการศึกษา

ตามหลักสูตรปริญญาการศึกษาดุษฎีบัณฑิต สาขาวิทยาศาสตรศึกษา

สิงหาคม 2554

วชิรศรณ์ แสงสุวรรณ. (2554). *การพัฒนาการเรียนรู้ที่ใช้หลักการเป็นฐาน เรื่องจริยธรรมในชั้นเรียนวิทยาศาสตร์*. ปริญญานิพนธ์ กศ.ด. (วิทยาศาสตรศึกษา). กรุงเทพฯ: บัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ. คณะกรรมการควบคุม: ว่าที่ร้อยตรี ดร.มนัส บุญประกอบ, รองศาสตราจารย์ ดร. สมสรร วงษ์อยู่น้อย, ผู้ช่วยศาสตราจารย์ ดร. ศิรินุช เทียนรุ่งโรจน์

การวิจัยครั้งนี้มีจุดมุ่งหมายเพื่อพัฒนาการเรียนรู้ที่ใช้หลักการเป็นฐาน เรื่องจริยธรรมในชั้นเรียนวิทยาศาสตร์สำหรับนักเรียนชั้นมัธยมศึกษาตอนปลายในประเทศไทย ซึ่งเป็นการวิจัยแบบผสมที่ประกอบด้วยการวิจัย 2 ระยะ กล่าวคือ ระยะที่ 1 เป็นการศึกษาเชิงสำรวจ และระยะที่ 2 เป็นการนำผลการวิจัยที่ได้จากระยะที่ 1 มาวิเคราะห์ พัฒนาและนำไปใช้ในภาคสนามกับห้องเรียนวิทยาศาสตร์ วัตถุประสงค์ของการวิจัยนี้ มีดังนี้ 1) เพื่อส่งเสริม พัฒนา และประเมินความเข้าใจของนักเรียนเกี่ยวกับจริยธรรมทางวิทยาศาสตร์ 2) เพื่อส่งเสริม พัฒนา และประเมินทักษะความคิดและทักษะการสื่อสารของนักเรียน 3) เพื่อศึกษาความคิดเห็นของนักเรียนที่มีต่อการเรียนรู้จริยธรรมในชั้นเรียนวิทยาศาสตร์ 4) เพื่อประเมินความเหมาะสมของวิธีการเรียนรู้จริยธรรมทางวิทยาศาสตร์แบบผสม

ผู้วิจัยได้ออกแบบและพัฒนาแบบสำรวจ เพื่อใช้เก็บข้อมูลทั้งเชิงปริมาณและคุณภาพกับนักเรียนวิทยาศาสตร์ในระดับชั้นมัธยมศึกษาตอนปลาย จำนวน 288 คน และครูวิทยาศาสตร์ที่สอนในระดับชั้นมัธยมศึกษาตอนปลาย จำนวน 107 คน ของโรงเรียนมหิดลวิทยานุสรณ์ (องค์การมหาชน) และโรงเรียนในกลุ่มจุฬาภรณราชวิทยาลัยทั้ง 12 แห่ง ในภาคเรียนที่ 2 ปีการศึกษา 2550 สำหรับการวิจัยในระยะที่ 2 ผู้วิจัยได้พัฒนาการเรียนรู้ที่ใช้หลักการเป็นฐาน เรื่องจริยธรรมทางวิทยาศาสตร์ โดยใช้ข้อมูลจากผลการวิจัยในระยะที่ 1 ด้วยวิธีการเรียนรู้แบบผสม (Hybrid learning) ซึ่งเป็นการผสมผสานระหว่างการเรียนรู้ในชั้นเรียนปกติกับการใช้เว็บไซต์ประกอบการเรียนรู้ งานวิจัยนี้ได้ทดลองภาคสนามกับนักเรียนชั้นมัธยมศึกษาปีที่ 4 ของโรงเรียนมหิดลวิทยานุสรณ์ (องค์การมหาชน) ที่เรียนรายวิชา เคมีพื้นฐาน 1 ห้องเรียน จำนวน 24 คน ในช่วงเดือนพฤษภาคมถึงเดือนกันยายน ของภาคเรียนที่ 1 ปีการศึกษา 2552 เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูลได้แก่ 1) แบบสอบถามความคิดเห็นครูและนักเรียนวิทยาศาสตร์ที่มีต่อจริยธรรมในชั้นเรียนวิทยาศาสตร์ 2) แบบสอบถามวัดความคิดเห็นนักเรียนต่อการเรียนรู้จริยธรรมทางวิทยาศาสตร์ 3) แบบทดสอบวัดความรู้ ความเข้าใจเกี่ยวกับจริยธรรมทางวิทยาศาสตร์ 4) แบบประเมินทักษะการคิด และ 5) แบบสัมภาษณ์ สถิติพื้นฐานที่ใช้ในการวิเคราะห์ข้อมูลเชิงปริมาณ คือ 1) ค่าเฉลี่ย และ 2) ค่าเบี่ยงเบนมาตรฐาน ส่วนข้อมูลเชิงคุณภาพ ใช้การวิเคราะห์เนื้อหา

ผลการวิจัยพบว่า

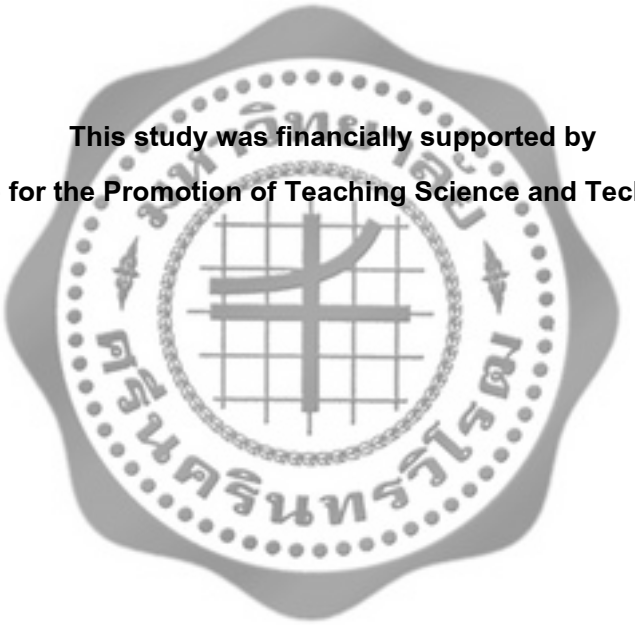
1. ในการวิจัยเชิงสำรวจ นักเรียนที่คิดว่าตนเองเข้าใจจริยธรรมทางวิทยาศาสตร์อยู่ในระดับสูงถึงสูงมาก คิดเป็นร้อยละ 37.9 และนักเรียนร้อยละ 66.3 มีความสนใจที่จะเรียนรู้จริยธรรมทางวิทยาศาสตร์ ที่สำคัญคือ นักเรียนร้อยละ 92.7 มีความเห็นว่าจริยธรรมทางวิทยาศาสตร์มี

ความสำคัญต่อนักเรียนวิทยาศาสตร์ในระดับสูงถึงสูงมาก นอกจากนี้ ครูร้อยละ 61.2 และนักเรียนร้อยละ 55.1 คิดว่าจริยธรรมทางวิทยาศาสตร์ควรจะนำมาสอนโดยการสอดแทรกหลักการจริยธรรมทางวิทยาศาสตร์เข้าไปในรายวิชาวิทยาศาสตร์ปกติมากกว่ารายวิชาเพิ่มเติม ครูและนักเรียนส่วนใหญ่มีความเห็นว่าทักษะการคิดและทักษะการสื่อสารควรได้รับการส่งเสริมและพัฒนาในการเรียนจริยธรรมทางวิทยาศาสตร์ อีกทั้ง ครูร้อยละ 62.6 และนักเรียนร้อยละ 64.6 มีความเห็นว่าการเรียนรู้แบบผสมสามารถนำมาใช้เป็นวิธีการจัดการเรียนรู้จริยธรรมทางวิทยาศาสตร์ได้อย่างเหมาะสม

2. สำหรับระยะที่ 2 ของการวิจัย พบว่านักเรียนมีความรู้ ความเข้าใจเรื่องจริยธรรมทางวิทยาศาสตร์ในระดับที่สูงขึ้นกว่าก่อนเรียน เช่นเดียวกับทักษะการคิดและทักษะการสื่อสารที่ได้รับการส่งเสริมและพัฒนาให้ดีขึ้น นอกจากนี้ นักเรียนยังมีความคิดเห็นที่ดีต่อการเรียนรู้จริยธรรมทางวิทยาศาสตร์และมีความพึงพอใจกับรูปแบบการเรียนรู้แบบผสม โดยจำเป็นต้องมีการปรับปรุงในส่วนของเว็บไซต์อยู่บ้าง

This study was financially supported by

The Institute for the Promotion of Teaching Science and Technology (IPST)



The dissertation titled

"The Development of Principle-Based Learning on Ethics in a Science Classroom"

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Washirasorn Saengsuwan

has been approved by the Graduate School as partial fulfillment of the requirements for the Doctor of Education degree in Science Education of Srinakharinwirot University.

…….. Dean of the Graduate School

(Assoc. Prof. Dr. Somchai Santiwatanakul)

August ……., 2011

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(Asst. Prof. Dr. Sirinoot Teanrungroj)

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Special thanks to Dr. Orvil L. White, who has assisted me with proofreading and revisions on my research proposal since I was at the School of Education, Indiana University of Bloomington (IUB) in Bloomington, Indiana, USA. He is currently an Assistant Professor in the Childhood / Early Childhood Education Department at The State University of New York at Cortland (SUNY Cortland). He has also completed the English language revisions on my dissertation. I also have to thank Dr. Thomas Licona, a SUNY professor who has been kindly shared ethical knowledge with me.

I also wish to thank IUB professors; Robert D Sherwood, Associate Dean for Research and Professor of Science Education, as my advisor, Peter Kloosterman, Professor of Mathematics Education and Mary B McMullen, Associate Dean for Graduate Studies and Professor of Curriculum Studies in Early Childhood Education for giving me guidance and permission to participate in their classes. Special thanks also to all of my IUB classmates, especially Alena R. Treat who helped me brainstormed some ideas on ethics education. She is currently Dr. Treat. I am very grateful to Jeff Graf & Craig Eich, librarians at Herman B Wells Library, Indiana University of Bloomington for their kind assistance on the bibliography. Also, thanks to all Thai students at IUB, especially Dr. Wanphen Pratoomtong for her encouragement and assistance, Dr. Suphawat Pookcharoen, Department of English, Faculty of Liberal Arts, Thammasat University, Dr. Khemmawadee Pongsanon, an academic officer at the Institute for the Promotion of Teaching Science and Technology (IPST). Also, Miss Pornsuree Jamsri, Master of Science in Human Computer Interaction Design, School of Informatics, Indiana University Bloomington, Indiana, USA. She is currently a Ph.D and Teaching/Graduate Assistant, School of Information Science & Learning Technologies, University of Missouri, Columbia, MO, USA for their kind support. I

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Many thanks go to Dr. Thongchai Chewpreecha, a former principal of Mahidol Wittayanusorn School (MWITS) for his kind permission and guidance to give me a great opportunity to study for my doctoral degree. I also would like to express my sincere thank to Assistant Professor Dr. Yuvadee Nakapadungrat, the current principal of Mahidol Wittayanusorn School for her kind encouragement and also her permission to allow me attend the 16th International Conference on Learning at University of Barcelona, Spain, under the financial support of IPST and to eventually get my research paper published in the International Journal of Learning for attending and presenting a part of my research study at the conference.

My great appreciation also goes to Dr. Sakchai Panha, the principle of Princess Chulabhorn's College (PCC), Pathumthani for his assistance as a coordinator to the other 11 Princess Chulabhorn's Colleges (PCCs) for the data collection of the first phase of the study. Also, thank all PCCs' teachers and students for their cooperation in this research.

I am also very grateful to the MWITS teachers and students for their invaluable time and contributions on taking a survey in the first phase of the study. Special thanks also go to my beloved students, MWITS19 room 7, who actively participated in the second phase of the study. I also would like to thank all of my colleagues at Mahidol Wittayanusorn School for their kind encouragements. In particular, Ms. Jane Kanjanaphoomin, an International student counselor & English teacher, and Mr.Niall

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I also would like to express my gratitude to the Institute for the Promotion of Teaching Science and Technology (IPST) for their financial support since I finished my undergraduate degree.

Most importantly, I wish to acknowledge my wonderful family, my beloved mother and father who always have great inspiration for me to be a great and successful person and also my two brothers and four sisters for their valuable encouragement. A special note of appreciate goes to my younger sister, Miss Natpatsorn Saengsuwan, for her magnificent caring, support and encouragement.

I especially thank all of my teachers, friends and staffs at Science Education Center for their breathtaking encouragement and motivation. Finally, thanks my old and new friends, relatives and everyone who comes to my life. I truly believe that all of them have inspired me to be a successful and ethical person.

Washirasorn Saengsuwan

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CHAPTER 1

INTRODUCTION

BACKGROUND

My interest in ethics being taught as part of high school science curriculum came about through my own experience as a science teacher at the Mahidol Wittayanusorn School (MWITS), a science school in central Thailand that was designed for students demonstrating exceptional aptitude in mathematics and sciences. This chapter is divided into three parts; the first two parts give a general overview of Mahidol Wittayanusorn School's mission, objectives and goals, and curriculum; and of the Princess Chulabhorn's Colleges (PCCs), regional science schools, in order to provide the study's context. Then, the third part of chapter explains the motivation for the study and the overall need to incorporate ethics into the science classroom, beginning with high school level science.

1. Mahidol Wittayanusorn School

At present Thailand lacks the process of the development of researchers and science and technology inventors, therefore the teaching and learning of science and mathematics in schools is being promoted together with the establishment of Mahidol Wittayanusorn School and the Princess Chulabhorn's Colleges; these are schools that put a heavy emphasis on the teaching of science subjects. There are thirteen (13) such schools set up to provide educational services to students while the curriculum and management of teaching and learning are conducted as in other schools. At present the government has a policy to encourage children and juveniles who display special talents in science and mathematics to pursue their talents in fullest. This requires special procedures and curricula that are different from the teaching and learning in other schools. Therefore it is appropriate to establish special science schools to only provide the concentrated teaching and learning of science to students who have these special talents in science and mathematics. This will serve as a basic preparation for persons who demonstrate high potential in the study of science at the university level in order to produce excellent scientists and technical experts for the country. For the school to have their teaching and learning management independently, expediently and effectively, it was appropriate that the school become a public organization under the law, therefore Mahidol Wittayanusorn School was established as such in order to be a model school for the others of the same type (The

Royal Decree for the establishment of Mahidol Wittayanusorn School. B.E.2543 [2000]: Online).

According to its mission, Mahidol Wittayanusorn School has the esteemed goal of providing a world class education at upper secondary level (Grade 10 – 12) for exceptionally gifted and talented students in science, mathematics and technology so that they will have all the prerequisites necessary to become avid lifelong learners, researchers and innovators. The curriculum also strives to be well balanced and therefore promotes physical fitness as well as humanistic moral and ethical values. Being proud of their Thai identity, the students will be dedicated to national development and environmental protection while at the same time having a congenial attitude towards others both in Thailand and the world at large (Mahidol Wittayanusorn School. 2006: Online).

As for the school's objectives and goals, in anticipation that not less than 70 percent of Mahidol Wittayanusorn School's graduates will be potential candidates for post-doctoral education and become the world class researchers in science, mathematics and technology, the school is committed to inculcating into its students the following requisites:

1. Self-esteem; self-discipline; observance of Buddhist principles or those of their religions; and moral, ethical and other desirable values;
2. Mastering of basic mathematical and scientific concepts and principles comparable to world standards;
3. Creativity and the inquisitive mind of researchers, innovators and inventors in the fields of science, mathematics and technology comparable to world standards;
4. Avidity for learning, reading, writing, and systematic inquiry;
5. Knowledge and skills in foreign language and information and communication technology comparable to world standards;
6. Pride in Thai identity; appreciation of the nation's historical development; attachment and pride in the motherland and their own roots; good citizenship; and adherence to the democratic system of the government under a constitutional monarchy;
7. Appreciation of the need to preserve the Thai language, Thai art and culture, Thai wisdom, customs and traditions; environmental and natural protection; and congenial attitudes towards other world citizens;
8. Social responsibility as well as commitment to provide continuous social services to the best of their ability in recognition of the benefits received from society; and
9. Good health; regular physical exercise; and self-care for physical and mental strength (Mahidol Wittayanusorn School. 2006: Online).

These objectives and goals are a part of Mahidol Wittayanusorn School's curriculum and are integrated in the classes given.

Mahidol Wittayanusorn School has 9 curriculum features as follows:

1. Emphasis on fostering students' cognitive, moral, physical, and skill development;
2. Embracing all required courses of the B.E. 2544 [2001] Basic Education Curriculum of the Ministry of Education;
3. Inclusion of higher and more intensive subject content in science, mathematics, technology and English courses;
4. For electives, prominence given to subjects related to science, mathematics, computer and foreign language;
5. Encouragement to study a second foreign language in addition to English;
6. Curricular flexibility enabling students to acquire knowledge to the best of their ability and in accord with their interest and aptitude;
7. Provision of a wide range of activities both inside and outside the school, enabling the students to acquire desirable characteristics in accord with the school's objectives and aspirations;
8. Encouragement of creativity, innovative thinking and effective project implementation; prior to graduation, students are required to present a minimum of one project; and
9. Encouragement of credit transfer from sources of the three types of learning-formal, non-formal and informal (Mahidol Wittayanusorn School. 2006: Online).

2. Princess Chulabhorn's Colleges

The Princess Chulabhorn's Colleges are boarding schools. They were founded as a royal project on behalf of Her Royal Highness Princess Chulabhorn in honor of the 36th anniversary of her birth; July 4th, 1993. They received the honorable name from Her Royal Highness Princess Chulabhorn as "Princess Chulabhorn's College" and they were established by the General Education Department of the Ministry of Education on February 3rd, 1995. The schools place a heavy emphasis on the teaching of science subjects. These schools set up to provide educational services to students while the curriculum and management of teaching and learning are conducted as in other schools (Princess Chulabhorn's College Phitsanulok. 2011: Online; & Mahidol Wittayanusorn School. 2006: Online).

According to Princess Chulabhorn's Colleges Development Project (2011: Online).

On December 28th, 2010, Mr. Chinnaworn Boonyakiat, the Minister of Education, provided some important information regarding a project on the development of Princess Chulabhorn's Colleges to become regional science schools. The Minister said that the Cabinet had agreed to the project in principle. This is a project which forms part of the second decade of national education reform and will result in the development of Thai citizens in the areas of science and mathematics. The cabinet, as part of this project has decided to upgrade Princess Chulabhorn's Colleges to regional science schools in accordance with the following principles:

To approve Princess Chulabhorn's Colleges to become regional science schools. The college will also be a boarding school in order to provide education for students who are good at science and mathematics from levels Mattayom Suksa 1-6. The budgetary allocation will be 94,000 per head per annum.

To approve Princess Chulabhorn's Colleges as regional science schools in order to provide educational opportunities to students who excel in the fields of science and mathematics in their region. At present there are 12 colleges located nationwide. These colleges are to be enhanced towards international standards.

To approve an administrative committee and advisory committee of the project in order to stimulate schools implementation and coordinate with related agencies. With this in mind, they will be autonomous schools and have freedom in academic areas.

The Minister went on to say that the administrative committee will seek cooperation from Mahidol Wittayanusorn School and the faculty of science of other universities located in the region in order to enhance the quality of scientific education provided to students. Moreover, the cabinet also approved the establishment of science and mathematics classrooms in 12 schools in the region. The Office of the Basic Education Commission has been assigned to allocate 27 million Baht for this specific purpose.

The 12 Princess Chlabhorn's Colleges located in the region will recruit students for Mattayom Suksa 1 and 4 in the 2011 academic year. For Mattayom Suksa 4, the name list of students who have applied to Mahidol Wittayanusorn School will be used and only 24 students will be selected. The students' application for Mattayom Suksa 1 will cover January 24th - 29th, 2011 with the entrance examination taking place on February 4th, 2011.

3. Motivation for the study

My interest in ethics being taught as part of the upper secondary school science curriculum came about when I began my doctoral study in science education at the

Science Education Center, Srinakharinwirot University (SWU) located in Bangkok, Thailand. I started thinking back about my teaching experience as a chemistry teacher for a year (2003-2004) at Mahidol Wittayanusorn School located in Nakhon Pathom province, Thailand. I first considered the school's mission, objectives and goals and also curriculum features. According to the first and eighth of my school's objectives and goals and also from the first and seventh of the school's curriculum features, I was interested in the matter of ethics in a science classroom, specifically honesty and social responsibility. In theory, the school has the customized curriculum which emphasizes in fostering the students' cognitive, moral, physical and skills development but in practice, regarding moral development, it has been developing in only a few courses of ethical or moral development in the humanities, and not in the science subjects.

In my investigations, I found that there has been a great deal of scientific misconduct, particularly dishonesty in science activities or research which takes place not only with scientists but also researchers and students of science all over the world. For instance; students will sometimes fabricate the data or results, copy the assignments of their peers, and do not assist other members with lab assignments and reports while their names were put in the reports, do the wrong citations, and plagiarize. I encountered students who had done something like this when I was working as a pre-service and in-service teacher. Therefore we should not overlook these issues. All of these issues made me more concern about the matter of ethics when considering my dissertation topic. I considered the study of ethics in a science classroom as an important and relevant subject worthy of study. When I thought seriously about the problem, I imagined that the current students' behavior was typical, an accepted fact of academic life, and perhaps the norm rather than an exception. To be good and ethical scientists including young future scientists, i.e. students in the science school who are either going to be scientists in the near future or citizenry in knowledge-based society, ethical values should be taken into account. They should not behave unethically. For example, if they fabricate, falsify or misrepresent data for convenience or for some other reason, how much better would they behave as scientists who may compromise rigorous scientific research for personal, professional and social gain? I truly believe that ethical behavior and thinking are essential to scientific society and should be taught to all students. Schools such as Mahidol Wittayanusorn School need to cultivate and convince students to appreciate the importance of scientific ethics and primarily emphasize, to the science student, that their honesty and social responsibility are paramount.

Fortunately, I had a great opportunity in June 2006 to be a visiting scholar for a year at Indiana University of Bloomington (IUB), the state of Indiana, USA to develop my dissertation proposal. I found that the western educational system has been studying ethics, in particular, moral education, ethics education, character education and value education, in the science classroom both pre-college and collegiate level for several decades. From my investigation there I discovered many useful resources and ideas that can be appropriately adapted or modified in order to incorporate ethics into the science curriculum and to introduce ethics in the science classroom for upper secondary school students in Thailand.

When I returned to Thailand in June 2007, I found that the Ministry of Education has been seriously trying to urgently promote teaching moral and ethical issues to Thai students. The teaching of ethics or moral development in Thailand has been developing for decades. As an example, in the past 20 years, there were many lectures given by P.A Payutto on moral development. In accordance with the 1991 Program of Activities in Science and Technology in the Asia and the Pacific Program of Education Innovation for Development (APEID) of UNESCO, PROAP, a Regional Experts' Workshop on Development of Strategies and Methods for Teaching Values in the context of Science and Technology. Participants from many countries in Asia, including Thailand, attended the workshop that was held in November 1991 in Penang, Malaysia. These evidences ensured me that I have been working towards the right method of learning and introducing ethics in the science classroom. Hopefully, I will be able to take part in developing Thai students in their learning of ethics in the science classroom.

As always, there is disagreement among scholars about the relevance of teaching ethics for upper secondary school science students. On the other hand, there are so many people who agree that including ethics coursework in the science curricula is vital to the science students. However, I was positive that I would be able to introduce and teach ethics in science for the students at Mahidol Wittayanusorn School in that I already had experienced with the school and students.

All things considered, first and foremost, I was willing to work on ethics education to be considered as an integral part of science education for science students in order to develop and push forward the teaching of ethics in the science classroom as one of Mahidol Wittayanusorn School's strengths. The study was conducted in order to introduce and develop a principle-based learning course on ethics, based on 12 principles of ethics in science proposed and defended by David B. Resnik (1998), in the science

classroom at Mahidol Wittayanusorn School through hybrid learning in which a face-to-face learning and web-based learning are combined. Essentially, all teachers have been promoted to integrate Information and Communication Technology (ICT) into the classroom since computers with a wireless system are provided in every classroom. The school also provides every student with a laptop computer so that it would be easier and more convenient for them to access to the internet and learn on their own at anytime and anywhere. It would also be more interesting and effective to learn ethics in science by using a website along with cooperative group discussion than merely face-to-face learning alone. Above all, I would hope to see that future generations of students would be able to live their personal and professional life happily and ethically, also to be willing to assist others around them to have a better life. I do believe that if we could do this, we would have a better and more beautiful world than it has ever been.

Purposes of the study

This study is divided into two phases as follows:

Phase I: The purpose of this phase is to survey teachers and students' opinions on ethics in science in Thailand in order to:

1. Find the school's general learning in ethics
2. Find the respondents' ethics learning in the science classroom
3. Find the respondents' opinion on learning ethics in the science classroom

Based on phase I, results were further used in phase II in order to find an appropriate learning approach of ethics in science for the main study.

Phase II: The purpose of this phase was to create a learning approach of ethics in science classroom at Mahidol Wittayanusorn School in order to:

1. Promote, develop and assess students' understanding of key ethical concepts and principles in science
2. Promote, develop and assess students' analytical, creative, practical and ethical thinking skills along with communicative skills in learning ethics in science
3. Determine students' opinion on learning ethics in a science classroom
4. Evaluate the effectiveness of a learning approach of ethics in a science classroom

Significance of the Study

The significance of this study is to be considered whether science teachers' training on teaching ethics in science is likely to be conducted. Additionally, in order to have the more effective learning approach, teachers are supposed to further modify or create their own approach of teaching ethics in science classroom in so far as they would be able to do that. More importantly, it needs to be carefully considered whether this learning approach could be developed and pushed forward as a core course of teaching ethics in science to different levels of students at Mahidol Wittayanusorn School and also be considered as a useful model for other schools.

Above all, the consequences of the study would be truly useful to everyone in our learning society. Science teachers as persons who get deeply involved in this learning approach and students as persons who either are or are not going to be scientists in the near future in order to be ethical inventors, innovators, researchers and leaders and to play a major role on social responsibility will benefit.

Scope and delimitation of the study

This study is a two-phase mix methods research conducted with one group pretest-posttest design, based mainly on 12 principles of ethics in science which are proposed and defended by David B. Resnik (1998). Other principles, besides these twelve principles, which will be likely to come across in the learning process, will be accepted and discussed in the course as new interesting principles. Time and condensed content are a major limitation in this study. Basically, it take time and it is not easy to have students (grade 10) fully understand and appreciate ethics in science in only one semester. Hopefully, when they are grown or get older, they will be able to learn more based on the preliminary knowledge. Therefore, this study aimed to introduce ethics in science to them early regarding their high potential in science and as they also become involved in all science processes.

Variables

Phase I: A Survey of Science Teachers and Students' Opinions on Learning Ethics in a Science Classroom

Population: 1) All of grade 10 students and all biology, chemistry and physics teachers at Mahidol Wittayanusorn School, Nakhon Pathom province, Thailand 2) All of

grade 10 students and all biology, chemistry and physics teachers at the 12 Princess Chulabhorn's Colleges, Thailand.

Sample: 1) 72 students (obtained by using simple random sampling) and all science teachers (N=27) at Mahidol Wittayanusorn School 2) 216 students (obtained by using multistage random sampling) and all science teachers (N=80) at the Princess Chulabhorn's Colleges.

Phase II: The Incorporation of Principle-Based Learning of Ethics into a Science Classroom

Independent variables: A hybrid learning approach of ethics in science classroom by using principle-based learning.

Dependent variables: 1) students' understanding of key ethical concepts and principles in science 2) students' analytical, creative and practical thinking skills 3) students' communicative skills in learning ethics in science 4) students' opinions on learning ethics in science in the science classroom 5) the effectiveness of a hybrid learning approach of ethics in the science classroom.

Population: The population was 240 of grade 10 students at Mahidol Wittayanusorn School, Nakhon Pathom province, Thailand.

Sample: The sample was 24 of grade 10 students in a general chemistry classroom at Mahidol Wittayanusorn School, Nakhon Pathom province, Thailand.

Definitions of terms

1. Ethics is concerned with what is right or wrong, good or bad, fair or unfair, responsible or irresponsible, obligatory or permissible, praiseworthy or blameworthy. It is associated with guilt, shame, indignation, resentment, empathy, compassion, and care. It is interested in character as well as conduct. It addresses matters of public policy as well as more personal matters. On the one hand, it draws strength from our social environment, established practices, law, religion, and individual conscience. On the other hand, it critically assesses each of these sources of strength. Ethics is complex and often perplexing and controversial and it defies a concise or clear definition. Yet, it is something with which all of us, including young children, have a working familiarity (Onlineethics. 2007: Online).

2. Ethics in science involves systematizing, defending, and recommending concepts and principles of honesty, social responsibility, right and wrong behavior of scientists and science students in conducting science activities. This study was based primarily on twelve principles of ethics in science proposed and defended by David B. Resnik (1998). This can be measured by using tests, questionnaires, observations, self- and peer- assessment tools, and interviews. Modified from http://www.utm.edu/research/iep/e/ethics.htm and http://onlineethics.org

3. A hybrid learning approach of ethics in science refers to "a hybrid learning" which is a combination of face-to-face learning and web-based learning for teaching ethics in a science classroom with a wide variety of inside classroom activities with the main use of a website and collaborative discussion on the ethical concepts and principles in science. A wide variety of techniques is applied to fit the different lesson plans are: (1) lecture (2) small-group discussions (3) experiments (4) role playing (5) paintings and cartoons (6) small group presentations (7) case studies (8) ethics quotes (9) ethics before class (10) worksheets and lab reports (11) quizzes and exams. This learning approach can be measured by using the participating students' opinions for its effectiveness.

4. Science classroom refers to a general chemistry classroom including experiments at Mahidol Wittayanusorn School.

5. Principle-based learning refers to the learning with the introduction of ethics into the classroom by incorporating the 12 principles of ethics in science which were proposed and defended by David B. Resnik, (1998). The learning aimed to apply them to different aspects of the research process in order not to violate commonly accepted moral standards and to promote the advancement of scientific goals. The twelve principles are; 1) Honesty 2) Carefulness 3) Openness 4) Freedom 5) Credit 6) Education 7) Social Responsibility 8) Legality 9) Opportunity 10) Mutual Respect 11) Efficiency 12) Respect for Subjects.

6. Understanding of key ethical concepts and principles in science refers to the ability to examine carefully the knowledge about key ethical concept and principles in science in order to make it clearer. It can be measured by using a test and group interviews.

7. Students' thinking skills refers to analytical, creative, and practical thinking skills of students, based on the Sternberg's theory of successful intelligence (2005), along with ethical thinking skills. Analytical thinking skill is involved when the information

processing components of intelligence are applied to analyze, evaluate, judge or to compare and contrast. Creative thinking skill is involved when new and effective things, methods, ideas are created by using imagination and skills. Practical thinking skill is involved individuals applying the components of their abilities to the kinds of problems that confront them in daily life to adapt, shape, and select environments. Ethical thinking skill is involved individuals thinking of what is the right conduct and character will be done on one's way of life. In this study, ethical thinking skill is included in practical thinking skill for their assessment. These thinking skills can be evaluated by questionnaires, observation made by researcher and group interviews.

8. Students' communicative skills refers to the ability of students to tolerate and deal effectively with ethical ambiguity and to reduce disagreement or conflict that is more likely to happen in the collaborative group discussion/activities of ethical principles in science. They must also deal with empathy; being able to express their feeling and ideas on issues, listen to and respect others; the ability to paraphrase another's point of view, the capacity to connect with another person's opinion, and feel able to disagree without fear of reproach and the ability to accept and judge another's point of view fairly (fairness). These communicative skills (both verbal and non-verbal communication) can be assessed by using observation and group interviews.

9. Students' opinions on learning ethics in a science refers to the opinions and feeling that students have about incorporating ethics in science into a high school science classroom to determine whether they would prefer to cover moral and ethical principles of science through regular classroom or an additional classroom at the school. Also, the students' opinions on the application of ethics in science to themselves and society. These can be measured by using questionnaires and group interviews.

10. The effectiveness of a hybrid learning approach refers to the productive results of using a learning approach employed in this study in terms of the students' opinions towards a hybrid-learning course. This can be measured by using group interviews.

Conceptual Framework of the Study

The conceptual framework of this study aims to identify and discuss the variables related to the study. It is derived from personal experience and relevant literature reviews including Barbour (1985), Gosling and Musschenga (1985), Eijkelhof (1985), Onlineethics

(2007: Online), Sternberg (2005) and several other educators. Barbour (1985), Eijkelhof (1985), Gosling and Musschenga (1985), and Onlineethics (2007: Online) addressed that the main aims of ethics in science education should be 1) recognizing and analyzing key ethical issues, concepts and principles 2) developing analytical skills and communicative skills.

Sternberg (2005) stated that the traditional instruction emphasizes mainly on cognitive domain and most of the tests measure primarily or exclusively memory and analytical skills. There are a number of learning methods that help students excel in learning the sciences and motivate them to pursue a scientific course of study. There is much less emphasis, in science curricula, on teaching to the effective domain. From the researcher's experience and perspective, to achieve the educational objectives, close attention should be paid to Bloom's Taxonomy of Educational Objectives. Therefore, this study will cover three domains, which are the cognitive domain: mental skills (knowledge), affective domain: growth in feelings or emotional areas (attitude) and the psychomotor domain: manual or physical skill (skills) as stated in the purposes of the study. These skills, both mental and practical skills, are from Sternberg's Theory of Successful Intelligence (2005) which is composed of practical, analytical, creative thinking skills and were applied to the study by the researcher. Since ethics was involved in this study, then one more thinking skill, ethical thinking skill was added to this study by including in practical thinking skill. Therefore, besides cognitive and affective domains, this study also focused on the psychomotor domains which are practical, analytical, creative and ethical thinking skills: (PACE) thinking skills.

Generally, all teachers at MWITS have attempted to integrate Information and Communication Technology (ICT) into the classroom since computers with a wireless system are provided in every classroom. The school also provides students with a laptop computer so that it would be easier and more convenient for them to access to the internet and learn on their own at anytime and anywhere. Therefore, in this study, hybrid learning (a combination of face-to-face and web-based learning) was used.

In this study, the researcher mainly makes use of 12 principles of ethics in science, which are proposed and defended by David B. Resnik (1998). He has stated that many philosophers, who study applied ethics, prefer to work with general, ethical principles rather than moral theories. This is because one can use principles to support an ethical decision or a social policy without defending an entire (possibly controversial) moral theory and another reason for employing general principles is that they are easier to understand,

to teach and learn than moral theories. Barber (2002) also agreed that moral principles should be used instead of moral theories. The 12 principles are; 1) Honesty 2) Carefulness 3) Openness 4) Freedom 5) Credit 6) Education 7) Social Responsibility 8) Legality 9) Opportunity 10) Mutual Respect 11) Efficiency 12) Respect for Subjects.

In FIGURE 1, it is an attempt to explain the conceptual framework of the study and to identify the relationship between principle-based learning on ethics in science through hybrid learning. Students' understanding of key ethical concepts and principles in science, thinking skills, communicative skills, students' opinions on learning ethics in science and the effectiveness of hybrid learning approach of ethics in science are included.

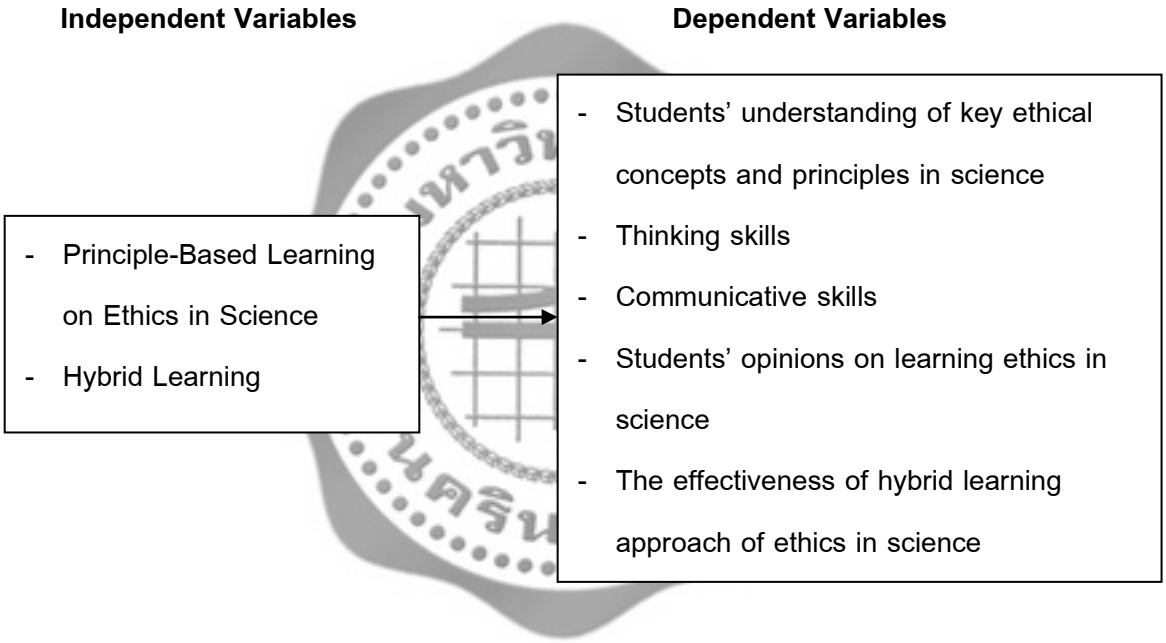

FIGURE 1 CONCEPTUAL FRAMEWORK OF THE STUDY

Framework of the Study

A research framework for this study is described and explained as to how it serves as the research agenda for the study. This framework consists of two phrases: Phase 1) A Survey of Science Teachers' and Students' Opinions on Learning Ethics in Science, which mainly focuses on quantitative data from a survey study. Phase 2) The Incorporation of Principle-Based Learning of Ethics into a Science Classroom, which includes both the quantitative and the qualitative data from implementing the preliminary results from the first phrase into an actual science classroom as shown in FIGURE 2.

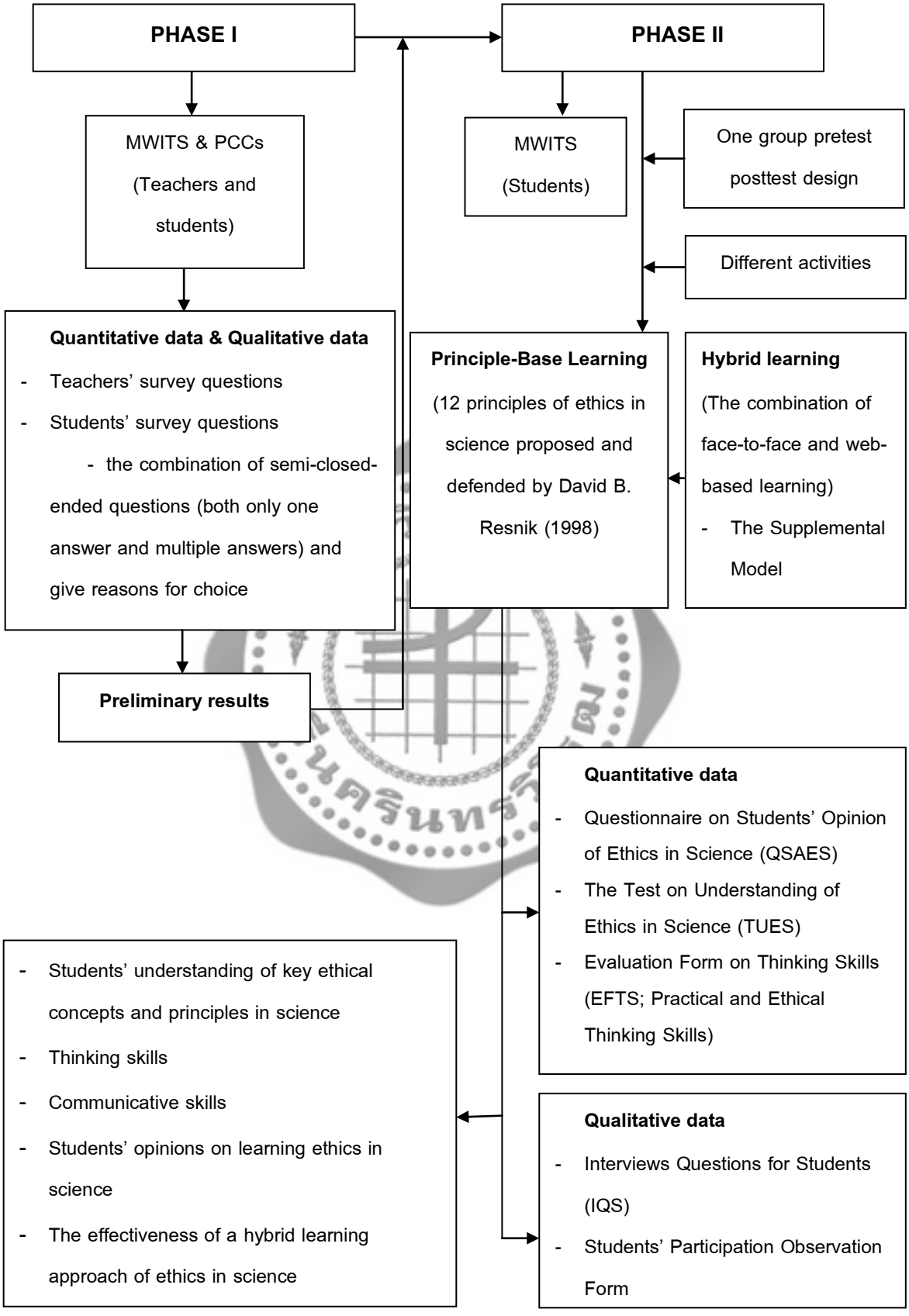

FIGURE 2 FRAMEWORK OF THE STUDY

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter reviews related literature that is relevant to the study objectives and the circumstances in which they are explored. The literature review aims to identify the various exemplary perspectives of science education and ethics in science classroom that can be used to explain this study. The review is summarized in seven sections as follows:

1. Why bring ethics into the science classroom?
2. What is ethics?
   - 2.1 Defining ethics and morality
   - 2.2 Philosophical ethics
   - 2.3 Principles of ethics in science
3. Teaching ethics in science
   - 3.1 A set of objectives
   - 3.2 Can ethics be taught?
   - 3.3 Techniques and strategies
   - 3.4 Obstacles of teaching ethics in science
4. Principle-based learning
5. Hybrid learning
6. Research related to ethics in science classroom
7. Research related to hybrid learning

1. Why Bring Ethics into the Science Classroom?

There is a great deal of ideas in introducing ethics into science classroom (Birch. 1985). Introduction of ethics in science classroom for high school science students would be a great idea for science teachers to perform. Indeed, they should act as good ethical role-models for their students. But at the same time, they need to be scrupulous in encouraging open discussion of different moral perspectives among their students (Onlineethics. 2007: Online).

Birch (1985) addressed that one of defects in teaching of science today is the failure of science to invest its facts with values, with the consequence that it appears to be ethically and morally detached. There is a way of solving this failure which is to improve our teaching of science by introducing ethics into the classroom.

Eijkelhof (1985) addressed that achievement of teaching of ethics in science strongly depends on the availability of curriculum materials, on the attitude and skills of the teacher, the receptivity and capabilities of the students and general ethos of the schools. Gosling and Musschenga (1985) also agreed that at the secondary school level, the introduction of ethical aspects in science education depend strongly on the teachers.

The implications for science education and teacher education are also stated as shown in TABLE 1.

TABLE 1 THE IMPLICATIONS OF INTRODUCING ETHICS IN SCIENCE FOR SCIENCE EDUCATION AND TEACHER EDUCATION

Implications for science education	**Implications for teacher education**
1. In secondary science education we must a. adopt as a primary educational objective the training of pupils for active participation in decision-making processes in a democratic society. b. avoid a too early and too rigid division of the complete group of children of this age into two separate groups of (1) pre-scientists, and (2) pupils without professional aspirations towards science and technology. c. realize this by (1) postponing the moment of “streaming” as long as possible, and (2) presenting-even after the establishment of separate streams-some part of science education to mixed group of children recognize that students should not be forced to have an opinion; this is a personal matter and should be respected.	In considering teacher education in respect to science and ethics there are two inter-related aspects: 1. The development of science teachers’ awareness of the nature of science and its social, political, economic and moral context. 2. The provision of opportunities to develop skills for creating methods of teaching which take into account the ethical dimensions of science and to enable them to work cooperatively with other teachers.

TABLE 1 (continued)

Implications for science education	Implications for teacher education
2. With respect to the subject matter of secondary science education and the organization of the content of curricula, the following are recommended: a. concentration on the scientific and technological environment of the pupils; b. thematic organization of syllabi; c. focus on the problems of "science, technology and society"; d. development of a fuller image of scientific knowledge and of the role of science and technology in society; integration of the discussion of ethical issues and science education at relevant points of the curriculum.	

Science teachers have responsibility to their teaching methods to enable the study of issue of science and society to arise in their science programs. This means that it is important that we should not consider science education in isolation, but in relation to moral education in particular (Gosling; & Musschenga. 1985). Additionally, the moral development of students must be promoted as an integral part of science education (Eijkelhof. 1985).

Davis (1985) and Barbour (1985) presented that the most promising way to participate in the public, to be responsible in science and technology and to raise ethical issues concerning applied science and technology should start in schools and universities. This can be done by developing science courses dealing with specific public issues such as energy policy, environmental policy, mineral policy, food and agricultural policy, pollution or nuclear weapon policy.

There must be a change in emphasis in science education from simply teaching scientific knowledge and skills to learning how to use knowledge and skills in personal and social life. Such a change of emphasis suggests the need to consider the role of schools in relation to moral education (Gosling; & Musschenga. 1985). On the other hand, science

may be value free but the application of science is most certainly not (Delaney. 2000: Online).

Mehlinger (1986) expressed that there are three main reasons for including ethical issues at schools, in university courses, in communications to the general public, and as an important part of lifelong education.

1. So many decisions which have to be made today, whether in developing or developed countries, involve some aspects of science and technology. All these decisions in some way affect people, and most of the decisions involve making judgments balancing positive (socially desirable) and negative (socially undesirable) effects.
2. Public opinion is a powerful force. If the general population has knowledge and understanding of the social ethical issues of science and technology, then it can much better be involved in decision-making.
3. There is a real danger of society becoming divided into a minority having some knowledge and understanding of science and its social issues, and the majority who feels that science is too difficult to understand, not of its concern, and that it is being manipulated. The existence of this feeling may lead to hostility towards science and even to some of the irrational behavior in society today. Social psychologists claim that ignorance may produce fear, and that fear may produce irrational behavior.

In the United States, there is one concern that is frequently raised by teachers and that is the national, state and local science curricula do not prescribe the insertion of ethics and values in science instruction. Additionally, the National Science Standards published by the National Research Council contains various recommendations in its Science Content Standards for subject matter that includes ethics and values components throughout the K-12 curriculum under the headings "Science as Inquiry". Also, in practice of the introduction of ethics in science classroom, there was a National Science Foundation (NSF)-funded program for Long Island, New York secondary school science teachers, included two-week summer institutes in 1994, '95 and '96 and school year follow-up sessions. The program was designed to support teachers to incorporate ethics and values content in their classroom science lessons. It is convinced, from this program, that student understanding of science and the increasingly significant role science plays in society is enhanced by the infusion of ethics and values content (Onlineethics. 2007: Online).

“Should schools be teaching science ethics?” is a very interesting question to debate as a part of BBC news’ website, Talking Point (2000: Online). There are different

points of view from several educational backgrounds of people; for example, teachers, scientists, science educators, and science communicators on introducing or teaching ethics in science classroom at schools. The report found that more than half of the comments agreed that science ethics should be taught in the classroom. Here are some astonishing comments on that debate;

> Science may be value free but the application of science is most certainly not. As a science educator, I have held many discussions with students on the social impact of science. Students appreciate the opportunity to express and explore their views and to find out how others view the same subject. Teaching science ethics is not New Labour brainwashing but a chance to equip future generations with a rational way to interpret scientific progress - whatever their final opinion happens to be. ***Dominic Delaney, UK***

> Having taught science at a variety of secondary schools in the UK, Kenya and Switzerland, I came to the conclusion some time ago that a values-based approach is essential if science teaching is to equip our children and young adults with critical thinking skills and personal qualities. These include integrity, honesty, responsibility and respect, so that they can tackle the challenges of the future with confidence, understanding and maturity. I believe that values exist naturally in every human being - they just need to be re-awakened through providing a supportive learning environment, suitable resources and, most importantly, through teachers, parents and other adults that act as role models for such values. ***Helen Sayers, Switzerland***

> The consideration of the implications of science has now become unavoidable. Every pupil will have to deal with an increasingly scientific society as adults. In this case it seems fair to try and equip them with the means to deal with complex ethical issues. As a teacher I feel that this is something that is best left to post 16 education. Ethics has become an intrinsic part of science so why not science education as well? ***Matthew, Switzerland***

> As a science communicator, I think debates on science issues should be grounded in fact, and that science teachers should have access to the relevant facts. Perhaps they also need help on how to facilitate debate that, although factually based, is by nature concerned with simple ethical and philosophical principles. I do not believe, like some other contributors, that such debate in schools is, or should be, about telling pupils what to think. It is all about getting pupils to think for themselves. ***Barbara Davies, UK***

> Ethical issues and allowing children to determine what their own thoughts on morality are, based upon facts and alternative opinions, is part of their development process. If they learn

both the facts and opinions in school, they then (when they leave) have the basics to form their own individual opinions which is inevitable no matter how much or what you "drill" into them. Morality isn't just what you learnt in school but your whole social and economic background. However I do believe that science ethics will help children to form moral opinions of their own that are based on an overall view or insight of a subject. ***Gema, España***

Allowing pupils to explore the issues surrounding science is crucial. Science Year is about preparing young people for a future that is exciting, challenging and increasingly scientific and only by looking at all the facts, including moral and ethical issues will we fully be able to achieve these goals. ***Professor Nigel Paine, UK***

The people who suggest that teaching ethics within a scientific context - an essential aspect of modern science - means influencing children to think along certain lines, are simply wrong. The whole idea is to get children to debate ethics, but with a solid basis in ethical theory. It actually achieves the opposite of brainwashing - when people go to work, in science or anywhere else, if they are ignorant of ethical debates they are more likely to go along with the groupthink prevailing in their organization. Thus, scientists are for science, priests are against (to oversimplify). We want our children to be well-informed in ethical debate so as to make their own minds up as to what is acceptable to them, having first weighed the arguments. ***Dafydd Lewis, UK***

Ethics and morals are basic general knowledge that should be assumed in anyone attending high school. I'm surprised that such things are not already discussed in philosophy classes at that level here in the UK, and suggesting that these issues should be "merged" into Science classes is pure nonsense. ***Dan, Scotland (Portuguese)***

In a broad sense, yes - these issues are an integral part of science (and other areas). But perhaps the term "teaching" implies something too hard and fast. Children should be made aware of the ethical issues, take part in discussions surrounding them, and be invited to take a view. ***Andi -Tsuyoshi Williams, Japan***

Most scientists begin their careers by obtaining a doctorate of philosophy (as I did). However it is possible to gain this prestigious qualification without even a rudimentary understanding of philosophy. Scientists need to be trained in ethics, morals and indeed the philosophy of science to make them better scientists. Science without ethics is like learning to drive without the Highway Code! ***N.A. Gostick, UK***

All French students, in their last year at lycee (17-18 years old), are taught philosophy - not just morals or ethics which may only represent one view. This is the place, I think, to study the implications of science. Science lessons are just not the right place. ***Pascal Jacquemain, UK (French)***

The ethical questions which science and technology brings up should be discussed in school. This is not a way of indoctrinating children with fixed notions of right and wrong, as some respondents seem to think, but rather creating an atmosphere in which pupils may be allowed to discuss such issues freely. The goal of all education is to make pupils more aware about what goes on around them, and they should learn to participate more actively in matters that concern society and indeed the whole of mankind. ***Edwina Ramsay, Norway (ex. UK)***

I teach science at university level and train scientists in communication skills. I agree with the Wellcome Trust report: the present school curriculum does not provide a basic foundation of scientific literacy for pupils to debate the ethics of science. Some of my colleagues who have entered secondary school teaching have been shocked at the lack of scientific literacy shown by many other trainees (some of whom do not understand basics such as gravity, what a gene is etc). Unless those areas are addressed, you risk simply generating more uninformed debate - just like that seen in the mainstream media on most of these subjects e.g. GM, IVF. ***Jon Copley, UK***

The above comments show various views of teaching ethics in science. The majority thought that it is crucial to introduce ethics to high school students.

2. What is ethics?

2.1 Definition of ethics and morality

There are different definitions of ethics as follows:

Rachels (1999: 1,19) proposed “Minimum conception” of morality which is a core that every moral theory should accept, at least as a starting point. Morality is, at the very least, the effort to guide one’s conduct by reason, that is, to do what there are the best reasons for doing while giving equal weight to the interests of each individual who will be affected by one’s conduct.

The following definition of ethics is interesting which is provided by Onlineethics (2007: Online);

Ethics is concerned with what is right or wrong, good or bad, fair or unfair, responsible or irresponsible, obligatory or permissible, praiseworthy or blameworthy. It is associated with guilt,

shame, indignation, resentment, empathy, compassion, and care. It is interested in character as well as conduct. It addresses matters of public policy as well as more personal matters. On the one hand, it draws strength from our social environment, established practices, law, religion, and individual conscience. On the other hand, it critically assesses each of these sources of strength. Therefore, ethics is complex and often perplexing and controversial. It defies concise, clear definition. Yet, it is something with which all of us, including young children, have a working familiarity. This makes ethics sound like morality (Onlineethics. 2007: Online).

Shaw (1998: 3) stated that;

"The word ethics comes from the Greek word ethos, meaning character or custom," writes philosophy professor Robert C. Solomon. Today we used the word ethos to refer to the distinguishing disposition, character, or attitude of a specific people, culture, or group (as in, for example, " the American ethos" or "the business ethos"). According to Solomon, the etymology of ethics suggests its basic concerns: (1) individual character, including what it means to be " a good person", and (2) the social rules that govern and limit our conduct, especially the ultimate rules concerning right and wrong, which we call morality.

Some philosophers like to distinguish ethics from morality. To them morality refers to human conduct and values, and ethics refers to the study of those areas. Ethics does, of course, denote an academic subject, but in everyday parlance we interchange ethical and moral to describe people we consider good and actions we consider right. In addition, we interchange unethical and immoral to describe what we consider bad people and wrong actions…

Thiroux (1998: 2-3) declared that in ordinary language, we frequently use the words ethical and moral (and unethical and immoral) interchangeably; that is, we speak of the ethical or moral person or act. On the other hand, we speak of codes of ethics, but only infrequently do we mention codes of morality. Some reserve the terms moral and immoral only for the realm of sexuality and use the words ethical and unethical when discussing how the business and professional communities should behave toward their members or towards the public. More commonly, however, we use none of these words as often as we use the terms good, bad, right, and wrong. The important thing to remember here is that moral, ethical, immoral, and unethical, essentially mean good, right, bad, and wrong, often depending upon whether one is referring to people themselves or to their actions.

Luper (2001: 15) views that ethics is the attempt to clarify how people ought to live. It elucidates the nature of the good person and the good life, telling us

how to flourish or live well and it characterizes the obligations we have, enabling us to identify what we must do. Ethics is the wide ranging study of right and wrong, as well as good and bad, insofar as these pertain to conduct and character. It pays particular attention to clarifying the two most basic moral concepts --- the concept of the good and the concept of the right – and figuring out how these two concepts maybe related to each other.

Pojman (1998: 2) uses ethics to refer to the whole domain of morality and moral philosophy, since these two areas have many features in common. For example, both areas concerns values, virtues, and principles and practices, though in different ways.

P.A. Payutto (1992: Online)

> Buddhism is a religion that puts wisdom to the fore rather than faith. Intelligent and honest inquiry are not only welcomed, but encouraged. Part of this inquiry requires a good background understanding of the way cause and effect function on the personal level. This is the domain of ethics or morality, and the specific domain of kamma. What criteria are there for right and wrong behavior? As concepts, these words are open to a wide range of interpretations, but in the study of kamma we are concerned with finding definitions that are workable and sound. Such definitions must not only point out a clear direction for moral conduct, but also provide the reasons and incentives for maintaining it. The teaching of kamma satisfies these requirements.
>
> … In the law of kamma we are able to find meaningful and relevant definitions of "good" and "evil," an understanding of which not only clarifies the path of ethical practice, but also facilitates personal well-being and fulfillment. Not only individual needs, but problems and directions on a social level can be more readily understood with the help of this teaching. It is no wonder, then, that the Law of Kamma is one of the cornerstones of Buddhism.

In summary, ethics is used to refer to the whole domain of ethics, morality, moral philosophy, and the specific domain of kamma. It is the wide ranging study of right and wrong, as well as good and bad, insofar as these pertain to conduct and character. Ethics and morality were interchangeably used in this study.

2.2 Philosophical ethics

Traditionally, ethics has been taught at the college level mainly in departments of philosophy. In large part, philosophical ethics is normative in its focus. It examines

basic questions about what our values should be, what, if any, fundamental grounding they can be given, and whether they can be organized into a comprehensive, coherent theory. Another part of philosophical ethics is called *metaethics*, which studies the nature of the language and logic we use when we are concerned about morality (as distinct from, say, law or social etiquette) (Onlineethics. 2007: Online).

Resnik (1998) stated that many philosophers who study applied ethics prefer to work with general, ethical principles rather than moral theories because one can use principles to support an ethical decision or a social policy without defending an entire (possibly controversial) moral theory. Another reason for employing general principles is that they are easier to understand, to teach and learn than moral theories. Since principles are expressed in very general terms, therefore, they can be applied to a variety of cases and interpreted in different ways. This kind of flexibility allows one to apply principles to diverse cases without ignoring important details. Barber (2002) also agreed that moral principles should be used instead of moral theories as stated below;

> Although the variety of ethical theories is quite bewildering, there is actually a great deal of overlap in the values that they support and the standards of conduct they recommend. Many ethical theories have similar practical ramifications. For this reason, many applied ethicists avoid restricting themselves to any one ethical theory. Instead of focusing on theory, such pluralists direct their attention to core moral principles with which most people can agree. Applied ethics, including scientific ethics, and professional ethics in general, can operate effectively on the basis of a few fundamental principles drawn from widely held values. Thus the Nuremberg code, which stipulates the rights of human research participants, has three major principles (rights to informed consent, freedom from harm, and termination of participation) that are based on the ethical value of autonomy or personal liberty. The code also states that scientific research using human participants should have the potential for benefiting humanity, reflecting the value of beneficence. Other values that form the basis for applied ethical principles include privacy, honesty, fidelity, and fairness. Thus, professionals are expected to respect the privacy of their clients, avoid defrauding them, live up to promises they have made, and treat people with the same consideration regardless of differences in age, ethnicity, religion, or income. Applied ethicists are guided by fairly straightforward ethical principles. Ethical dilemmas arose when these principles are in conflict with each other. When that happens, the ethicists might elevate one principle over another. For example, an ethicist on an institutional review board might decide that the scientific benefits of an experiment in social psychology were more important than the participants' right to informed consent.

2.3 Principles of ethics in science

Resnik (1998) proposed and defended twelve principles of ethics in science, which apply to different aspects of the research process in order to not violate commonly accepted moral standards and to promote the advancement of scientific goals. The principles are explained, in part, as shown in TABLE 3.

TABLE 3 THE TWELVE PRINCIPLES OF ETHICS IN SCIENCE

Principles of ethics in science	Descriptions
1. Honesty	"Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and trustful in all aspects of the research process."
2. Carefulness	"Scientists should avoid errors in research, especially in presenting results. They should minimize experiment experimental, methodological, and human errors and avoid self-deception, bias, and conflicts of interest."
3. Openness	"Scientists should share data, results, methods, ideas, techniques, and tools. They should allow other scientists to review their work and be open to criticism and new ideas."
4. Freedom	"Scientists should be free to conduct research on any problem or hypothesis. They should be allowed to pursue new ideas and criticize old ones."
5. Credit	Credit should be given where credit is due but not where it is not due."
6. Education	"Scientists should educate prospective scientists and insure that they learn how to conduct good science. Scientists should educate and inform the public about science."
7. Social Responsibility	"Scientists should avoid causing harm to society and they should attempt to produce social benefits. Scientists should be responsible for the consequences of their research and they should inform the public about those consequences."
8. Legality	"In the process of research, scientists should obey the laws pertaining to their work."
9. Opportunity	"Scientists should not be unfairly denied the opportunity to use scientific resources or advance in the scientific profession."
10. Mutual Respect	"Scientists should treat colleagues with respect."
11. Efficiency	"Scientists should use resources efficiently."
12. Respect for Subjects	"Scientists should not violate rights or dignity when using human subjects in experiments. Scientists should treat non-human, animal subjects with appropriate respect and care when using them in experiments."

3. Teaching ethics in science

3.1 A set of objectives

For the past several decades, colleges and universities have been wrestling with the question of the place of ethics in higher education. Traditionally, its proper place was thought to be in departments of philosophy or religion. However, beginning in the early 1970's courses in ethics began a rapid expansion into programs in medicine, law, business, education, engineering, journalism, communication, psychology, and so on. In the late 1970's a group of educators representing a broad range of disciplines gathered at the Hastings Center to explore the question of what the objectives in teaching ethics in higher education should be. What is particularly striking is that, despite the differences among their respective academic disciplines, these educators developed a consensus statement of five basic objectives. Teaching ethics in higher education, they concluded, should 1) stimulate the moral imagination of students 2) help students recognize moral issues 3) help students analyze key moral concepts and principles 4) stimulate students' sense of responsibility and 5) help students deal effectively with moral ambiguity and disagreement. Although intended for ethics in higher education, this set of objectives seems appropriate at the pre-college level as well, especially in junior and senior high school (Onlineethics. 2007: Online). Also, for the overall aim is to help science students to appreciate the ethical dilemmas and values implicit in the activity, and in the results and situations to which scientific research gives rise. These values and, of course, were tried to expose and discuss the student's' own views. Science education then becomes the context of ethical education. Clearly, conventional science education does not have this character (Edge. 1985).

Barbour (1985) addresses that in discussing such ethical questions; the teaching objective is not to promote a particular answer but to encourage the recognition of ethical issues and the ability to analyze them. In order to avoid indoctrination it is helpful to examine diverse views in particular cases in which scientists have confronted moral dilemmas on the job or in their public activity. The students must engage in critical thinking and moral reasoning in order to develop some capacity for judgment which could carry over to future life. This will require the science teacher to do some serious study in ethics or to work closely with a philosopher or theologian interested in ethical theory and application. More importantly, as Eijkelhof (1985) states that in his point of view science education must be changed from "teaching scientific knowledge and skills" to "learning how to use scientific

knowledge and skills in personal and social life". For this purpose science education should make use of controversial issues in which knowledge and skills are used in the context of values held by individuals or groups. In real life opinions are often presented as facts and it is very difficult to detect if one is not trained to do so. A systematic reflection on responsible decisions and actions would be very useful when dealing with controversial issues. And that is what I consider to be ethics."

The three main aims of ethics in science education should be, as shown in TABLE 4.

TABLE 4 THE THREE MAIN AIMS OF ETHICS IN SCIENCE EDUCATION

Aims of ethics in science education	**Descriptions**
Recognizing ethical issues	Students frequently think in term of a single solution, they must learn to recognize that often several alternatives are possible and that the choice between these depends not only on facts but also on the opinions and beliefs of those involved. This of course also requires an acknowledgement of freedom of choice and some doubts in the dominating social consensus.
Developing analytical skills	Being able to discuss value-issues rationally can be very helpful in deciding complicated issues or clarifying the opinions of oneself or other people. It provides students with the tools for a more articulate and consistent way of justifying their moral judgments and of describing the process of their ethical thinking. Developing analytical skills should be coupled with the development of communication skills such as listening and the ability to paraphrase others' point of view.
Tolerating and reducing disagreement	Ethical issues often arouse very emotional reactions. Students should learn how to express their feelings and ideas on an issue, and accept other points of view. They should then proceed to seek out points of agreement to reduce conflict and feel able to disagree without fear of reproach.

Gosling and Musschenga (1985) declared that secondary schools have a responsibility for moral education. The aims of moral education are to enable pupils to achieve the following:

- to form, articulate and express their own value judgments;
- to distinguish between different points of view (law, morality, self-interest ,religion)
- to take their own decision, justifying those referring to norms, values and principles;
- to learn the difference between the moral norms, values and principles one personally subscribes to (personal morality), and the moral norms, values, and principles to which one is expected to agree as a member of a group or society (public morality);
- to learn the difference between personal decisions in the private sphere and collective decisions in the public sphere;
- to accept the existence of different moral opinions and systems of morality;
- to accept the right of other persons to hold opinions different from one's own.

The following skills, competences and attitudes, are necessary in order to realize those aims:

- analytical skills as tools for a more articulate and consistent way of justifying moral judgments and of describing the process of moral reasoning;
- communicative skills: listening to others; the ability to paraphrase another's point of view and the capacity to connect with another person's opinion;
- Imagination and empathy.

It is very important to discuss each of these objectives and suggest how they might be adapted to the schools. However, at the outset, it is important to notice some assumptions about students that underlie this list. The first objective assumes that students already have moral imagination -- the aim is to stimulate it, not to implant it. The second objective assumes that students are capable of recognizing moral issues but that, like all of us, they can be assisted in this. The third objective assumes students are capable of analyzing key moral concepts and principles--the aim being to help them sharpen and refine their abilities. The fourth objective assumes that students already have, to some extent at least, a sense of responsibility. The fifth objective assumes that students are already familiar with moral ambiguity and disagreement, but that they need help in dealing effectively with this. In sum, students are viewed as active learners who already have some aptitude for the study of ethics they will be undertaking (Onlineethics. 2007: Online).

3.2 Can ethics be taught? Or should ethics in science be taught in school?

Can ethics be taught? This is one of the most important questions in science education today that people from all over the world should be aware of. From His Majesty the King of Thailand's speeches that shows how important having morality is for all human beings. It says;

การสอนให้คนเก่งนี้ ถ้าดูเฉพาะบางแง่บางมุม อาจเห็นว่าดีว่าสอดคล้องกับสมัยเร่งรัดพัฒนาแต่ถ้ามองให้ถี่ถ้วนรอบด้านแล้วจะเห็นว่าการมุ่งสอนคนให้เก่งเป็นเกณฑ์ อาจทำให้เกิดจุดบกพร่องต่างๆขึ้นในตัวบุคคลได้ไม่น้อย ที่สำคัญก็มี ..... ข้อ ๔ บกพร่องในจริยธรรมและความรู้จักผิดชอบชั่วดีเพราะมุ่งแต่จะแสวงหาประโยชน์เฉพาะตัวให้เพิ่มพูนขึ้นเป็นเหตุให้ทำความผิดและความชั่วทุจริตได้โดยไม่รู้สึกสะดุ้งสะเทือน (*พระราชดำรัสในพิธีทูลเกล้าฯถวายปริญญาดุษฎีบัณฑิตกิตติมศักดิ์ของ ๕ สถาบัน วันที่ ๓ ตุลาคม ๒๕๓๒*)

In today's world, teaching people to be clever might superficially be regarded as a good thing. However, when thoughtfully considering this, you can notice how teaching them solely to be clever may bring about some defects in them. One major defect is their incline in morality; they seek to gain maximum benefit for themselves. This result in their offences committed unknowingly (His Majesty the King's speech on the occasion of being conferred honorary doctorates by five institutions, or in Thai พระราชดำรัสในพิธีทูลเกล้าฯถวายปริญญาดุษฎีบัณฑิตกิตติมศักดิ์ของ ๕ สถาบัน, 3rd, October B.E. 2532 (1989)). *Unofficial translation*

คุณธรรมที่ทุกคนควรจะศึกษาและน้อมนำมาปฏิบัติ มีอยู่ ๔ ประการ ประการแรก คือ การรักษาความสัตย์ ความจริงใจต่อตนเองที่จะประพฤติปฏิบัติแต่สิ่งที่เป็นประโยชน์และเป็นธรรม ประการที่สอง คือ การข่มใจตนเอง ฝึกใจตนเองให้ประพฤติปฏิบัติอยู่ในความสัตย์ความดีนั้น ประการที่สาม คือ ความอดทนอดกลั้น และ อดออมที่จะไม่ประพฤติล่วงความสัตย์สุจริต ไม่ว่าจะด้วยเหตุประการใด ประการที่สี่ คือ การรู้จักละวางความชั่ว ความทุจริตและรู้จักสละประโยชน์ส่วนน้อยของตน เพื่อประโยชน์ส่วนใหญ่ของบ้านเมือง คุณธรรมสี่ประการนี้ถ้าแต่ละคนพยายามปลูกฝังและบำรุงให้เจริญงอกงามขึ้นโดยทั่วกันแล้ว จะช่วยให้ประเทศชาติบังเกิดความสุข ความร่มเย็นและมีโอกาสที่จะปรับปรุงพัฒนาให้มั่นคงก้าวหน้าต่อไปได้ดังประสงค์ (*พระราชดำรัสในพระราชพิธี บวงสรวงสมเด็จพระบูรพมหากษัตริยาธิราชเจ้า วันที่ ๕ เมษายน ๒๕๒๕*)

Moral principles that should be studied and practiced are comprised of (1) honesty and sincerity for ourselves in order to behave morally; (2) self-control to maintain that honesty; (3) tolerance and patience to prevent ourselves from acting dishonestly; and (4) refraining from dishonesty; sacrificing our trivial benefits for the sake of the entire society. With all these four principles, the nation will ultimately be in peace (His Majesty the King of Thailand's speech on the occasion of the merit-making ceremony in dedication to the past monarchs, or in Thai พระ

ราชพิธีบวงสรวงสมเด็จพระบูรพมหากษัตริยาธิราช, 5th May, B.E. 2525 (1982)). *Unofficial translation*

From above speeches, it shows that ethics/moral should be studied and practiced. In addition, the notion that ethics might be *taught* at the junior or senior high level is sometimes met with skepticism. Morality does need to have an early beginning in our lives. How, by whom, or even whether, morality should be *taught* in the early years are important questions. Moral learning is a life-long process. If the question is changed from *Can ethics be* taught? to *Can ethics be profitably studied*? Studying ethics, rather than trying to indoctrinate a set of moral prescriptions, is what the five Hastings Center objectives emphasize. Students are respected as active learners who bring with them considerable resources to undertake the study of ethics in this or that area and should not be subjected to misguided efforts to implant certain moral values in them. This respect should be extended to junior and senior high school students as well (Onlineethics. 2007: Online).

Mehlinger (1986) stated that typically, the family is the first and principal instructor for the moral values approved by custom and tradition. Mothers, fathers and members of the extended family play key roles. This is consistent to the idea of Lewis (1986) which is education for ethics and social responsibility should start as early as possible. Lewis (1986) agrees that it is wise to allow ethical issues to come up for discussion but it should be in the midst of normal science teaching rather than setting aside specific periods devoted to “ethics and social responsibility”, which can often promote an initial opposition. On the other hand, Edge (1985) thought that ethics can be introduced into science education by separate instruction and discussion. Harlen (1986) says

> It may seem that very few of the major moral and social issues which surround scientific advances, such as nuclear weapons, biotechnology or genetic engineering, can be made accessible in any way which has meaning and value to young children. However, even the most complex issues require a cognitive and effective base whose roots may reach down to the early years of education. It may well be that we are likely to find the contribution of primary education to these issues in terms of the establishment of this foundation rather than in the premature introduction of discussion on the social and ethical problems arising from scientific and technological activity.

It is necessary to include ethical issues in the science curriculum. Science education at secondary school level is still based on the traditional idea that science is neutral, value-free and insulated from questions of value and ethics (Eijkelhof. 1985). Frazer and Kornhauser (1986) addressed that it is not enough to stuff our students with information. Scientific problems should be described in their totality. It is not enough to teach about the splitting of the atom, also to talk about its terrible consequences. It is not enough to talk of lasers, also to mention “Star Wars”. It is not enough to talk of insecticides in chemistry, but to talk of the terrible use of insecticides and how it can damage people; it is not enough talking about genetic engineering but also talking about the terrible things the wrong experiments could produce.

Frazer and Kornhauser (1986) says,

> I believe that this kind of social responsibility that directly, or indirectly, gets rubbed off on young minds will help the world much more than anything else we might do. It is only science taught in this manner that would be appreciated by young minds and convince them irrespective of whether these young people are going to be scientists or not. Whenever such issues are raised, the young minds are somehow activated. The present day younger generation is more alive to world problems. We should also remember that not all students that we teach to are going to be scientists. Most of them are, in fact, going to do something else. Inculcation of the scientific temper and popularization of science are important not because it is good for science, but because we need friends for science. Those taking science courses in schools and colleges who are not going to be scientists need not know detailed equations of chemistry or physics but they need to know something about how science works and the total implications of science. I think that this is our most important role as science communicators.

The responsibility of the educational system in a country is to prepare young people for the world in which they will spend the rest of their lives. That world will involve decision-making, and for that reason decision-making should form a part of the educational process and such decision-making involves value judgments as well as moral and ethical considerations. Whatever is done in the school curriculum, it is essential that such ethical matters are not dealt with in an authoritarian way. In every case it is educationally desirable to put two sides of any argument, so that the young people concerned can indeed make up their own minds in the light of the evidence (Lewis. 1986).

In conclusion, ethics can be taught. Teaching ethics in science in a regular science course or an additional course still need to be investigated.

3.3 Techniques and strategies

Teaching strategies for presenting ethical dilemmas are also discussed by Agne (1986) that community service is described as the most ambitious and worthwhile educational activity.

There are several techniques or strategies on teaching ethics in science. According to Onlineethics (2007: Online), there are 7 techniques as shown in TABLE 5.

TABLE 5 SEVEN TECHNIQUES ON TEACHING ETHICS IN SCIENCE

Techniques	Descriptions
1. The use of case studies	Students are given a brief scenario, or a set of brief scenarios, designed to illustrate specific ethical issues associated with science. These can be fictional or they can be based on actual events. After reading the scenario(s) students, either individually or in cooperative learning groups, are asked to respond questions designed to probe their ethics and values contents.
2. The use of the structured controversy	Students are divided into groups of two pairs. In each group the pairs are given one of two brief essays describing opposing views on a controversial issue related to science. After reading and discussing the issue among themselves the pairs engage in a brief debate in which they focus on the ethics and values differences that underlie the conflicting positions. The pairs then exchange essays and again debate, this time supporting the opposite position. The teacher rotates among the debating groups with the goal of keeping the debates focused on questions of ethics and values.
3. Panel discussion	Students are given a description of a scientific dispute facing a community, as well as an outline of the positions likely to be taken by key parties to the dispute, governmental officials, and citizens groups. Students are then selected to represent the various parties and engage in a panel discussion, with the remainder of the class directing questions at the panelists. The entire class then engages in an analysis and discussion of the ethics and values issues raised by the panelists and questioners.
4. Simulation	After reading a background essay on the some controversial new application of scientific research, students engage in a simulation of some real-life activity that requires them to make decisions with ethics and values implications about the ways society may choose to make use of this new technology.

TABLE 5 (continued)

Techniques	Descriptions
5. Ethics and values from science fiction	Students read a science fiction story that illustrates real life ethics and values issues related to science and technology. Either individually or in cooperative learning group students respond to a series of questions designed to engage them in an analysis of the ethics and values associated with the choices made by the characters in the story, and to consider the ethics of the range of alternative actions open to the characters.
6. Maintaining an ethics and values journal	Students are instructed to make weekly entries in a journal concerning the ethics and values issues described in science articles appearing in newspapers or magazines. The teacher periodically collects these journals, comments on them and selects one each week or two for classroom discussion.
7. The moot court	Students are given details of a case involving an individual who is being accused of some form of scientific misconduct. Students are assigned to play the roles of defendant, prosecuting attorney, defense attorney, judge and a series of witnesses for the prosecution and the defense. A mock trial is held with the remainder of the class serving as the jury.

Creative teachers will surely be able to think of many additional classroom teaching strategies designed to meet the goals of ethics instruction. No matter what techniques are used, an ethics lesson will almost invariably benefit from the inclusion of a significant time period for discussion of the issues among students. Teachers should confine their roles in such discussions to keeping things moving and focused on the ethics and values issues at hand. The stimulation of the moral imagination and development of moral reasoning by students is generally promoted and enhanced by observing the differences and similarities in values and in modes of analysis employed by their peers.

There are a few words of caution on using these techniques;

The personal lives and experiences of students may be closer to some of these issues than we realize. Discussion of a debilitating hereditary condition may be painful for a student who has a family member or close friend who suffers from that condition. Children of scientists may be disturbed by suggestions that scientists are not all scrupulously honest at all times. Discussing the ethics of various techniques used to enhance reproductive techniques may distress a student who has learned that he or she is some form of "test tube baby." This doesn't

mean that such issues must not be discussed in class, but teachers should be sensitive to the potential personal impacts they may have on an individual student." (Onlineethics. 2007: Online).

Lewis (1986) says that the learning process will be more effective the more closely the pupils can be identified with the problems themselves. An ethical problem which will always promote considerable discussion is the issue of experiments on animals. Affection for animals and concern about experiments on them is natural amongst young people, and it would be unwise to try to promote discussion merely by producing arguments in favor of such experiments. It would be far wiser to approach the subject the other way round: should a new drug, which may or may not be effective, which may or may not have harmful side effects, be used on your own grandmother? How should that drug be tested? This makes the problem real and personal, and so the ethical discussion begins.

Frazer and Kornhauser (1986) says that many teachers are uncertain how to approach questions for which there are no clearly "right" or "wrong" answers. How can controversial subjects be taught? There are now a number of well tried methods for developing students' ability to make judgments and to form opinions. The choice of approach depends on:

- the aim of the instruction,
- the inclinations of the teacher (a teacher feeling "uncomfortable" with a particular style is unlikely to be successful using it),
- the expectations of the student,
- the issues itself,
- the availability of information about it,
- the resources available,
- the number of students to be taught,
- the time available

According to the view of Frazer and Kornhauser (1986), teaching styles of ethics in science consisted of four major styles which are;

1. Didactic approach

A didactic approach to teaching controversial issues is unlikely to be successful. We do not learn to make judgments by listening to someone else talk, and none of us take readily to being told what our beliefs and opinions should be. However the paper by R.M. Agne gives

examples of this style of teaching being used successfully for informing students about controversial subjects.

2. Debate and discussion

Students are likely to form an opinion about an issue if they are forced to think about it, because they have to express themselves in debate or discussion. There are a number of possibilities for arranging this style of teaching, but the essential feature is that the teacher must be able to provide as much objective information about the issues as the students require. The complexity of the information provided by the teacher will of course depend on the age, ability and interests of the students. However it is common experience that once students start to discuss an issue, their interest is aroused and their need for more information increases. A number of aspects concerning the debate and discussion method should be noted; many of them also apply to other teaching styles.

- It is best for the teacher to introduce the issue, to present some information and both sides of the argument, and then having provoked the students into discussion to keep in the background. The introduction might be in the form of a newspaper article, a picture, part of a film, etc. The teacher only intervenes (i) when approached by the students for further information, (ii) if the students are reaching a conclusion based on false logic, and (iii) to bring the lesson to a conclusion at the appropriate time.

- The debate either can be “open” with students freely expressing their opinions, or students can be forced to take sides. It is a useful educational experience to be forced to speak in support of a particular argument even though one does not actually believe in it. It is often useful to ask students to prepare their ideas about the issues for “homework” before the debate. One approach is to ask students to prepare two papers, one for each side of the controversy. Only as the lesson begins is the student told which paper is to be used.

- The teacher can chair the debate, in which case it is important that he or she should be “neutral”. Alternatively the teacher might appoint one of the classes to the chair.

- A “debate” or discussion about a controversial issue need not take a whole lesson. It is far better if ethical issues, and issues of social responsibility of scientists, are introduced naturally into normal science lessons. A 10 minute discussion about the social implications of the science topic being studied can greatly enliven a lesson.

- Another effective way of thinking the students think about open-ended problems is to “brainstorm”. Students are asked to call out as many ideas which relate to the topic in question as they can. These are listed on a blackboard without comment. When all the ideas are in front of the class, it is usually possible to arrange them in some sort of order. The class then sees the wide range of opinions which can be expressed on a particular issue.

- The size of the group is important. If there is a class of 30 and the debate lasts 30 minutes, on average each student has a speaking time of 1 minute. It is therefore much better

to divide a large class into a number of small groups. Six points about small group discussions are worth mentioning.

- It often helps if there is a 5 minute period before the groups are formed for each individual to write down any ideas about the topic. In this way each individual in the group has something ready to say and the group will not be dominated by the fast thinking extrovert. A period of quiet reflection and note making before breaking into groups is recommended.

- The issues to be discussed should be absolutely clear. It often helps to phrase it in the form of a question. It should be limited in scope.

- It is always helpful to have the group's report to a plenary session at the end.

- It is important not to allow groups to appoint their own spokesperson for the plenary session. Furthermore the spokesperson should not be appointed until the end of the group discussion. These conditions ensure that everyone pays attention throughout the group discussion.

- One way of making sure that a report is not too long is to ask each group to prepare a single acetate sheet for use with an overhead projector, and the spokesperson speaks to the headings on the acetate sheet.

- An alternative task for the group might be to prepare their conclusions in the form of a "poster" to be displayed later at a plenary session. Groups may be also asked to prepare a set of questions which are then presented to other groups or to the whole class.

3. Role-playing simulations, games and case studies

An effective way of introducing controversial issues is by simulations and role-playing. Students are asked to act particular roles. They are given a brief about their particular role, and they then have to react to simulated situations presented to them. They are required to make and defend decisions but always in terms of the role they have been assigned. In this way, students experience different sides of the argument.

Related to simulations and role-playing is the use of decision-making games. Students are provided with information which will enable them to reach a decision about a controversial subject. One of the problems with simulations and games is that the students may be left with the impression that they have solved a real problem. They may develop a view that complex problems are easy to solve. After all, a decision about sitting a nuclear power plant in real life has never been made during a 45 minute session. One way of overcoming this problem is the use of case studies of actual problems.

In the case study method students are provided with information from a real problem and they can see how various factors are taken into account in order to reach decisions.

4. Community service

The ultimate goal of moral education is that students should put their opinions and beliefs into action. One way of doing this is through community service out of school.

3.4 Obstacles of teaching ethics in science

Eijkelhf (1985) stated that anyone who is trying to introduce controversial issues into science education must be prepared to face resistance from various quarters. Some hesitations among teachers to deal with nuclear arms in physics classes: they felt too much involved with the issue, considered themselves not to be experts in the field-or else they defined physics in a more narrow sense. Official bodies are opposed to it because they want to avoid politics in science classes or are concerned about an increase in the general level of frustration among pupils about the future of society.

> The goal he began by setting out can only be attained subject to certain conditions. The first is the acceptance by all concerns that students are different: they are different interests, different backgrounds, different abilities, different styles of learning, and different views. Without respecting these differences any progress towards the main aims of ethics in science education would be hopeless. In the past science education has paid too much attention to differences in cognitive abilities.
>
> A second condition is the willingness of those in charge of science curricula to create possibilities for student activities which stimulate moral development. In most curricular little space is currently available. Thirdly, I wish to stress the readiness of teachers to accept that science education should make a contribution to the moral development of students. As a consequence they must be prepared to adapt some of the scientific content and methods of teaching.
>
> The fourth condition concerns the educational climate in the schools. I think this climate is of utmost importance. I do not see how moral development can be promoted in a school in which students are not allowed to carry responsibilities, in which someone with a dissenting opinion or deviant behavior becomes an outcaste and in which conflicts are not resolved in a respectful and fair way.

Eijkelhof (1985) addressed that achievement of teaching of ethics in science strongly depends on the availability of curriculum materials, on the attitude and skills of the teacher, the receptivity and capabilities of the students and general ethos of the schools. Gosling and Musschenga (1985) also agreed that at the secondary school level, the introduction of ethical aspects in science education depend strongly on the teachers. A distinction can be made between the following groups of teachers:

1. those who are against introducing ethical aspects in science education;
2. those who think it is not possible

3. those who are willing but do not know how to do it
4. those who try but meet a lot of problems
5. those who are successful.

Concerns about the reasons behind teacher's attitudes in groups 1 to 4 are identified by showing several factors which play a negative role as shown in TABLE 6. (Gosling; & Musschenga. 1985; & Agne. 1986).

TABLE 6 FACTORS WHICH PLAY A NEGATIVE ROLE ON TEACHER'S ATTITUDE OF INTRODUCING ETHICS ASPECTS IN SCIENCE EDUCATION

	Problems
1.	Overloaded science curricula pressurized by an oppressive examination system
2.	A pedagogical climate in the schools which is not favorable to moral development
3.	Lack of training in moral reasoning among science teachers
4.	Inability of teachers to deal with student activities which promote moral development so that students have little opportunity to face the consequences of their moral choices, and so are rarely challenged
5.	Resistance by teachers to changes in their role in classroom; fear of losing respect by shifting responsibilities to students when using new teaching methods
6.	Lack of communication and cooperation between teachers in different disciplines
7.	Lack of understanding among teachers of the contemporary nature of science and technology
8.	Inability of teacher to assess progress in moral reasoning
9.	Low motivation and a tendency to avoid professional risks
10.	The constraints of traditional teaching models

Chowning (2005) reported an article as details shown below:

There were some teachers are uncomfortable with teaching ethics, a subject that science teachers often have very little experience with. Ethics as a discipline is full of unfamiliar terms and its own jargon. Other teachers fear classroom discussions getting out of control, degenerating into a battle of opinions, or having parents and administrators confuse teaching "about" values and morals with teaching "particular" values and morals. In addition, something as seemingly subjective as ethics can be perceived as somewhat out of place in a science classroom, where the focus is ostensibly on objectivity: "Why are we studying values in science class?" Students often come to class discussions with preformed opinions on many

ethical issues. The challenging task for teachers is to help students learn to identify the facts of a case, recognize the underlying ethical dilemmas, and to understand the different perspectives involved. Most students lack familiarity with ethics as a discipline and consequently are unable to articulate their stance or participate in a reasoned discussion about ethical issues in science. Because bioethical issues offer no single right answers or simple solutions, they foster an understanding of the importance of logic and reason when approaching complex problems. Ethics provides an authentic, motivating context for understanding science and relevance. Three components are key to promoting effective discussions related to ethics and science: content and lesson strategies, a decision-making model, and a familiarity with ethical perspectives.

4. Principle-Based Learning

In study of ethics, there are several reasons why many philosophers decide to use principles, rather than moral theories. David B. Resnik (1998:22) states;

> Many philosophers who study applied ethics prefer to work with general, ethical principles rather than moral theories because one can use principles to support an ethical decision or a social policy without defending an entire (possibly controversial) moral theory and another reason for employing general principles is that they are easier to understand, to teach and learn than moral theories. Finally, since principles are generally expressed in very general terms, they can be applied to a variety of cases and interpreted in different ways. This kind of flexibility allows one to apply principles to diverse cases without ignoring important details.

Nigel Barber (2002:213) also agreed that using ethical principles is more appropriate than moral theory, he describes;

> … Many applied ethicists avoid restricting themselves to any one ethical theory. Instead of focusing on theory, such pluralists direct their attention to core moral principles with which most people can agree. Applied ethics, including scientific ethics, and professional ethics in general, can operate effectively based on a few fundamental principles drawn from widely held values …

Also, according to His Majesty the King of Thailand's speech on the occasion of the merit-making ceremony in dedication to the past monarchs, or Thai พระราชพิธีบวงสรวงสมเด็จพระบูรพมหากษัตริยาธิราช, 5th May, B.E. 2525 (1982), in which shows how important

having morality; especially, honesty and social responsibility, is for all human beings. It can be summarized as follows:

> Moral principles that should be studied and practiced are comprised of (1) honesty and sincerity for ourselves in order to behave morally; (2) self-control to maintain that honesty; (3) tolerance and patience to prevent ourselves from acting dishonestly; and (4) refraining from dishonesty; sacrificing our trivial benefits for the sake of the entire society. With all these four principles, the nation will ultimately be in peace. *Unofficial translation*

Therefore, in this study, researcher makes mainly use of twelve principles of ethics in science, which is proposed and defended by David B. Resnik (1998) and aimed to apply to different aspects of the research process in order not to violate commonly accepted moral standards and to promote the advancement of scientific goals. The twelve principles are; 1) Honesty 2) Carefulness 3) Openness 4) Freedom 5) Credit 6) Education 7) Social Responsibility 8) Legality 9) Opportunity 10) Mutual Respect 11) Efficiency 12) Respect for subjects.

5. Research related to ethics in science classroom

Hall (2004) presented an article that is the opening section is a criticism of the view that science can be a source of moral and ethical values. This is followed by a proposal that could address the serious ethical problems created by scientific advances. The concluding section applied this proposal to a particular educational problem in science.

Donnelly (2004) presented an article that discusses the place of ethics in science education and suggests that there are three domains in which science and ethics are judge to meet: the ethical conduct of science itself, the study of sentient living things, and the broader range of socio-political issues with a scientific aspect. It goes on to discuss the last of these in relation to current views on science curriculum reform.

Wellington (2004) presented an article that argues that, in dealing with ethical issues, scientists and science teachers can no longer be a “neutral chair” (as in the humanities curriculum project of the 1970s). Science teachers as part of the science profession, must have positions on socio-scientific issues and on citizenship. The author calls this position ‘the view from science’ and argues that teachers should present this view in discussing controversial issues, rather than presenting it (or any other view) as

their own personal view. In this way, science teachers can make a unique offering to developing citizenship education will be incomplete in schools without the scientist's perspective and values.

Ratcliffe, Harris and Whirter (2004) reported on a research project that investigates the benefits and practicalities of a cross curricular approach to the study of ethical issues in biomedical science. Ethical analysis was an important feature of a 'collapsed day' program in which science and humanities teachers collaborated in producing a novel and interesting event for key stage 4 pupils on social and ethical aspects of genetics. Pupils valued the opportunity to learn more about genetics and ethical implications and share views. Teachers of science and humanities valued the opportunity to share expertise with a socio-scientific issue. However, further professional development should be available for teachers across disciplines to deal with ethical analysis effectively.

Conner (2007) reported on a research that shows some of the problems related to assessing learning about social and ethical issues are discussed and exemplified through a case study intervention with a final-year high school biology class in New Zealand. Students were required to write an essay of about 500 words about the biological, social and ethical implications of the issues associated with cancer. Self-and peer-assessment were used as part of the learning to provide opportunities for students to improve their assays. There are implications for teachers supporting students developing the skills of self-questioning, independent enquiry, critical thinking and essay writing.

Macer (2004) presented an article on the project "Bioethics education for informed citizens across cultures' has produced free online and printed teaching materials for bioethics education in different countries, in response to a global need for such materials. The main products are: materials for teaching bioethics; a textbook that could be used in school and university classes to teach about bioethical issues; and a network of teachers in different countries. Since early 2003 a group of authors and teachers has produced, revised and tested an international textbook in China, India, Japan, the Philippines and Taiwan. The project is being tested in other countries in 2004 to develop the teaching materials. Others are invited to join this cooperative network to share teaching ideas and conduct class trials of materials to teach students to cope with environmental and medical ethics issues across a range of disciplines.

Kempton (2004) presented an article that examines how cartoons and paintings can be used to teach and assess the understanding of ethical issues in science. Among the resources explored are paintings, concept cartoons, books of science cartoons and the internet.

Lysaght, Rosenberger and Kerridge (2006) reported the findings of a questionnaire administered to 375 undergraduate biotechnology students from 19 Australian universities to determine their attitudes towards the teaching of ethics. The results suggest that undergraduate biotechnology students generally regard ethics education to be important and that ethics should be included in undergraduate biotechnology curricula. Students tended, however, to emphasize the professional and industrial side of ethics and not to recognize the personal effects of morals and behavior. They provide suggestions for rethinking how ethics should be taught.

Levinson (2002) reported a paper that presents a study that investigates the teaching and learning aspects of controversial issues in science education in English which is mandatory. The study carries an exploratory nature and was conducted with the participation of (n=29) students where they were asked to answer three questions: (a) How do you think a "designer baby" is made? (b) What do you think a test-tube baby is? and (c) Some people think parents should have the right to choose things like the sex or eye color of their baby, what are your thoughts? Results indicate that teaching ethical and social issues raises issues in the instructional effectiveness of teachers.

Choi and Cho (2002) reported on research that examines the effects of formal teaching of ethical issues related to science on middle school students' attitudes towards science and science achievement. The results show that teaching ethical issues in science had a positive influence on the students' attitudes toward science, specifically the interest level in science and perception of the practicality of science knowledge.

Reiss (1999) reported an article that summarizes arguments for and against teaching ethics within science education, and clarifies what might be the several aims of teaching ethics in science. Discusses how ethics instruction might be incorporated into the science curriculum.

Choi, Cho and Kim (2000) reported research that examines the effect of teaching science ethical issues relevant to the idle school science curriculum. Concludes that teaching ethical issues in science had a positive influence on student attitudes toward science and fostered a positive impression of science education.

In conclusion, ethics should be a part of education for all students at all level, guided by the moral principles and the principles of ethics in science. Principle-based learning in many forms can be used to accomplish this.

6. Hybrid Learning

6.1 Definitions

As of now, there is no consensus on a single agreed-upon definition for blended learning. The terms "blended," "hybrid," and "mixed-mode" are used interchangeably in current research literature (Martyn. 2003). Hybrid courses are a blend of face-to-face and online instruction (Nicoletcollege: Online). In "hybrid" classes, a significant amount of the course learning activity has been moved online, making it possible to reduce the amount of time spent in the classroom. Traditional face-to-face instruction is reduced but not eliminated. The "hybrid" course model is also referred to as "blended." These terms are interchangeably used (University of Wisconsin Milwaukee (UWM). 2011: Online). More description of hybrid or blended course is explained as follows:

> "Hybrid" or "Blended" are names commonly used to describe courses in which some traditional face-to-face "seat time" has been replaced by online learning activities. The purpose of a hybrid course is to take advantage of the best features of both face-to-face and online learning. A hybrid course is designed to integrate face-to-face and online activities so that they reinforce, complement, and elaborate one another, instead of treating the online component as an add-on or duplicate of what is taught in the classroom.

> The definition of hybrid or blended continues to be a much debated topic, as does the use of the term hybrid or blended itself. Although many definitions of hybrid and blended learning exist, there is a convergence upon the three key points identified above. (1) Web-based learning activities are introduced to complement face-to-face work; (2) "seat time" is reduced, though not eliminated altogether; (3) the Web-based and face-to-face components of the course are designed to interact pedagogically to take advantage of the best features of each. This Web site uses the term "hybrid" throughout for historical reasons specific to our campus; we intend our usage, however, to include the alternative nomenclatures "blended" or "mixed mode" (UWM. 2011: Online).

According to the Program in Course Redesign, funded by the Pew Foundation, the Pew researchers created three models of blended instruction: 1) Supplemental Model 2) Replacement Model and 3) Emporium Model.

The Supplemental Model

The supplemental model retains the basic structure of the traditional course and uses technology resources to supplement traditional lectures and textbooks. The supplemental model for blended learning incorporates technology into the instructional approach of the course, but does not alter its basic structure. Students may be required to complete online readings or activities, or participate in lab sessions. However, there is no reduction in course meeting time under the supplemental model; a three-hour course would still meet in-class for three hours per week.

The Replacement Model

The replacement model reduces the number of in-class meetings, or classroom "seat-time," and:

- replaces some in-class time with out-of-class, online, interactive learning activities
- makes significant changes in remaining in-class meetings.

Under a replacement model, there are fundamental changes to the course. Unlike the supplemental model, the online resources in a replacement model are fully integrated into the overall instructional effort. The online content acts as a replacement for time that would have been spent in a lecture hall. Consequently, the nature of the in-class activities is changed as well. Instead of traditional lectures, in-class time is freed for more interactive, collaborative learning experiences.

The Emporium Model

The emporium model eliminates all class meetings and replaces them with a learning resource center. This resource center, typically a large computer lab, offers access to course online materials in addition to live assistance and guidance. The emporium model is a radical reconceptualization of the traditional course. Though attendance at the learning center can be required, there are no longer lectures in a traditional sense. Course content is delivered via online materials, and in-person help is provided in the learning resource center.

In this study, the focus of using hybrid learning was on the supplemental model which maintains the basic structure of the traditional course and uses the website to supplement the traditional ones.

6.2 The significant of hybrid learning.

An experimental project at the University of British Columbia showed that a mixed-mode university course, combining online learning and face-to-face meetings, can

encourage students to formulate and express their own ideas more than would be the case in traditional classroom (Breton, et al. 2005).

Pape (2006) states that in recent years, thanks to the evolution of the Internet, wide availability of classroom computers and increased broadband access, blended learning is emerging as a new tool in the K-12 educational toolkit. Defined as learning that combines online and face-to-face approaches, blended learning is accomplished through the combined use of virtual and face-to-face resources. Blended learning enables classroom teachers to increase student learning opportunities beyond the school day and school year, more closely resembling the 24/7 model with which the current generation of students is most familiar. Moreover, Zongmin (2006) says that:

> Internet is today the ubiquitous supporting environment for virtual and distributed learning environments. Consequently, many institutions, both public and private, take advantage of new technologies to offer training products and services at all levels. Compared with the classical educational methods, learning over the internet, that is, Web-based learning/training, has some advantages. First, the individual who wants to learn is not restricted by his/her geographical location or time limitation. Second, a person who can quickly grasp the subject matter need not wait for others to understand too, which is not possible in a typical classroom environment. At the same time, a person who is a little slow may take the course at his or her own pace. Third, courses developed for the Web may prove cheaper than hiring a qualified teacher each time the course is administered. However, just putting a tutorial online does not provide education in the real sense. There is always a need for communication between the tutor and the students as well as among students. Therefore, facilities such conferencing, mailing, bulletin boards, and so forth need to be sensibly applied and integrated with the course material. The course conducted may also be a combination of classroom sessions and the internet. More important, the Web-based learning/training system should very similar to human tutor. So such systems should be more intelligent through the adoption of artificial intelligence and cognitive science techniques.

According to the Hybrid Course Project at University of Wisconsin Milwaukee (2011: Online), the advantages of hybrid course are stated as follows:

> **New teaching opportunities:** "The hybrid took something I always knew was possible and let me do it."
>
> - Faculty can teach using a variety of online and in-class teaching strategies, which make it possible to achieve course goals and objectives more effectively.

- The hybrid model allows faculty to develop solutions to course problems and to incorporate new types of interactive and independent learning activities that were not possible in traditional courses.

Student engagement: "In the online classroom, there is no place to hide and in that sense, students can become more responsible than you could ever make them in a face-to-face classroom."

- Instructors report that they feel more connected with their students and are able to get to know them better since they communicate both online and face-to-face.
- Hybrid environments have the potential to increase and extend instructor-student and student-student connectivity and to build relationships even more so than in traditional or online courses.
- Discussions started in class are continued online and online interaction often carries over into the traditional face-to-face classes.
- Integration of out-of-class activities with in-class activities allows more effective use of traditional class time.
- Students who rarely take part in class discussions are more likely to participate online.

Increased student learning: "My students have done better than I've ever seen; they are motivated, enthused and doing their best work."

- Faculty believe that their students learn more in the hybrid format than they do in traditional class sections.
- Instructors report that students write better papers, performed better on exams, produced higher quality projects, and were capable of more meaningful discussions on course material when reflecting online.
- Students are better able to master concepts and apply what they have learned compared to students in sections of their traditionally taught courses.
- Students may develop higher-order skills of critical thinking, problem-solving, and the ability to apply theoretical models to real-world data.

New pedagogical approaches: This format "may challenge you in a whole new way of teaching."

- Learning to teach a successful hybrid course leads to using more participatory and student-centered learning activities.
- Teaching a hybrid course transforms the teacher-student relationship to be more centered on student learning.
- Instructors found that their role as teacher changed from being the "sage on the stage" to become more facilitative and learner-centered.

Documenting the process as well as the product of learning: "The main benefit is that everything is all laid out, well organized. It is all right there. There shouldn't be any mystery."

- Many instructors report that their course management system has increased their pedagogic efficiency because of its ability to organize the course and automate some basic activities such as quizzes, grading, and surveys.
- All the discussion threads, course documents, announcements, and grades are easy to find, refer to, and print if necessary.
- It's far easier to document online group work and participation for purposes of assessment.

In summary, hybrid learning is helpful and advantageous for both teachers and students in developing learning system.

7. Research related to hybrid learning

Brown (2001) describes research that has investigated and compared students in face-to-face classes, Web-based classes, and hybrid courses which combine both methods. The results that show hybrid courses have the highest success rate.

Ellis, Goodyear, Prosser and O'Hara (2006: Abstract) reported a paper that shows a phenomenographic investigation into students' experiences of learning through discussion--both online and face to face (F2F). The study context was a second-year undergraduate course in psychology for social work in which the teacher had designed discussion tasks to begin in F2F mode and to continue online. A combination of open-ended questionnaires and semi-structured interviews was used to investigate students' conceptions of what they were learning, their intentions and their approaches to learning through discussion. Analysis of the interview and open-ended questionnaire data identified a number of qualitatively different conceptions, intentions and approaches to learning through discussion. Associations were found between what students thought they were learning through discussions, their approaches to learning through discussion and their course grade. Students with a cohesive conception and students adopting a deep approach (to learning through online discussion) got better course grades. There was no significant difference between deep and surface approaches to F2F discussion and course grade. The outcomes of this study have implications for the design of online and F2F discussion tasks and in particular for helping students adopt richer conceptions of what they stand to gain through discussion.

Welker and Berardino (2006: Abstract) presented an article about how two researchers are trying to comfortably and logically place blended learning somewhere in the middle of two extremes--traditional classroom at one end and fully online distance learning at the other end. Twenty-two faculty and 38 students at the State University of New York Institute of Technology (SUNYIT) responded to a survey on perceptions held about blended learning. Responses from faculty revealed enrollment as a major factor in the increased use of this course design; quality of assignments and course grades that are as good or better; and courses that are producing improved writing and discussions. While the design is easy to use, faculty reported more work on their part and some loss of traditional classroom dynamics. Students reported flexibility, convenience, and independence as advantages, along with confusion, reduced social interaction, and more work as disadvantages. However, there appears to be a net economic gain for students as tuition and financial aid remain unchanged while expenditure in time and travel are reduced. Course management technology and course design recommendations are provided for faculty consideration. The boundaries between traditional classroom instruction and fully online distance learning are blurring. As course design moves more toward a fully online look-alike, expectations for a smoothly operating course will be higher for both faculty and students.

Riffell and Sibley (2005: Abstract) developed a hybrid course format (part online, part face-to-face) to deliver a high-enrollment, introductory environmental biology course to resident (living on or near campus), non-science majors at a large, public university. The hybrid course was structured to include bi-weekly online assignments and weekly meetings in the lecture hall focused on active-learning exercises. To evaluate the effectiveness of the web-based component of the hybrid course, we taught the hybrid course simultaneously with a traditional course in which we used passive lectures to cover material in the online assignments. Both courses received the same active-learning activities in class. Students in the hybrid course reported that the quality of interaction with the instructor was high, that they read the text more often and studied in groups more frequently. Performance on a post-course assessment test indicated that the hybrid course format was better or equivalent to the traditional course. Specifically, online assignments were equivalent to or better than passive lectures, and that active-learning exercises were more effective when coupled with online activities. Performance gains were greater for upperclassmen than for freshmen, indicating that hybrid course formats might be a superior option for upperclassmen when satisfying general science requirements.

Krawiec, Salter and Kay (2005: Abstract) A basic bacteriology course was offered in two successive academic years, first in a conventional format and subsequently as a "hybrid" course. The latter combined (i) online presentation of content, (ii) an emphasis on online resources, (iii) thrice-weekly, face-to-face conversations to advance understanding, and (iv) frequent student postings on an electronic discussion board. They compared the two courses through statistical analysis of student performances on the final examinations and the course overall and student assessment of teaching. The data indicated that there was no statistical difference in performance on the final examinations or the course overall. Responses on an instrument of evaluation revealed that students less strongly affirmed the following measures in the hybrid course: (i) The amount of work was appropriate for the credit received, (ii) Interactions between students and instructor were positive, (iii) I learned a great deal in this course, and (iv) I would recommend this course to other students. They recommend clear direction about active learning tasks and relevant feedback to enhance learning in a hybrid course.

Hall (1999: Abstract) stated that a "connected classroom" model was used for an educational psychology class which relied heavily on both face-to-face and Web-based collaborative discussion. As part of the class, students were required to participate in collaborative discussion that consisted of a structured environment in which students addressed open-ended questions about foundational class material. Each week students completed a Likert questionnaire on which they were asked to rate their subjective reactions to both Web-based and face-to-face collaborative activities. Results indicated that: (1) for the majority of subjective questions asked, responses to the face-to-face versus Web-based collaborative learning did not significantly differ; (2) students found the face-to-face learning to be more socially positive, and they reported learning more about others in their group; (3) for Web-based discussion, students found discussions of opinion questions to be less effective for promoting learning than application questions; and (4) students' appreciation of group members' views and the amount they reported learning about other students decreased over the course of the class across both formats.

From the aforementioned research, it can be summarize that hybrid learning provided both advantages and disadvantages for students. Frequently, the effectiveness of hybrid learning seems to be better or equivalent to the traditional approach and is the learning method that has the highest success rate.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter describes the details of the research methodology which was used to explore the study in order to develop and assess a learning approach of ethics in science with an emphasis on high school science students. This study is conducted in both quantitative and qualitative ways by using a one group pretest-posttest design. The research methodology in this study was comprised of five major sections as follows:

1. Participants
2. Research Procedures
3. Research Instruments
4. Data Collection
5. Data Analysis

Phase I: A survey of teachers and students' opinions on ethics in a science classroom

Participants

Teachers and students who participated in this study are as follows:

1. Pilot Study

1.1 Participating teachers were 3 Mahidol Wittayanusorn School social sciences and arts teachers.

1.2 Participating students were 28 Mahidol Wittayanusorn School students.

2. Main Study

2.1 Participating teachers were 107 science teachers from Mahidol Wittayanusorn School (MWITS) and 12 Princess Chulabhorn's Colleges (PCCs).

2.2 Participating students were 288 of grade 10 science students from Mahidol Wittayanusorn School (obtained by using simple random sampling) and 4 Princess Chulabhorn's Colleges (obtained by using multistage random sampling).

Research Procedures

There are 8 major steps in the first phase research study:

Step 1: Studying, gathering and summarizing information about survey study and related documents

Step 2: Creating, writing and determining the quality of the survey instruments

Step 3: Contacting, selecting and preparing involved teachers and students

Step 4: Conducting pilot study/preliminary study

Step 5: Revising the research instruments

Step 6: Conducting main study

Step 7: Gathering and analyzing data

Step 8: Drawing a conclusions

Research Instrument

The instruments used in this study were a Questionnaire of Science Teachers' Opinions on Learning Ethics in Science and a Questionnaire of Science Students' Opinions on Learning Ethics in Science (See Appendix B). The questionnaires consisted of four major parts as follows; Part I: Personal data of respondent, Part II: School's ethics learning in general, Part III: Respondent's ethics learning in the science classroom, and Part IV: Respondent's opinions on learning ethics in the science classroom.

The questionnaires were the combination of semi-closed-ended questions (both only one answer and multiple answers) and give reasons for choice in a survey. The researcher has modified some questions from a survey of Joan M. Booth and Jinnie M. Garret, Department of Biology, Hamilton College, Clinton, New York which was an instrument of a research study entitled "Instructors' Practices in and Attitudes towards Teaching Ethics in the Genetics Classroom". There were twenty-two questions for teachers and twelve questions for students in the surveys, most of them were created by the researcher. The Index of Consistency was conducted by three experts and then modified. A pilot test of the questionnaires was carried out with three teachers and twenty-eight students at Mahidol Wittayanusorn School. The questionnaires were revised and ready to use in the main study.

Data collection

The questionnaires were delivered to the coordinator of each school. At Mahidol Wittayanusorn School, the questionnaires were delivered to the main coordinator at school by the researcher himself. When it came to the12 Princess Chulabhorn's Colleges, the questionnaires were delivered to the main coordinator at Princess Chulabhorn's College Pathum Thani. Then, they were sent to all Princess Chulabhorn's Colleges. Eventually, science teachers and students completed and returned the questionnaires to the researcher, giving the response rate of 73.79 and 70.59 percent of teachers and students, respectively. These response rates were considered acceptable (Creswell. 2005).

Data analysis

Data analysis consisted of examining survey answers of teachers and student responses to the questions. Data were analyzed using descriptive statistics namely frequencies and percentages for respondents' answers. In addition, document analysis was used for open-ended questions.

Phase II: The incorporation of principle-based learning on ethics into a science classroom

Participants

Teachers and students who participated in the second phase of this study are as follows:

1. **Pilot Study**

Participating students were 23 of grade 10 students at the Mahidol Wittayanusorn School who studied in a general course of "Foundation of Chemistry" taught by the researcher in the first semester of the 2008 school year. Also, included were 28 students in a classroom of tenth graders at the Mahidol Wittayanusorn School in an elective course of "Scientific Ethics" taught by the researcher in the second semester of the 2008 school year.

2. **Main study**

Participating students were 24 of grade 10 students at the Mahidol Wittayanusorn School who studied in a general course of "Foundation of Chemistry" taught by the researcher in the first semester of the 2009 school year.

Research Procedures

There were 8 major steps of research procedures in this phase of study:

Step 1: Studying, gathering and summarizing information from the first phase of study as a preliminary result and also from related documents

Step 2: Creating, writing and finding the quality of lesson plans and research instruments

Step 3: Contacting, selecting and preparing the course

Step 4: Conducting the pilot study

Step 5: Revising lesson plans and research instruments

Step 6: Conducting the main study

Step 7: Gathering and analyzing student's learning outcomes

Step 8: Evaluating the learning approach

Research Instruments

There were 5 major research instruments used in this phase of study: 1) Questionnaire on Students' Opinion of Ethics in Science (QSAES) 2) The Test on Understanding of Ethics in Science (TUES) 3) Evaluation Form on Thinking Skills (EFTS; Practical and Ethical Thinking Skills) 4) Interviews Questions for Students (IQS) 5) Students' Participation Observation Form (SPOF).

Developing instruments and of finding the quality of each instrument are explained as shown in TABLE 7.

TABLE 7 DEVELOPING AND FINDING RESEARCH INSTRUMENTS' QUALITY

Research Instruments	Methods		Instruments' quality	
	Created by researcher	Adapted from others	Validity	Reliability
1. QSASTES	X	X	IOC*	CA**
2. TUES	X		IOC	Inter-rater coefficient
3. EFTS	X		IOC	CA
4. IQS	X		IOC	
5. SPOF	X		IOC	

* IOC = Index of Consistency

** CA = Cronbach's Alpha

Data collection

The data were collected from 24 participating students in a general chemistry class. Data were gathered during the main study phase. These data were obtained from various types of research instruments at different times as shown in TABLE 8.

TABLE 8 REASEARCH INSTRUMENTS AND DATA COLLECTION PERIODS

Instruments	Data collection periods			Subjects
	Before	During	After	
	the instruction			
1. TUES	X		X	All PS*
2. EFTS	X		X	All PS
3. QSAES	X		X	All PS
4. IQS			X	All PS (2 groups)
5. SPOF		X		All PS

*PS = Participating Students

TABLE 9 ETHICAL PRINCIPLES INCORPORATED IN THE LESSON PLAN IN THIS STUDY

Lesson Plan (Period)	Topics**	Ethical principle mainly used*	Lecture	Experiment	Assignment	Case study	Others
1-2	Orientation and introduction	1-12	√		√		
3-4	Atomic structure: atomic models	1,2,3,6 &10	√	√		√	
5	Subatomic particles	2 &7	√				√
6-7	Wave and its properties	1,2,3,10,11&12	√	√	√		√
8-9	Spectrum	9	√				
10	Ionization Energy	3 &10					√
11	Electron configuration	3 &10	√				√

TABLE 9 (continued)

Lesson Plan (Period)	Topics**	Ethical principle mainly used*	Lecture	Experiment	Assignment	Case study	Others
12	Cloud atomic model	3 &10					√
13-15	Electron configuration in shells	3 &10					√
16	Chemical bonding	3 &10					√
17-19	Ionic bonds	3,5,9,10 &11	√		√		√
20	Energy and ionic formation	9	√				√
21-22	Dissolution of ionic compound	1,2,3,10 &11	√	√	√		
23-24	Molecular and ionic formula	1,2,3,10 &11	√	√	√		
25	Conductivity of ionic compound	1,2,3,4,10 &11	√	√	√		
26	Types of covalent bonds	7					√
27-29	Covalent compounds' formula and nomenclature	3,6,7 &10	√		√		√
30-32	Shapes of covalent molecule and VSEPR	1,2,3,10 &11	√	√			√
33-35	Shapes of covalent molecule and VBT	3 &10					√
36	Molecular polarity	3&10	√				
37	Bond length, bond angle and bond energy	3,6 & 9	√				√
38-39	Bond energy calculation	9	√				√
40-41	Intermolecular forces	1&5	√		√		
42	Network covalent solids	3&10					√
43	Metallic bonds	7					√
44	Periodic table	1,9&10	√			√	√
45	The properties of elements in rows and periods	3,6&10			√		√
46-47	The properties of compounds in periods	1,2,3,10&11		√			
48	Transition elements and their properties	1,2,3,7,10&11		√			
49-50	Complex compound of transitions	1,2,3,10&11		√			
51	Complex compound formula and IUPAC nomenclature	6&9			√		√
52	Radioactivity	2,3,7,9&10	√		√		√
53	Nuclear reactions	1,2,3,4,7,9&10	√		√		√
54	Element position and property prediction	1-12	√				√

* 1 = Honesty	2 = Carefulness	3 = Openness	4 = Freedom
5 = Credit	6 = Education	7 = Social responsibility	
8 = Legality	9 = Opportunity	10 = Mutual respect	
11 = Efficiency	12 = Respect for Subjects		

From TABLE 9, besides the principles mainly used in the lesson plans such as in a lecture, assignment, experiment and case study, there were other approaches where principles incorporated, for instance, sub quiz or exam, group discussions, self-directed learning, ethics before class, ethics quotes, and a website.

Data analysis

The descriptive statistics, means and standard deviation, were mainly used to find the quantitative results. Document analysis was employed to find the qualitative results in the interviews.

Qualitative data analysis was also used to support the quantitative results of the learning outcomes. The observations were carried out during the on-going classroom instructions and follow-up interviews were performed after the completion of the course.

Development and examination of instruction materials

1. Lesson plans
   1.1 Related content and course syllabus of the fundamentals chemistry was studied.
   1.2 The obtained data from 1.1 was analyzed and used to create the lesson plans for 54 periods of teaching incorporated with the12 principles of scientific ethics.
   1.3 The lesson plans were submitted to a group of three experts who are involved with the social sciences, chemistry and educational subjects. The congruence evaluation of each lesson plan which was evaluated by the experts to find whether it is congruent with the objectives of the lesson, was performed by using questionnaires with a 3- level rating scale consisting of 1) congruent 2) not sure 3) not congruent (See Appendix J). Each lesson plan was analyzed by Item - Objective Congruence (IOC). Improvement of the lesson plans, regarding content validity, and language

was reconstructed consistent with the experts' suggestions and comments.

1.4 Students in grade ten at Mahidol Wittayanusorn School tried out the improved lesson plans for both clarification the appropriateness and quality. Lesson plans were tried out in a regular class of the fundamentals of chemistry in the 1st semester of the 2008 school year, and in part, mainly case studies, were also tried out in an additional class of scientific ethics in the 2nd semester of the 2008 school year taught by the researcher. Improvements of the lesson plan were done for making use of them in the main study, according to the students' comments and feedback.

2. A website of teaching ethics in science

A website, was created by the researcher, was based on the findings of the surveys. The procedures for developing and examining the website were as follows:

2.1 Related documents and research, mainly from the findings in the first phase of this study which are suggested by science teachers and students were studied.

2.2 The obtained data from 2.1 was analyzed and used to create the website which consists of important components regarding the survey results (See Appendix G)

2.3 The website was submitted to a group of three experts who are involved with the social sciences, chemistry and educational subjects. Another group of three experts are those who are involved with web page design and education technology to check on the consistency of the content and of the performance of web page. Improvement of the website, regarding content validity, language, patterns, color, font size and other aspects was reconstructed in regards to the experts' suggestions and comments.

2.4 The improved website was tried out with three ten graders at Mahidol Wittayanusorn School for clarification of language and performance. The determination of its appropriateness was performed and it was prepared for use in the main study.

Development and examination of research instruments

The objective was to evaluate the congruence of research instruments that were

created by the researcher and then examined by experts in order to find the defects of each component of the instruments so that improvements could be made before the field experiment. The examination of all research instruments is presented as follows:

1. Questionnaire on Students' Opinions on Ethics in Science (QSAES)

1.1 Related documents and the twelve principles of ethics in science were studied in details by considering David B. Resnik's (1998) description of each principle.

1.2 The 20 statements of questionnaire were created using the data from 1.1, based on Likert's 5 level rating scale of both positive and negative statements:

The positive rating scales of agreement

Strongly agree	:	5
Agree	:	4
Neutral	:	3
Disagree	:	2
Strongly disagree	:	1

The negative rating scales of agreement

Strongly agree	:	1
Agree	:	2
Neutral	:	3
Disagree	:	4
Strongly disagree	:	5

Meaning interpretation of mean scores is divided into five levels:

Very High	:	4.50 - 5.00
High	:	3.50 – 4.49
Moderate	:	2.50 – 3.49
Low	:	1.50 – 2.49
Very low	:	1.00 – 1.49

1.3 The questionnaire was submitted to three experts who are involved with the social sciences, chemistry and educational subjects. Improvement of the questionnaire, regarding IOC (content validity, language) was reconstructed being consistent with the experts' suggestions and comments.

1.4 The improved questionnaire was tried out with grade 10 students at

Mahidol Wittayanusorn School for clarify of language and a determination of questionnaire quality for each statement were performed. Finally, 17 efficient statements were chosen.

1.5 Determination of the questionnaire obtained from 1.4 was used to find reliability, calculated by using α-coefficient of Cronbach' method (Aiken. 1991:100). The reliability of the questionnaire by Cronbach's alpha is 0.887

2. The Test on Understanding of Ethics in Science (TUES) for measuring students' knowledge and understanding of ethical principles, issues and concepts in both pre-test and post-test were constructed using the following step:

2.1 Ethical principles, issues and concepts were studied based on David B, Resnik's (1998) proposal and defense.

2.2 The obtained data from 2.1 were used to create opened-understanding test.

2.3 The understanding test was submitted to a group of three experts who are involved with the social sciences, chemistry and educational subjects. Improvement of the test, regarding content validity, language was reconstructed in accordance with the experts' suggestions and comments.

2.4 The improved test was tried out with grade ten students at Mahidol Wittayanusorn School for clarify of language and determination of understanding test quality for each item were performed. Finally, 5 efficient test items were chosen.

2.5 Determination of the test quality obtained from 2.4 was used to find reliability, inter-rater reliability, calculated by using Pearson Product Moment Correlation (Aiken. 1991: 26). The reliability of the test by Pearson's correlation coefficient is 0.948.

3. Evaluation Form of Thinking Skills (EFTS; Practical Thinking Skills)

Evaluation form of thinking skills, Practical thinking skills was to check students' thoughts and opinions on scientific activities they are involved with both in practical and ethical ways. The evaluation form was administered before and after the main study with the following steps:

3.1 The twelve principles of ethics in science were studied in detail by considering at David B. Resnik's (1998) description of each principle.

3.2 The 48 statements for evaluation were created using the data from 3.1, based on Likert's 5 level rating scale of both positive and negative statements:

The positive rating scales of agreement

Strongly agree	:	5
Agree	:	4
Neutral	:	3
Disagree	:	2
Strongly disagree	:	1

The negative rating scales of agreement

Strongly agree	:	1
Agree	:	2
Neutral	:	3
Disagree	:	4
Strongly disagree	:	5

Meaning interpretation of mean scores is divided into 5 levels:

Very high	:	4.50 - 5.00
High	:	3.50 – 4.49
Moderate	:	2.50 – 3.49
Low	:	1.50 – 2.49
Very low	:	1.00 – 1.49

3.3 The evaluation form was submitted to three experts who are involved with the social sciences, chemistry and educational subjects. Improvement of the evaluation form, regarding IOC (content validity, language) was reconstructed in accordance with the experts' suggestions and comments.

3.4 The improved evaluation form was tried out in grade ten with students from Mahidol Wittayanusorn School for clarify of language and determination of evaluation form quality for each statement were performed. Finally, 38 efficient statements were chosen.

3.5 Determination of the evaluation form obtained from 3.4 was used to find reliability, calculated by using α-coefficient of Cronbach' method (Aiken. 1991:100). The reliability of the evaluation form is 0.848.

4. Interview Questions for Students (IQS)

4.1 All activities with incorporated ethics in classroom and research objectives were studied.

4.2 The obtained data from 4.1 was analyzed and used to create the questions of students on learning ethics in science.

4.3 The interview questions were submitted to a group of three experts who are involved with the social sciences, chemistry and educational subjects. The congruence evaluation of each question which was evaluated by the experts to find whether they were congruent with the objectives of the questions, was performed by using questionnaires with a 3 - level rating scale consisting of 1) congruent 2) not sure 3) not congruent (See Appendix C). Improvement of the questions, regarding content validity, and language was reconstructed in consistent with the experts' suggestions and comments.

4.4 The improved questions were tried out in grade ten with students from Mahidol Wittayanusorn School for clarify the appropriateness and quality. Improvements of the questions were done for making use in the main study, regarding to students' comments and feedback.

Statistics

1. Statistics used to analyze the quantitative data in this study were descriptive statistics, means and standard deviation. Document analysis was also used to analyze the qualitative data.

1.1 Means

1.2 Standard deviation

2. Statistics used to develop the instruments for validity and reliability are as follows:

2.1 Content Validity by Index of Item-Objective Congruence (IOC)

$$IOC = \sum R/N$$

Where IOC denotes Item-Objective Congruence

$\sum R$ denotes the sum of expert's opinion scores

N denotes the number of experts

Each congruent item is converted to a scoring system

"Congruent" is assigned a score of +1

"Not sure" is assigned a score of 0

"Not congruent" is assigned a score of -1

2.2 Cronbach's Alpha Coefficient

Cronbach's alpha (α) is a general formula for estimating the reliability of a test consisting of items on which two or more scoring weights are assigned to answers. It was a measure of squared correlation between observed scores and true scores. In other words, reliability was measured in terms of the ratio of true score variance to the observed score variance. The Cronbach's alpha equal to 1.0 when the total score variance was perfectly attributable to the common factors running through the test items. Cronbach's Alpha Coefficient was calculated by

$$\alpha = (k/(k-1)) * [1- \sum (s^2_i)/s^2_{sum}]$$

Where α denotes Cronbach Alpha Coefficient

k denotes the number of items in the group

S^2_i denotes the variances for the k individual items

s^2_{sum} denotes the variance for the sum of all items

2.3 Inter – rater reliability

Inter-rater reliability is a method of measuring reliability. It was used to determine the extent to which different raters agree with each other in scoring the responses of different examinees and items. The most common approach to determining this inter-rater reliability is to have two persons score the responses of a sizable number of examinees and then compute the correlation between the scores assigned by the two scores. This process yields an inter-rater reliability coefficient. In this study, the Pearson Product-Moment Coefficient or r, was used. The range of r is in value from -1.00 (perfect inverse relationship) through 0.00 (absence of a relationship) to +1.00 (perfect direct relationship).

CHAPTER 4

FINDINGS

This chapter presents the results and interpretations of the two phase mixed-methods research which are a survey and experimental research. Data analysis and the results of the research are provided as the following topics:

1. The results of phase I: A survey of teachers and student's opinions on ethics in a science classroom
2. The results of phase II: The incorporation of principle-based learning of ethics into a science classroom

Phase I: A survey of teachers and students' opinions on ethics in a science classroom

The results of a quantitative survey of teachers and students' opinions on learning ethics in science are shown as follows,

1. Personal data of respondent

Personal data of respondents, teachers and students from Mahidol Wittayanusorn School (MWITS) and Princess Chulabhorn's Colleges (PCCs), are presented in TABLE 10 and 11, respectively.

TABLE 10 SUMMARY OF THE QUESTIONNAIRE TEACHERS' PROFILE

Variables		Schools				Total	%
		MWITS		PCCs			
		N = 27	%	N = 80	%	N = 107	100
Gender	Male	12	44.4	28	35.0	40	37.4
	Female	13	48.2	40	50.0	53	49.5
	Not specify	2	7.4	12	15.0	14	13.1
Age (year)	20-25	1	3.7	5	6.3	6	5.6
	26-29	12	44.5	14	17.5	26	24.3
	30-35	10	37.0	28	35.0	38	35.5
	36-40	-	-	8	10.0	8	7.5

TABLE 10 (continued)

Variables		Schools				Total	%
		MWITS		PCCs			
		N = 27	%	N = 80	%	N = 107	100
	More than 40	4	14.8	25	31.2	25	27.1
Level of education	Bachelor's	8	29.6	46	57.5	54	50.5
	Master's degree	16	59.3	32	40.0	48	44.9
	Doctoral degree	1	3.7	-	-	1	0.9
	Other	2	7.4	2	2.5	4	3.7
Years of teaching experience	1-5	13	48.2	13	16.2	26	24.3
	6-10	10	37.0	23	28.8	33	30.8
	More than 10	4	14.8	44	55.0	48	44.9
Field of subjects	Chemistry	9	33.4	25	31.25	34	31.8
	Biology	10	37.0	25	31.25	35	32.7
	Physics	8	29.6	30	37.5	38	35.5
Grade of teaching	Grade 10	17	63.0	41	38.7	58	40.5
	Grade 11	12	44.4	34	32.1	46	32.2
	Grade 12	8	29.6	31	29.2	39	27.3
Participation in scientific ethics activities	Yes	8	29.6	24	30.0	32	29.9
	No	19	70.4	56	70.0	75	70.1

From TABLE 10, it is seen that the majority of the respondents are female who are in the age range of 30-35. Most of teachers have a Bachelor's and Master's degree and have more than of 10 years of teaching experience. The number of chemistry, biology and physics teachers is almost the same. Most teach grade 10 students. As for participation in scientific ethics activities, mostly, they have not participated.

The results also indicated that 87.5%, 6.25% and 6.25% of teachers have ever studied/been trained/ attended a seminar or conference on ethics in science for 1-5, 5-10 and more than 10 times, respectively. In addition, 53.1% of teachers rated their level of satisfaction of their participation in activities as high or very high.

TABLE 11 SUMMARY OF THE QUESTIONNAIRE STUDENTS' PROFILE

Variables		Schools				Total	%
		MWITS		PCCs			
		N =72	%	N =216	%	N=288	100
Gender	Male	46	63.9	74	34.3	120	41.7
	Female	25	34.7	142	65.7	167	58.0
	Not specify	1	1.4	-	-	1	0.3
Age (year)	14	-	-	1	0.5	1	0.4
	15	25	34.7	49	22.7	74	25.7
	16	42	58.3	149	69.0	191	66.3
	17	-	-	13	6.0	30	4.5
	Not specify	5	7.0	4	1.8	9	3.1

TABLE 11 shows that the majority of the respondents are female who are at the age of 16.

2. School's general learning in ethics

A total of 82.2% teachers reported that their schools offer at least one course in ethics to students. Mostly, (66.3%) the courses do not include any that focuses on science and ethics in science and 15.9% reported that there is one course focuses on science and ethics. About 18 percent of teachers addressed that their school does not offer any courses. Most of teachers stated that the schools have core requirements that include some ethical components for all students by requiring students to take a specific course relating to ethics or to attend some non-classroom activity; for instance, ethics camp and community service.

The survey showed that 37.9% of students rated their level of understanding of ethics in science as high or very high as shown in FIGURE 3.

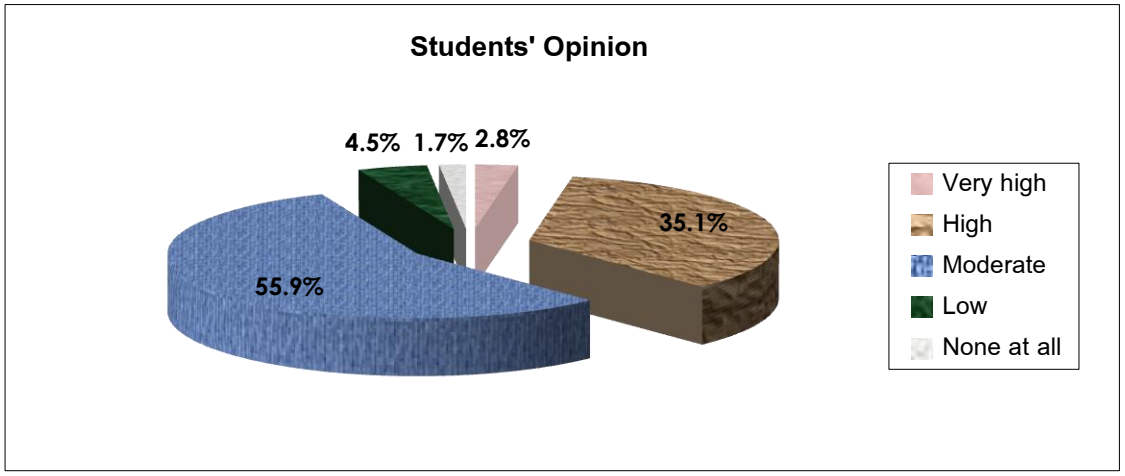

FIGURE 3 STUDENTS' OPINION ON THIER LEVEL OF UNDERSTANDING ETHICS IN SCIENCE

In addition, 66.3 % thought that they are interested in studying ethics in science as high or very high as shown in FIGURE 4.

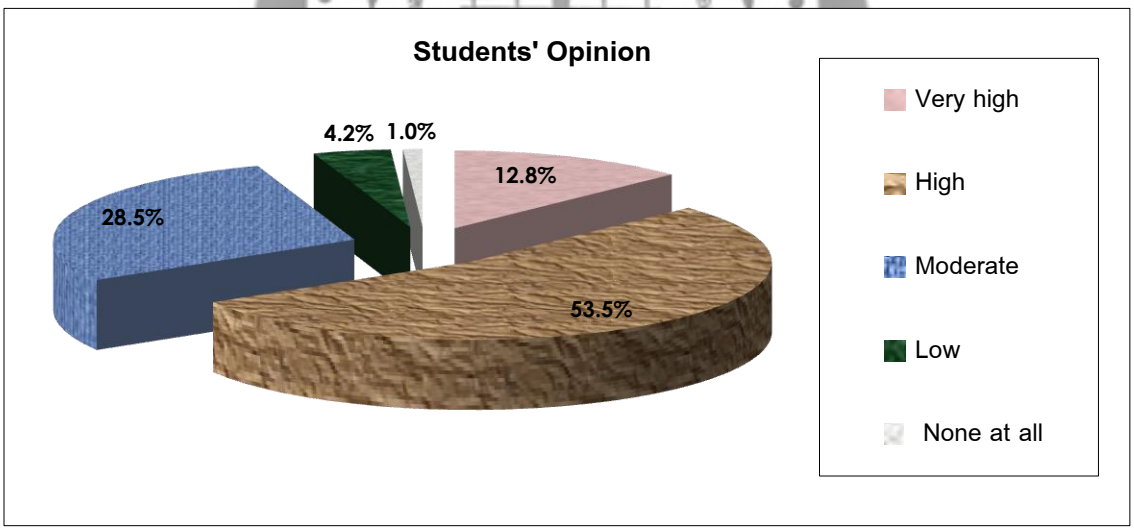

FIGURE 4 STUDENTS' OPINION ON THEIR INTEREST IN STUDYING ETHICS IN SCIENCE

That ethics in science is important was rated high or very high by 92.7 % of the students (See FIGURE 5). The reasons of such importance are as in the following examples that were given;

"If scientists have no ethics, the consequences would be harmful to public",

“Ethics is what all scientists must have in doing research”,

“Science can be used in both good and bad sides, but if it does not get along with ethics, then it will be damaged”

“To make us good and ethical scientists”

“Ethics will build a good society”

“If scientists had no ethics in working, the results would not be successful and would be harmful to others as well”.

“If scientists lack ethics, then the research findings would not be trusted”

“If scientists lack ethics, then the advancement will decrease”

“To be highly successful, scientists should be ethical”

“Without ethics, everything will be mistaken”

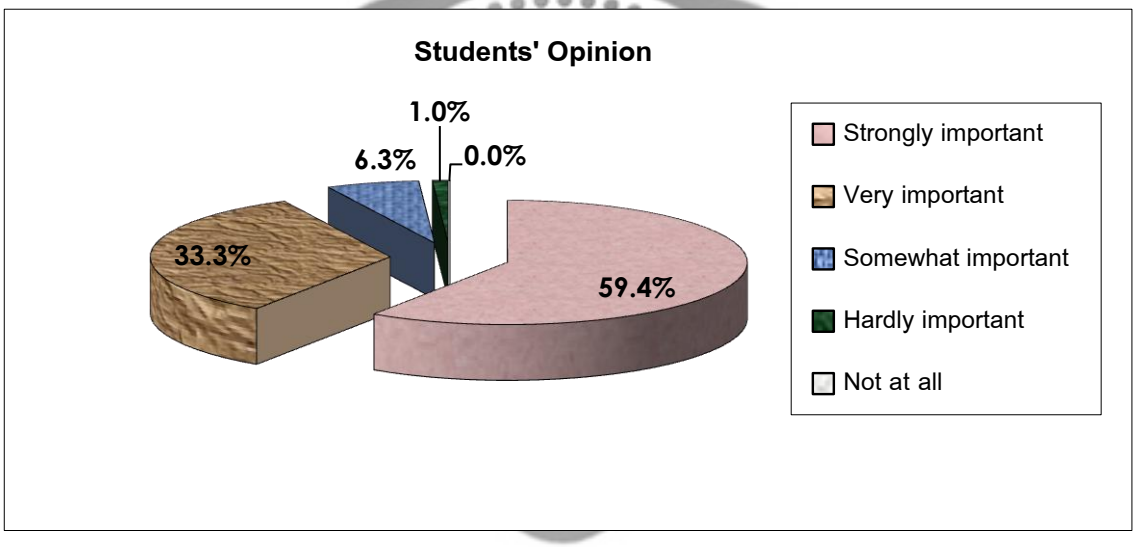

FIGURE 5 STUDENTS’ OPINION ON THE IMPORTANCE OF ETHICS IN SCIENCE

3. Respondent’s ethics learning in the science classroom

The survey reported that 91.6% of teachers introduced or incorporated ethics into a science classroom by using different pedagogical methods; for example, formal lecture, assigned readings and papers, open informal discussions/small group discussions/debate, inquiry-based learning, simulations/role-playing/drama projects, small group research and seminar presentations and others. Forty nine percent of these teachers rated their satisfaction with their introduction of ethics in the class as high or very high. For teachers who have never introduced or incorporated ethics into a science classroom but are

interested in doing so, they would like to introduce it into the science classroom by using simulations/role-playing/drama-projects, watching/editing TV news video, inquiry-based learning, science fiction and games and so on.

As for students, 61.8% learned ethics in the science classroom through formal lecture, having a visiting speaker, assigned reading and papers, and science fiction and so on. About 58.4% of students in this group rated their satisfaction with learning ethics in science as high or very high. Approximate 38.2% of students who have never learned ethics in science before, but would like to do so. They reported that they would like to learn it through simulations/role-playing/drama projects, science fiction, having a visiting speaker, watching or editing TV news video, painting, cartoons, inquiry-based learning, issue-based learning, open informal discussion/small group discussions/debate, case study analysis and so on.

In total, 68.2 % of teachers included ethical issues in the main assigned textbook. Mostly, in a special section separated from the main body of the text. The ethical issues included were a variety of prominent ethical principles, impact of research on the individuals or society and consideration of diversity of values and beliefs which are the first three ethical issues students have learned in their science classrooms. About 26.2% of teachers indicated that they have not included ethical issues in the main assigned textbooks at all. Furthermore, 49.5% of teachers incorporated extra materials into the lesson aside from the assigned text book that specifically focused on ethical issues. About 25.3% of teachers devoted approximately 20% of their class time to ethical issues and 71% of teachers in this group counted the ethical components of the class towards the students' grades which were based on papers/assignments and participation in discussions.

Most of teachers (53.3%) reported that they included as much coverage of ethical issues in their course as they think it should be and 43.9% of them were satisfied with that amount as high or very high. About 46.7% of teachers stated that they did not think that they included as much coverage of ethical issues in their course as it should be. The main reasons given are the 1) lack of class time for ethical issues 2) uncomfortable, lack of knowledge and resources on the subject 3) lack of preparation time for ethical issues as shown in FIGURE 6. There was only one teacher who was not interested in it and thought it was not necessary to teach. Three of them who chose others, their responses were as follows:

"Ethical issues were not evaluated directly, just incorporated ethics during activities regarding of appropriateness"

"Ethical knowledge was not focused on, but more of ethical practise"

"The consistency between the content and incorporated ethics"

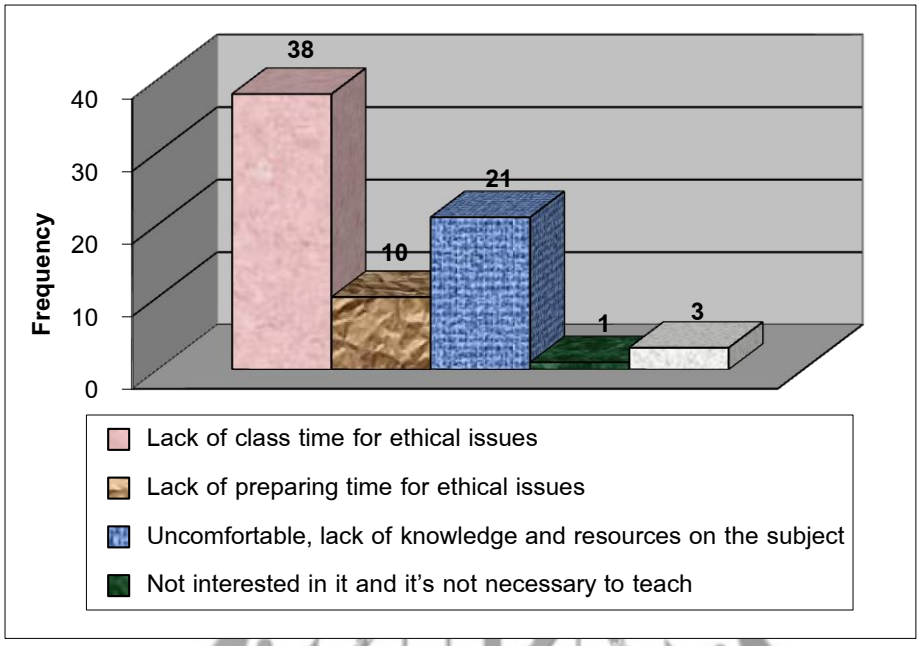

FIGURE 6 THE REASON WHY TEACHERS DID NOT INCLUDE AS MUCH COVERAGE OF ETHICAL ISSUES IN THEIR CLASS

4. Respondent's opinion on learning ethics in the science classroom

Science teachers and students chose 5 out of 12 principles of scientific ethics (proposed and defended by David B. Resnik, 1998) that they thought are most important and ranked them in order of importance. The results are as shown in FIGURE 7.

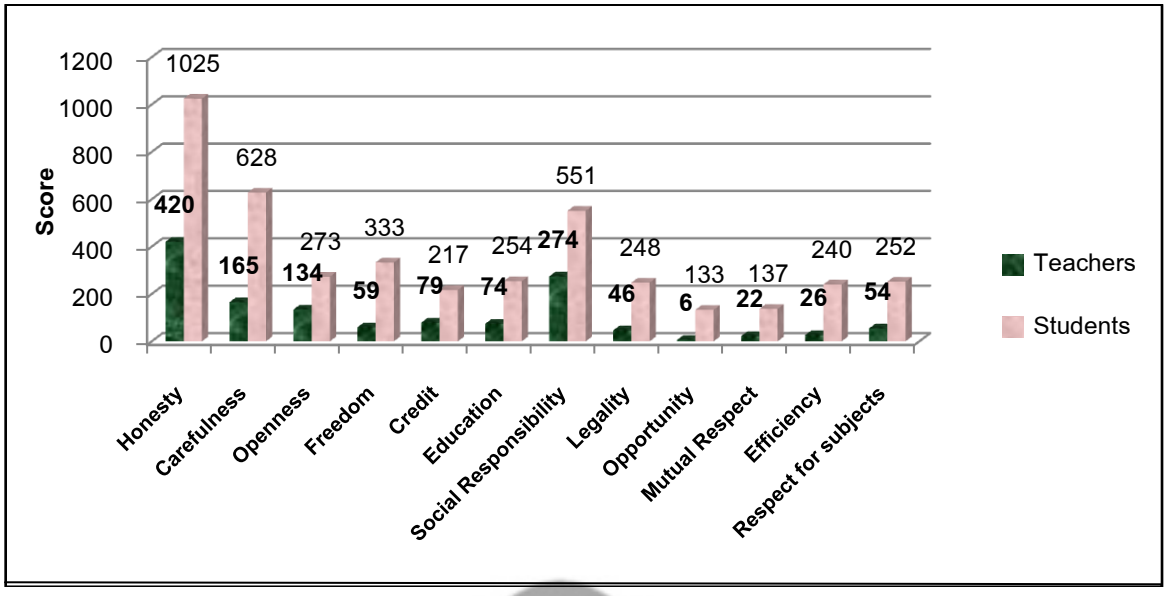

FIGURE 7 THE RANK OF THE IMPORTANCE OF SCIENTIFIC ETHICS PRINCIPLES

From FIGURE 7, the top five important scientific ethics principles, for science teachers, are honesty, social responsibility, carefulness, openness and credit, respectively. When it comes to science students, the results are honesty, carefulness, social responsibility, freedom and openness, respectively.

A total of 76.6% of teachers thought that there should be an academic requirement of ethics for science students. Majority of these teachers, 75.6%, recommended that it should be in the core curriculum requirements for all students and 20.7% of them recommended that it should be in the elective courses for the students who are only interested in it. About 61.2% of teachers thought that science students should be exposed to ethical issues in a regular science classroom. On the other hand, 16.5% of them thought that it should be in a class with a specific science and ethics focus, and 18.2% thought that it should be in unrelated ethics courses offered by schools as shown in FIGURE 8. Interestingly, 2.5% thought that it should be in other ways such as students should learn both in regular science classroom and in a class with a specific science and ethics focus. Another idea was to encourage students to be active in ethical activities. On the other hand, there were two teachers (about 1.6%) who thought that science students should not be exposed to ethical issues or concepts.

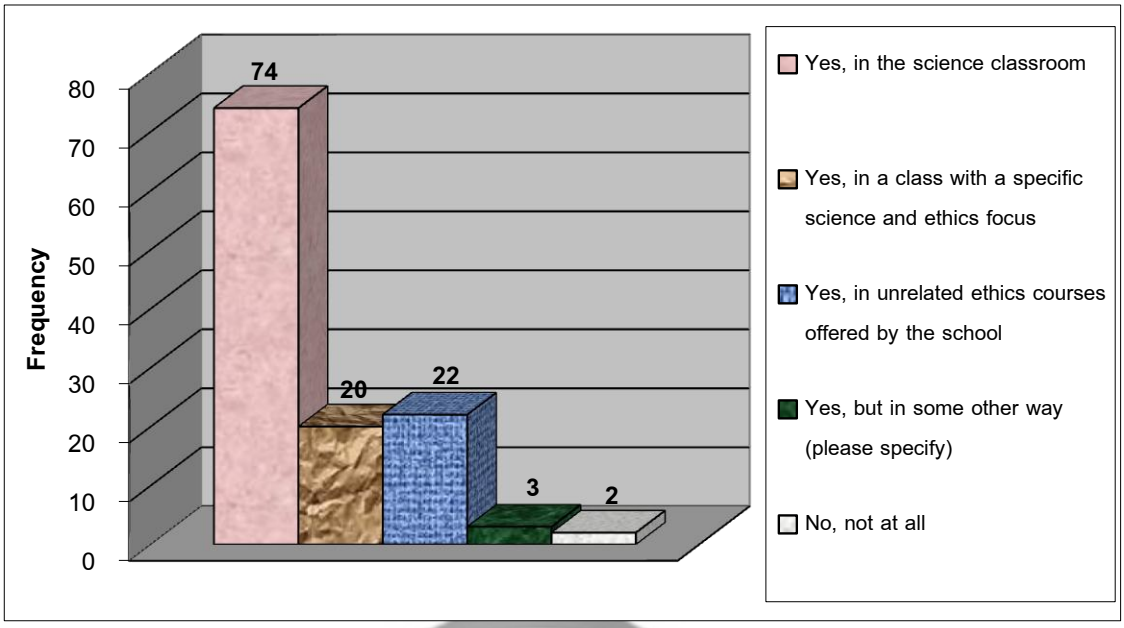

FIGURE 8 THE CLEAR EVIDENCE THAT LEARNING ETHICS SHOULD BE IN A REGULAR SCIENCE CLASSROOM RATHER THAN AN ADDITIONAL ONE

In total, 71.2% of students thought that there should be an academic requirement of ethics for science students. About 55.1% of these students recommended that it should be in the core curriculum requirements for all students and 38% of them recommended that it should be in the elective courses for the students who are only interested in it.

Most of science teachers and students are interested in several different kinds of activities, inside and outside of the classroom, group discussions and web-based learning as pedagogical methods for learning ethics as shown in FIGURE 9.

A majority (62.6%) of teachers and 64.6% of students thought that hybrid learning (the combination of face-to-face and web-based learning) would be an appropriate pedagogical method of learning ethics. The website should look fashionable and interesting, be easy to access and use, be easy to learn from anywhere, anytime and have various components as shown in FIGURE 10. The major components of the website should be 1) learning materials 2) resources or related websites 3) news and announcements 4) course syllabus 5) web board or chat room 6) moral music or songs. There were more recommendations which are animation, ethical movies, etc. (See FIGURE 11)

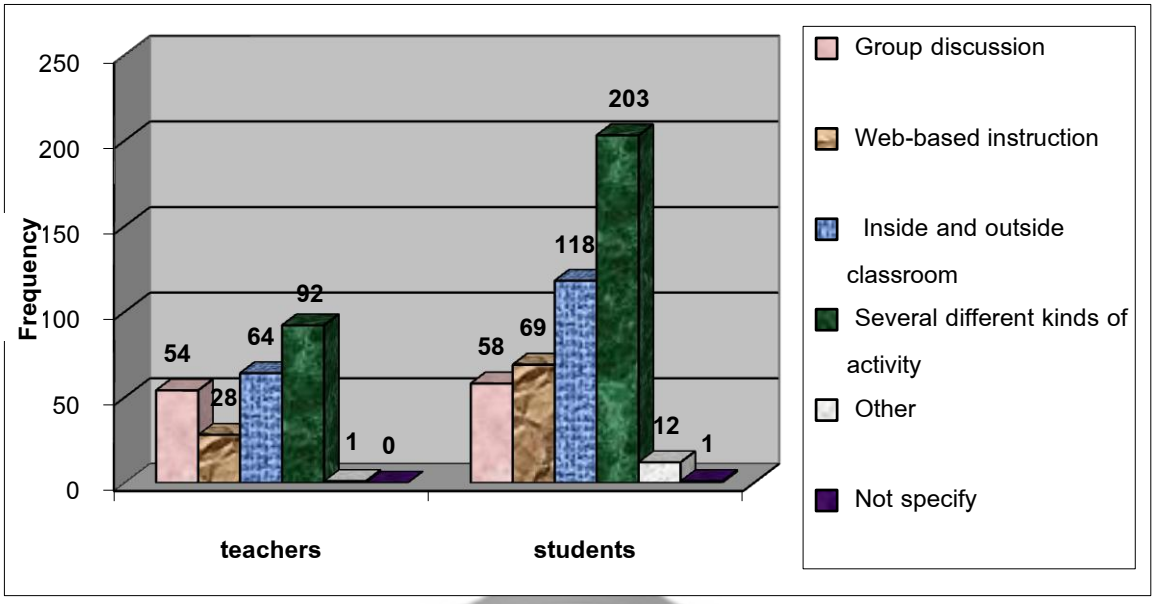

FIGURE 9 TEACHERS' AND STUDENTS' OPINIONS ON PEDAGOGICAL METHODS FOR LEARNING ETHICS

Most of teachers thought that there should be enhancements of thinking skills for students in learning ethics in science which are practical, ethical, analytical, and creative thinking skills. Most of students thought that there should be creative, ethical, practical and analytical thinking skills. Furthermore, synthesis thinking skill, team working, and scientific process could be enhanced as well.

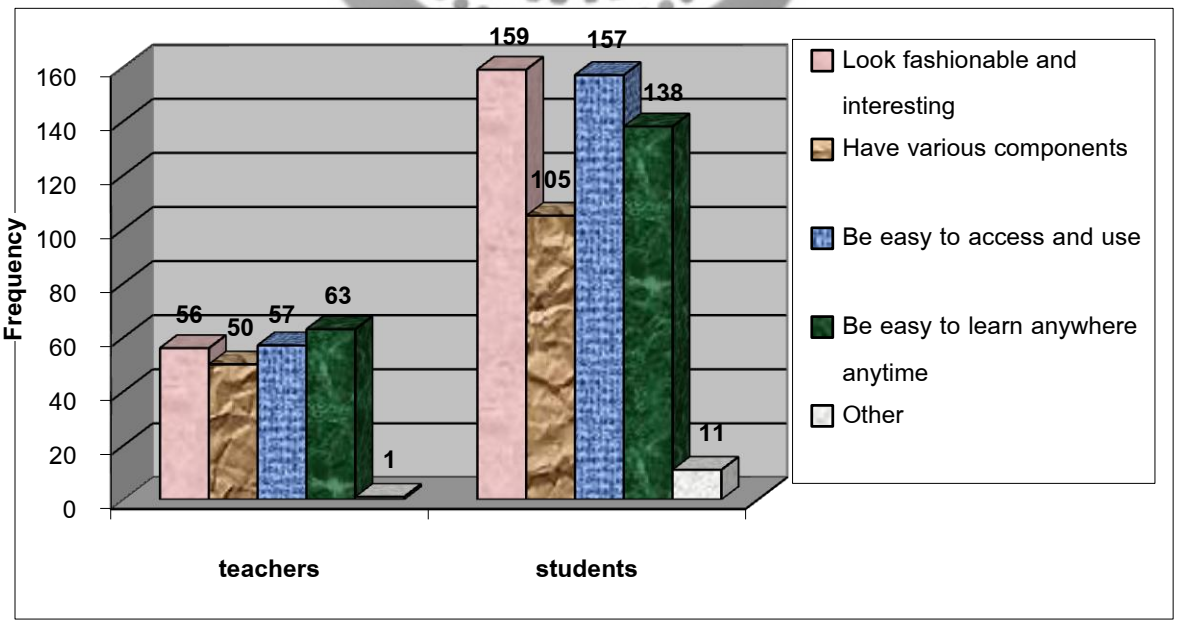

FIGURE 10 TEACHERS' AND STUDENTS' OPINIONS ON THE WEBSITE

The survey found that 85% of teachers would participate if there was to be a training workshop or seminar on pedagogical methods of ethics for science teachers. Their responses were as follows:

"If it would be interesting and could be applied in reality"

"It is interesting, helpful and should be cultivated to everyone."

"I seriously would like to implement it in the science classroom."

"It could be a guideline for curriculum development."

"It could be a guideline for helping students to aware of scientific ethics."

"To fulfill the knowledge for the teachers themselves and to have experience and expertise for teaching students with several ways in classroom"

"It seems to be interesting and beneficial to society."

"It is more important than academic knowledge."

"To share techniques and teaching method of scientific ethics in classroom"

The reasons of about 8.4% of teachers who wouldn't participate are "Not sure yet" and "No enough time to participate."

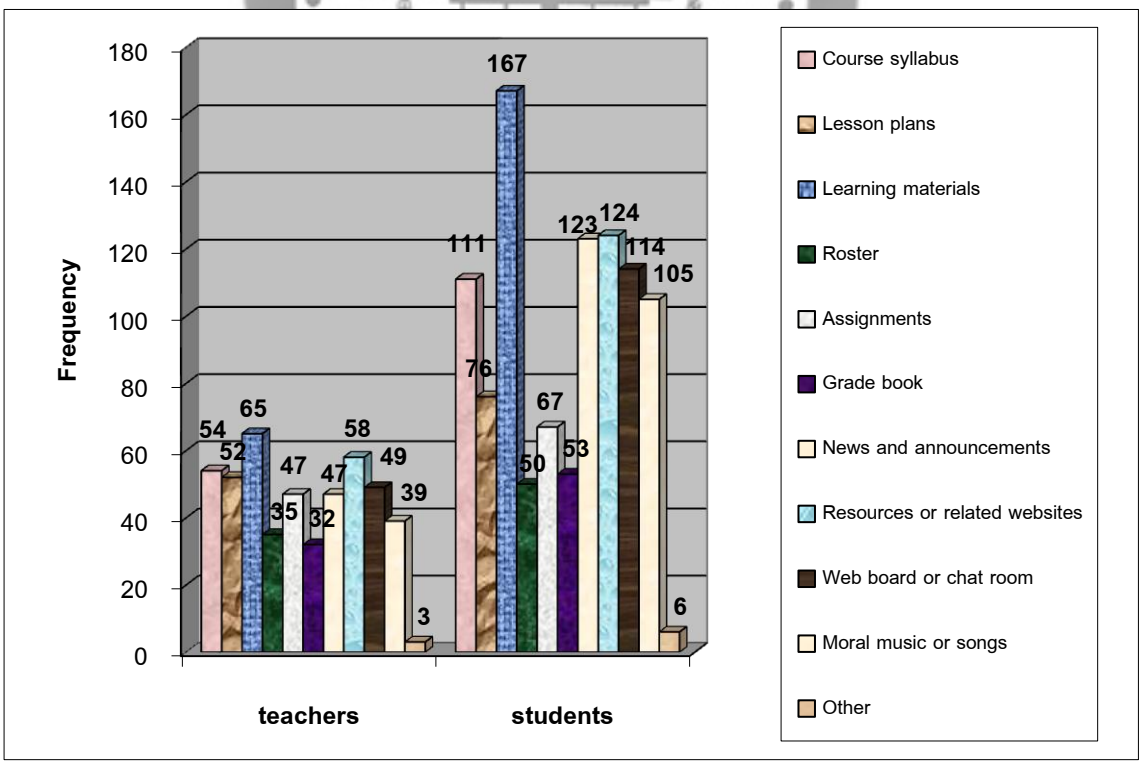

FIGURE 11 TEACHERS AND STUDENTS' OPINIONS ON THE MAJOR COMPONENTS OF THE WEBSITE

Phase II: The incorporation of principle-base learning on ethics into a science classroom

1. The results of the first objective: to promote, develop and assess students' understanding of key ethical issues, concept and principles in science.

The result of the understanding test on ethics in science is shown in TABLE 12.

TABLE 12 PRETEST AND POSTTEST SCORE OF THE UNDERSTANDING TEST ON ETHICS IN SCIENCE

No.	Score		No.	Score	
	Before	After		Before	After
1	8.0	15.0	13	6.0	13.5
2	6.5	14.0	14	5.5	14.0
3	7.5	12.5	15	5.0	13.5
4	8.0	14.0	16	5.5	11.5
5	7.5	13.0	17	4.5	13.5
6	7.5	11.0	18	4.0	14.5
7	7.0	15.0	19	5.0	12.0
8	7.0	12.5	20	5.5	12.5
9	3.5	10.0	21	2.0	13.5
10	9.0	14.5	22	4.0	14.0
11	7.0	12.5	23	7.0	11.0
12	7.0	9.5	24	9.5	15.0
			Mean	**6.2**	**13.0**
			S.D.	**1.81**	**1.55**

From TABLE 12, the posttest score of all students are higher than the pretest score. The mean of pretest and posttest are 6.20 (S.D. = 1.81) and 13.0 (S.D. = 1.55) respectively. This showed that the mean of posttest is greater than the pretest. It can be concluded that students have better understanding of ethics in science.

According to the interviews, when the students asked what they thought about the understanding of the concepts and principles of ethics in science they have learned in this semester, some of their thoughts were:

- I better understood because I never learned this in a lower secondary school. There was just general ethics, especially, Buddhism ethics. When I learned here, I better understood the principles of ethics in science.
- In terms of “animals in research”, I have never known this before. I always thought that killing animal is prohibited. In fact, we can use animals and kill them if needed, basically for research purpose.
- To use animals in research, if the researcher has no ethics, animals could die. On the other hand, if the researcher has ethics, they should minimize the number of animals and try not to harm them.
- I agree, Based on Buddhism beliefs, killing animals is wrong, but in research, they must be killed after the research is done. Even though it conflicts with the religious principle, but it’s for all, for public.
- I understand that there is a teacher who is interested in ethics more than other teachers.
- I got better understanding because there were case study worksheets to do.
- I understand but I don’t know if there would be anyone who takes it to action. It depends on individuals and time or sometimes from the experimental results.
- Most parents care about only grade point so that sometimes students needed to copy others’ homework. Also, it depends on each individual’s value and time limitation. We had to make up labs because most teachers always look at the results first.
- I got better understanding on it.

2. The results of the second objective: to develop and assess students’ analytical, creative, practical and ethical thinking skills along with communicative skills in learning ethics in science.

The results of thinking skills from the questionnaire are shown in TABLE 13.

TABLE 13 THE MEANS AND STANDARD DEVIATION OF PRACTICAL THINKING SKILLS

No.	Statement	Before		After	
		Mean (S.D.)	Interpretation	Mean (S.D.)	Interpretation
1	Honesty I draw a conclusion and report my result as its real data as obtained from an experiment.	4.13 (0.61)	High	4.25 (0.53)	High
2	I don't fabricate or falsify data from experiment in order to get the expected result.	3.79 (0.59)	High	4.04 (0.81)	High
3	I ask or copy my friends' exams.	4.29 (0.89)	High	4.46 (0.66)	High
Mean rating for the principle of honesty		**4.07**	**High**	**4.25**	**High**
4	Carefulness I conduct an experiment and present results by minimizing experimental and human error.	3.83 (0.70)	High	4.08 (0.93)	High
5	I avoid self-deception and bias in experiments.	3.92 (0.78)	High	4.17 (0.76)	High
Mean rating for the principle of carefulness		**3.88**	**High**	**4.13**	**High**
6	Openness I usually would like to share data, results, methods or ideas with peers.	4.21 (0.66)	High	4.67 (0.48)	Very high
7	I would like my peers to be able to review my experimental results or science project.	4.04 (0.62)	High	4.54 (0.59)	Very high
8	I am open to criticism and new ideas on my experimental results or science project.	4.25 (0.61)	High	4.54 (0.59)	Very high
9	I don't want anybody know important data of my results or science project that I am doing, and not completely finish yet	3.21 (0.78)	Moderate	3.50 (1.18)	High
10	I don't want to perceive new ideas, methods, or peers.	3.71 (1.00)	High	4.54 (0.59)	Very high
11	I like working cooperatively and trust the others.	3.96 (0.69)	High	4.42 (0.58)	High
Mean rating for the principle of openness		**3.90**	**High**	**4.37**	**High**

TABLE 13 (continued)

No.	Statement	Before		After	
		Mean (S.D.)	**Interpretation**	**Mean (S.D.)**	**Interpretation**
12	Freedom I like to be free to conduct research on any problem or hypothesis.	4.04 (0.69)	High	4.29 (0.69)	High
13	I like to be free in doing inquiry in science for my experiment or science project.	4.04 (0.81)	High	4.71 (0.46)	Very high
14	If I had a freedom in doing an experiment that may harm the others, I would do it.	3.96 (1.08)	High	4.71 (0.46)	Very high
Mean rating for the principle of freedom		**4.01**	**High**	**4.57**	**Very high**
15	Credit I put my friend's names who are not involved in the experiments or group work in the report or assignment.	2.58 (0.78)	Low	2.25 (1.19)	Low
16	I agree on the punishment for students who copy other students' assignment or plagiarize	3.50 (1.06)	High	3.79 (1.02)	High
Mean rating for the principle of credit		**3.04**	**Moderate**	**3.02**	**Moderate**
17	Education I always teach or explain my friend on the topics or experiments they don't understand.	3.83 (0.70)	High	4.42 (0.65)	High
18	I want to make sure that my friends always do the good and proper experiment.	3.58 (0.78)	High	4.50 (0.59)	Very high
19	If I had a change to educate or give a seminar or workshop in science to community or public, I am willing to do it.	3.88 (0.80)	High	4.29 (0.69)	High
Mean rating for the principle of education		**3.76**	**High**	**4.40**	**High**
20	Social responsibility I will definitely not do any science experiment that harm school or society.	4.38 (0.58)	High	4.71 (0.46)	Very high
21	I will try to bring scientific knowledge to make best benefit to society.	4.29 (0.62)	High	4.54 (0.51)	Very high
22	I will take my responsibility on my science experiment or project I have conducted.	4.08 (0.72)	High	4.54 (0.59)	Very high

TABLE 13 (continued)

No.	Statement	Before		After	
		Mean (S.D.)	Interpretation	Mean (S.D.)	Interpretation
23	I will inform public or society knows about the scientific results or findings.	3.88 (0.74)	High	4.13 (0.45)	High
Mean rating for the principle of social responsibility		**4.16**	**High**	**4.48**	**High**
24	Legality I always do my experiments or science project under the code of conduct or related standard.	4.17 (0.92)	High	4.46 (0.66)	High
25	I will conduct an experiment with high get paid regardless of legality.	4.00 (0.98)	High	4.42 (0.58)	High
26	I do not use hazardous and prohibited chemicals, human and animals in experiment if I am not legally allowed.	4.46 (0.78)	High	4.75 (0.44)	Very high
Mean rating for the principle of legality		**4.21**	**High**	**4.54**	**Very high**
27	Opportunity I'm not satisfied if It is unfair for me in using resources in doing science experiment or project.	3.83 (0.82)	High	4.13 (0.99)	Very high
28	I think female scientists should get the equal opportunity as well as male scientists in doing scientific work.	4.67 (0.56)	Very high	4.92 (0.28)	Very high
Mean rating for the principle of opportunity		**4.25**	**High**	**4.53**	**Very high**
29	Mutual respect I don't want my peers to harm me both physically and mentally.	4.17 (0.70)	High	4.75 (0.44)	Very high
30	I respect the privacy of all group members.	4.08 (0.65)	High	4.58 (0.50)	Very high
31	I won't get involved in my peers' experiment which can cause danger, if not allowed.	4.21 (0.51)	High	4.38 (0.65)	High
Mean rating for the principle of mutual respect		**4.15**	**High**	**4.57**	**Very high**

TABLE 13 (continued)

No.	Statement	Before		After	
		Mean (S.D.)	**Interpretation**	**Mean (S.D.)**	**Interpretation**
32	Efficiency I always use materials and chemicals in experiments efficiently. (worth, value, and most effective).	3.96 (0.69)	High	3.88 (0.61)	High
33	I will minimize animals in lab and most efficient or I will use other subjects instead of animals if possible.	4.17 (0.87)	High	4.54 (0.66)	Very high
34	I will use resources that can be reused.	3.88 (0.61)	High	4.21 (0.51)	High
Mean rating for the principle of efficiency		**4.00**	**High**	**4.21**	**High**
35	Respect for subjects I will treat animal subjects with care and respect	4.33 (0.64)	High	4.58 (0.50)	Very high
36	I will take good care of animal subjects regarding of their welfare such as enough space place to live, sterile, enough food and water, and no torturing.	4.29 (0.55)	High	4.63 (0.49)	Very high
37	I don't think animal subjects should be taken care much because they eventually will be killed.	4.21 (0.88)	High	4.67 (0.70)	Very high
38	Subjects have their own rights to stop or withdraw from experiment anytime if they feel that they will be harm or killed.	4.50 (0.59)	Very high	4.75 (0.44)	Very high
Mean rating for the principle of respect for subjects		**4.33**	**High**	**4.66**	**Very high**
Mean of all principles		**3.98**	**High**	**4.31**	**High**

From TABLE 13, the mean of all principles of ethics in science before and after studying ethics in science were high. The mean of after studying (4.31) was higher than before (3.98). In addition, the mean ratings for all principles after studying were rated as high and very high. The principles of freedom, social responsibility, legality, opportunity,

mutual respect, and respect for subjects were rated as very high after studying. This can be seen in FIGURE 12.

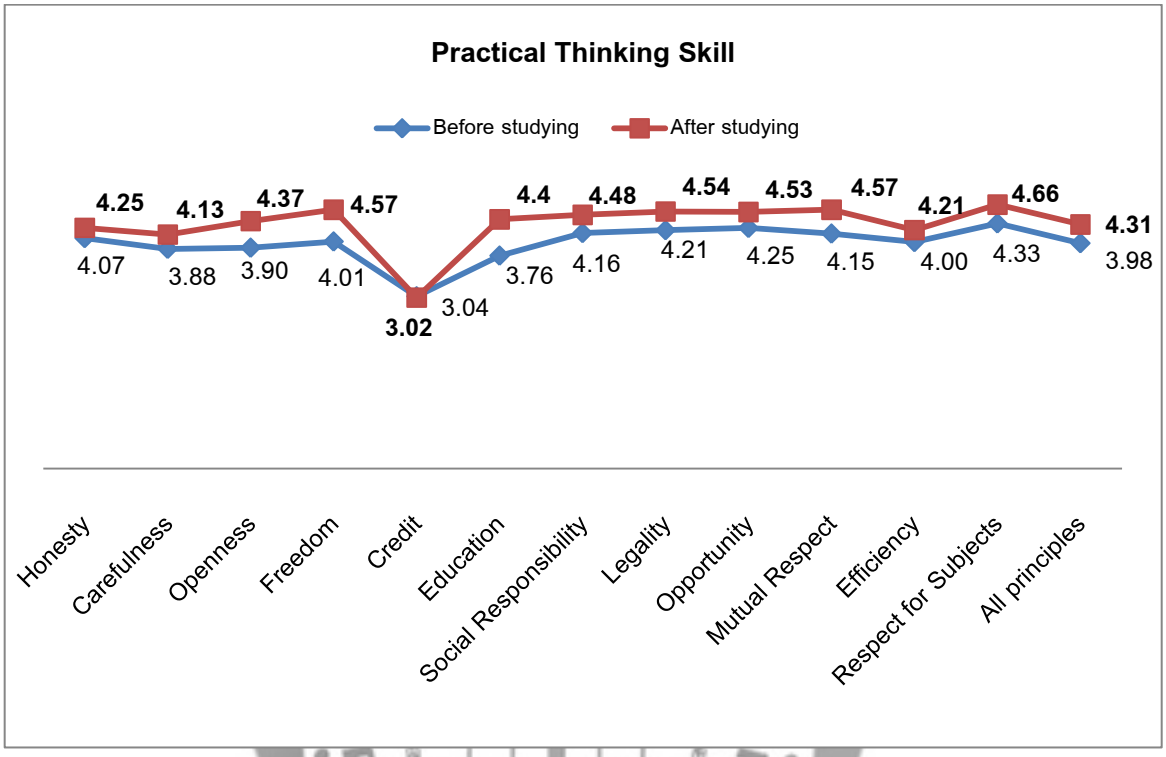

FIGURE 12 CHART OF THE MEANS FOR STUDENTS' PRACTICAL THINKING SKILL BEFORE AND AFTER STUDYING

At the beginning of the class, students were introduced to ethics quotes by well-known people and also by their senior students who have studied ethics quotes before in "scientific ethics" course. Then, students were asked to create their own ethics quotes. They submitted an ethics quote they wrote at the end of a semester which used various examples they were introduced to throughout the semester. Here are all of their wonderful ethics quotes submitted,

- Science leads us to the origins of life, ethics teaches us how to live life
- A future in science without ethics, is no future at all
- If scientists are likened to a clock with inaccurate time, … how then can they be useful?
- A scientist with good resolution and vision can change the world, a scientist with ethics and morals protects the world

- Progressive science, visionary scientists, uphold ethics culminate into progressive research
- An eagle and a vulture may seem similar, but are different. The same holds true between an ethical and unethical person.
- If science is a tree, ethics is the water that helps it grow beautifully
- If gratitude symbolizes good people, then ethics symbolizes good scientists.
- If knowledge is the trunk of a tree, then ethics is the root of its very strength
- A successful scientist who achieves fame through unjustifiable means is like an unsuccessful person in life
- An ethical scientist is like a warrior with well-equipped weapons. An unethical scientist is also a warrior with weapons, but ones that are chipped and faulty.
- If a scientist is likened to an inflated ball, an unethical scientist is a deflated ball that has no use.
- A true scientist not only understands the theory of ethics, but practices it.
- Scientists that uphold ethics are like physicians with tools to cure patients. Unethical scientists are like ill-equipped physicians with knowledge, but no curing skills.
- “Words of Blessings” Now that I am in this world, pray not let me be poor. If I am poor, pray not let me be unethical. If I am unethical, pray not let me be ungrateful. If I am ungrateful, pray not that I am not born into this world.
- If a mold shapes materials, then morality shapes the mind
- Do not let science be unethical, think wisely and do no wrong, then happiness follows.
- Scientists without ethics are not true scientists
- Morality is like an anchor that steers a country ahead
- We must believe in what we can prove, but the proven must not be unethical
- Science is like a light bulb, if wrongly used, you will only see darkness. Only when you can make brightness out of darkness, you can fully reap the benefits.
- Do goodness - based research

- All disciplines originate from the purity of goodness

From the ethics quotes, the students needed to think creatively and also had to communicate by writing (communication, generally, we don't have much time in class to discuss, therefore mostly, students shared their ideas outside classroom, what we can observe is that when they presented their assignment or oral presentation). One student said that he did talk to his father to get "the world of blessing" which is good to have him communicate with his parents.

According to the interviews, when students were asked to explain whether learning science incorporated with ethics helps promote and develop the thinking skills, which are practical thinking skills, analytical thinking skills, creative thinking skills and communicative skills. As for practical thinking skills, the following are their responses:

- This helped a lot. When we knew ethics in science, eventually we utilized it in the experiments like we use chemicals efficiently and not played in labs.
- I think this helped. To do an experiment ethically, the results would be real. If (you) do it carelessly, the results would not be real. Therefore, we should make the results as real as it should be.
- This really helped. Like in labs, when we made something wrong and we had to repeat it .This made us more careful.
- This helped us write the references or citation more accurately.

When it comes to analytical thinking skills, the responses are as follows:

- It was good. I made us analyze better. We can analyze whether an experiment should be conducted by taking ethics in science for granted. For example, taking chemicals to animals, we had to think whether it's good or not.
- It was wonderful. In particular, case studies, we analyzed other people behaviors or conduct before giving a presentation. The case studies made us learn whether we should do like the others (in case studies) do. For example, Dr. Art-Ong Jumsai Na Ayudhaya, he landed the Viking to the surface of the moon for real.
- Ethics quotes also needs analytical thinking skills.
- The case study helped much on analytical thinking skill.
- Analytical thinking skill made us more careful and to pay more attention to work.
- This helped thinking to the point.

For creative thinking skills, the responses are as follows:

- This was a very good help. In case study presentation, we had to think about how to design the power point presentation in order to get friends attracted.
- The painting contest on animal subjects that our friends attended brought art and science together which help greatly in creative thinking.
- In doing experiments, it helped us to come up with new methods corresponding to ethics in science, for instance, using chemicals worthily and efficiently.
- It helped promote us to work in groups creatively. Also, the paintings on animal subjects helped our imagination.

In favor of communicative skills, the responses are as follows:

- We got this skill from working as a group and also from giving a presentation of the case study.
- Very good. We got this skill from doing a case study, group work which needs mutual respect, the power point presentations, painting is another way of communication.
- Presentation on case study, group working and brainstorming helps in promoting this skill.

3. The results of the third objective: to determine students' opinion on learning ethics in a science classroom.

The results of students' opinions on learning ethics in science are shown in TABLE 14.

TABLE 14 THE COMPARISON OF MEANS AND STANDARD DEVIATION OF STUDENT'S OPINION ON LEARNING ETHICS IN SCIENCE BEFORE AND AFTER EXPERIMENT

No.	Statement	Before		After	
		Mean (S.D.)	Interpretation	Mean (S.D.)	Interpretation
1	I always like studying science in new perspectives.	4.33 (0.48)	High	4.38 (0.58)	High
2	I think that science and ethics are related.	4.04 (0.69)	High	4.58 (0.65)	Very high
3	I'm interested in and curious about how I will be a good scientist.	3.71 (0.81)	High	4.38 (0.71)	High
4	I understand ethics in science well.	3.54 (0.78)	High	4.33 (0.70)	High
5	I think that study ethics in science would be the basis of becoming a good scientist.	4.17 (0.82)	High	4.54 (0.51)	Very high
6	I would like to be a good, ethical, and role model scientist to other ones.	4.04 (0.75)	High	4.46 (0.59)	High
7	Study of behaviors and characteristics of ethical scientist is interesting.	3.75 (0.61)	High	4.42 (0.58)	High
8	I think that all science students should study about ethics in science as a basis for studying other science subjects.	4.21 (0.66)	High	4.63 (0.58)	Very high
9	I think ethics in science is difficult and boring to study.	3.46 (0.98)	Moderate	3.96 (1.08)	High
10	Studying ethics in science helps me open up my point of view on another side of science that I have never known before.	3.88 (0.80)	High	4.25 (0.74)	High
11	Studying ethics in science is useful for me to live my daily life, further education and professional job.	4.13 (0.68)	High	4.38 (0.58)	High

TABLE 14 (continued)

No.	Statement	Before		After	
		Mean (S.D.)	Interpretation	Mean (S.D.)	Interpretation
12	Studying ethics in science makes me aware and appreciate in the importance and value of way of life.	3.92 (0.65)	High	4.46 (0.59)	High
13	Studying ethics in science teaches me that I have to make more social responsibility.	4.21 (0.59)	High	4.38 (0.58)	High
14	I'm interested in pursuing my career on ethics in science.	3.21 (0.78)	Moderate	3.75 (0.85)	High
15	Ethics in science is very important for science student, also scientists in different fields of interest.	4.33 (0.56)	High	4.58 (0.58)	Very high
16	I would like all schools to provide ethics in science in science curriculum.	3.83 (0.96)	High	4.21 (0.78)	High
17	Ethical scientist will help society be prosperous, livable and make everyone live together happily.	4.67 (0.56)	Very high	4.63 (0.58)	Very high

From TABLE 14, most of the mean scores for students' opinions on ethics in science after studying were higher than before. There was only one statement which is "Ethical scientist will help society be prosperous, livable and make everyone live together happily." was slightly lower (from 4.67 to 4.63). Interestingly, all statements, after studying, were rated as high or very high. That means students agreed or strongly agreed with the statements. This can be seen in FIGURE 13.

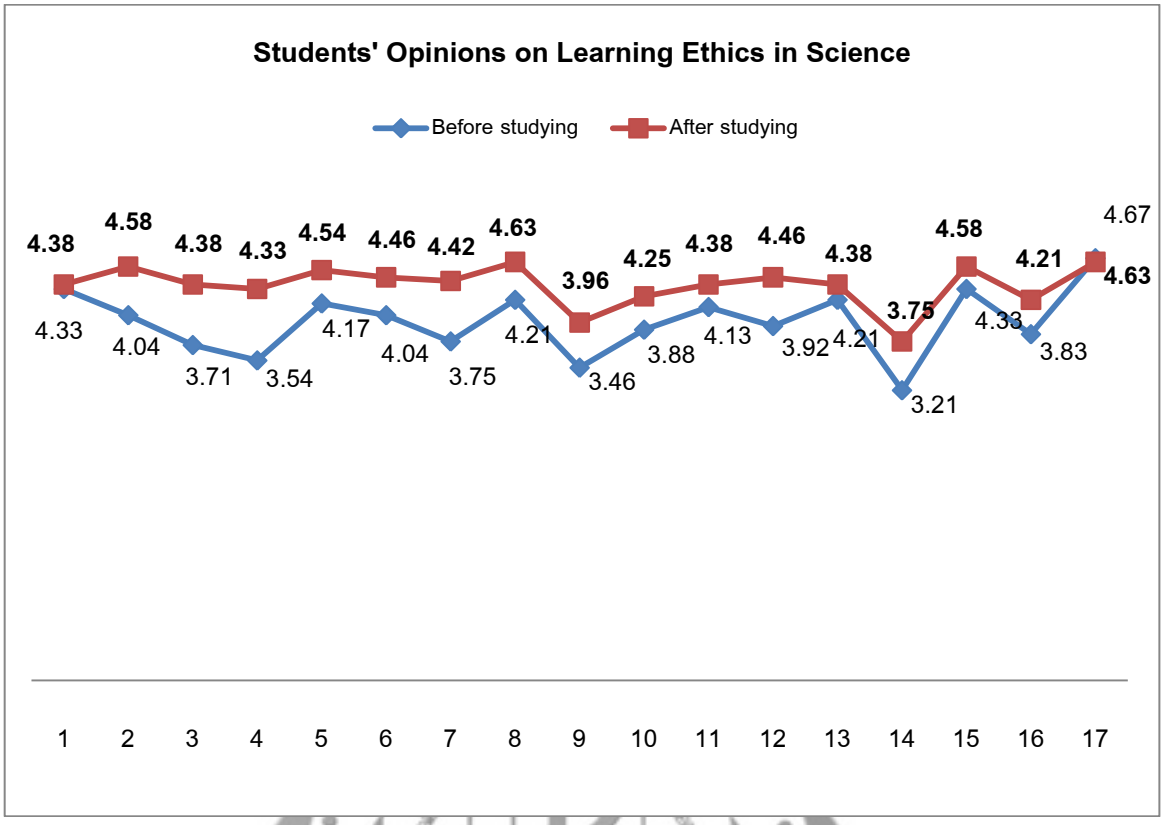

FIGURE 13 CHART OF THE MEANS FOR STUDENTS' OPINIONS ON LEARNING ETHICS IN SCIENCE BEFORE AND AFTER STUDYING

According to the group interviews, they responded to the questions. The first question asked students to describe how important they think ethics in science is for science students. Here are some of their responses:

- Most important. Research data without ethics are just made-up data, not from the truth. It doesn't seem to be important. Therefore researchers must have ethics.
- A smart student, but not good, will not be able to develop our nation. We must be good and we should be scientifically ethical, including general ethics.
- Very important. Doing research without ethics is for ourselves, not for others so we might have to do something wrong. For others, we might have to contribute something, just for the others, and for the peace of our country.
- What do scientists really do research for? For mankind! Without ethics,

making up the data will affect what will further develop our world, for instance, Hwang Woo Suk. He lost his reputation, discredited himself, was unreliable, wasted time and also wasted resources.

- Most important. A science student might be a future scientist. Scientist should be cultivated ethically because people will believe the findings' a scientist has made even it is either good or bad.
- Very important. Ethical scientists will make themselves more reliable or credit.

When asked students to describe whether they think science students should learn about scientifically and socially questionable issues (this means conflicts or questionable issues of science in society; for example, scientists' honesty, animal experimental subjects, illegal research or experiments). The following are responses from students:

- Learning for these issues makes us good scientists in the near future and we will be able to develop our nation.
- We should learn it in order to use it as a lesson on the bad consequences, of those who had misconduct, got so that we won't do it unethically.
- We should learn it. If we learn only the content or theory we will not be able to know what the consequences are. If we did (something) wrong, and no had punishment, but when we learned from the case study, and then we knew the punishment we will get when we do wrong.
- We should learn it. Like lawyers, they have to consider the old cases in order to further their work. Therefore, scientists need to know if there were any wrongs in what they do and they won't do it. If it is a good thing, take it as a good model and this also helps us go with the world current/flow.
- We should learn it because it might affect our life. For instance, genetically modified organisms (GMO), what are going to happen if we eat them? So we as scientists should be social responsible, open minded and educate our society.
- I don't know if we should learn about it. For example, in case of Hwang Woo Suk, we learned it, but some might not take it into account. There might be several factors involved. Some have learned from their parents, environments, some might learn later on which will be used for real.

When asked to decide whether they agree that all science students should be taught about concepts and principles of ethics in science in order to use it as a guideline or regulation in learning or doing experiments ethically? The responses with several reasons are as follows:

- I agreed, when we get taught it will make us become good scientists. If not, even if we are smart, but not good, it's just like a robot without a heart/mind. If we get educated about this, we can help develop our country.
- Experiments need to go along with ethics in science. Our school gets grants from Thais' taxes so we have to spend money worthily and also should focus on carefulness.
- I agreed, if we don't follow the principles of ethics in science, then society will be condemned. Also, if they do it illegally, they will get caught and their future is a dead end. Deplored for their knowledge which will not be able to be used develop our country.
- Buddhist or religious precept will cover ethics in science.
- I agreed, experiments need ethics because the results would tell us if it's theoretically correct. We also can check if there were any mistakes in the experiments. This made us not to make up our labs and we should do it carefully and honestly.
- I agreed. For example, a scientist who thinks of producing medicine to cure patients but he is not becoming rich so he might think of 2009 influenza virus, then release it in order to sell it the cure expensively. Therefore, students should be instructed about this.
- I agreed. If all of Mahidol Wittayanusorn Schools' smart students, who are going to be future scientists or leaders, are without ethics it can be like a time bomb. If they don't think ethically, there would be harm. So they should do good because if they don't do good, they can ruin our world.

When asked if there would be a course of having students understands the concepts and principles of ethics in science for all science students, what would they think it should be? Should it be taught in incorporated in a general science course or in an additional course? Here are some of their perspectives:

- It can be incorporated in all science subjects, but it should be in general science class for all students. As for an additional class, some students would be not able to take it.
- All students already knew about ethics. If it's in a general science class, it will make us know what ethics in science is.
- Both, to make it clearer, in a general science class, this can be incorporated in any of the topics involved. In an additional class, just focus on ethics in science.
- It should be taught separately in an additional class in order to have enough time to learn.
- It should be taught in a regular science class because, for example, when we do labs, we would not to do it ethically wrong, such as no making up data.
- It was not supposed to be incorporated in science class (time limited) or additional class (some students would (not) be able to take it). It should be a regular subject for all.
- Both, start from a regular science class first, then, anyone who is interested in it could attend the additional class later. Case studies should be provided more.
- Both. In regular science class, time is limited. In an additional science class, there might be not many students to take that class. So, it should be separated in order to have students fully learn and more understandably.
- It should be incorporated in a regular science class because it doesn't waste time and also can be used in labs which ethics is really needed. Plus, the teacher can evaluate students. For an additional science class, students would probably not be interested in it because of small the number of credits provided for an additional course.
- It should be incorporated in a regular science class but not be scored as part of sub exam. Science club would be better for this.
- It should be incorporated in a regular science class because study in a regular class helped more to restate and accumulate the knowledge.
- Incorporation in a regular class would be better because some students would take the additional class by following their friends.

4. The results of the fourth objective: to evaluate the effectiveness of a learning approach of ethics in science classroom

Based on the interview, when asked to describe how they think whether learning ethics in science class with the combination of face to face and web-based learning is appropriate. Some of their responses were:

- It was appropriate, both face-to-face and web based-learning.
- In case of the website, we could go study more at any time when we need it.
- Sometimes, class time was not enough. Time is limited. There would be more time to study when it comes to a website.
- It was appropriate. Class time was not enough and also too much content. We could learn more when we have a website.
- As for a website, there should be more case studies, more interviews on important scientists, more beautiful and attractive pictures.
- A website was good. There would be more time to learn it and also be brave to share ideas in the website.
- Face-to-face learning would be better. It could probably be both. Anyway, I would prefer face-to face learning.

When asked to describe how they think about the website corporately used in the chemistry class this semester, the responses from students are as follows;

- Very appropriate, there were several ethical things to learn, such as examples and cartoons which were enough.
- It should be updated more often.
- There should be more new videos.
- There should be more media.
- It was appropriate but font should be bigger, font and background color should be more attractive.
- There should be science news and also a web board.
- It was good but should have more lovely pictures to attract attention.
- There should be case studies and also big name (important/renowned scientists) interviews

When asked students to comment on what this course should improve or develop in order to have more effective chemistry class with ethics incorporated, here are some of their comments;

- It should be more fun and interesting, for example, more videos and cartoons.
- It was appropriate but still in a narrow group of students. One who never learns will never know about it so it should be spread out to all general science classes and should be presented in the morning activity in front of the flag in order to show it's important.
- There should be a stage drama with an ethics focus.
- There should be more stories to read, and more attractive.
- It should be more distinguished, highlighted.
- It should include the issue of a country with not enough food.
- There should be a debate or role play in front of the flag in the morning.

In summary, the majority of both the students and teachers believe that ethics should be taught in schools. The findings give clear indications as to the improvements in the student's ethical understanding. Improvements in student thinking skills and communicative skills can also be seen. Teachers should be made aware of the findings and take advantage to this at all grade levels.

CHAPTER 5

CONCLUSIONS, DISCUSSIONS AND RECOMMENDATIONS

This chapter summarizes and discusses the findings of the study, offers practical recommendations for using principle-based learning and hybrid learning as a learning method and a tool for learning ethics in science, and makes recommendations for further investigations related to learning ethics in science classrooms for both science schools and general or non-science schools.

Phase I: A survey of teachers and students' opinions on learning ethics in Science in Thailand

Objectives

This phase of the research aimed to explore teachers' and students' opinions on learning ethics in science in Thailand in order to be used as preliminary results for the second phase of the research. There are three main objectives as follows:

1. To find the school's general learning in ethics
2. To find the respondents' ethics learning in the science classroom
3. To find the respondents' opinion on learning ethics in the science classroom

Research methodology

In the first phase of the study, data were collected during the second semester of the 2008 academic year from science students and teachers at both Mahidol Wittayanusorn School and 12 Princess Chulabhorn's Colleges. Quantitative data were collected using a researcher-designed survey. Questions used on the survey corresponded to the three primary research objectives. Open-ended questions provided qualitative data to clarify and enrich the quantitative results.

Conclusions

The preliminary research showed that 37.9 percent of students rated their level of understanding of ethics in science as high or very high. In addition, 66.3 percent stated that they are interested in studying ethics in science. More importantly, that ethics in

science is important for science students was rated high or very high by 92.7 percent. A total of 61.2 percent of teachers and 55.1 percent of students indicated that scientific ethics should be taught for science students by incorporating its' principles into a regular science class, rather than as an elective class. Students' thinking skills and communicative skills should be promoted. Additionally, 62.6 percent of teachers and 64.6 percent of students thought that hybrid learning, the combination of face-to-face and web-based learning, can be an appropriate pedagogical method of learning ethics in science.

Phase II: The incorporation of principle-based learning of ethics into a science classroom

Objectives

This phase of the research aimed to answer the following four main objectives:

1. To promote, develop and assess students' understanding of key ethical issues, concepts and principles in science.
2. To promote, develop and assess students' analytical, creative, practical and ethical thinking skills along with communicative skills in learning ethics in science.
3. To determine students' opinions on learning ethics in a science classroom.
4. To evaluate the effectiveness of a learning approach of ethics in science classroom.

Research methodology

This study is a mixed method research (Creswell. 2005). A pre-and post-test, questionnaires and group interviews were used to gather data. The sample group was 24 (9 females and 15 males) of grade 10 science students from Mahidol Wittayanusorn School, in the first semester of the 2008 academic year, in Thailand. Students' understanding on ethics in science, thinking skills, and communicative skills were assessed. Hybrid instruction was also evaluated.

Conclusions

In the second phase of the study, it was found that students' understanding were increasingly promoted and developed as well as their thinking and communicative skills.

Students had positive opinions on learning ethics in science. In addition, students reported that they were satisfied with the hybrid learning they experienced, even though some improvement is needed.

Discussion

Phase I: A survey of teachers and students' opinions on learning ethics in a science classroom

All of research objectives are discussed as shown below.

Most of teachers and students agreed that scientific ethics is very important and should be taught for science students. This is corresponded to the idea of Jeffrey Kovac (1996: Online) who stated "My own experience is that the teaching of scientific ethics is valuable and rewarding for both faculty and students."

Interestingly, when the researcher asked students about their understanding of ethics in science in a survey, most of them seemed to understand it, but from the pretest in the main study, it showed that most of students do not know it very well. It seemed like they did not even know the principles of ethical conduct in science. After they learned ethics in science, it was found that their understanding was much better than before. This can be seen from the mean score of the test they had taken. The pretest mean score was 6.2 (S.D = 1.81) and the posttest mean score was 13.0 (S.D = 1.55). This obviously showed that they understood the ethics in science better than before.

As discussed in chapter two there is some research on the teaching of ethics in science classroom. However, despite these claimed advantages to the use of teaching ethics in science, this pedagogical technique is not widely used among science teachers and research on this approach has been minimal.

The results of the present study corresponded to the majority opinion that learning ethics in science should be taught by incorporating into a general science classroom, rather than an additional class. In fact, this finding is interesting but there are some factors that need to be considered such as the objectives of teaching, class time, the correspondent of the content and the ethical issues relevant and so forth. From my teaching experiences as a chemistry teacher at Mahidol Wittayanusorn School, this research found that class time was hardly enough for the general chemistry content so the pedagogical method of learning ethics in science emphasizing on thinking skills and communicative skills, which is time-

consuming, would probably not work as well as expected. The possible solution for that could be in a class with a specific science and ethics focus. That method would help students learn and practice better on thinking skills and communicative skill through several different activities. This also corresponded to the ideas of other scholars or educators from literature reviews. As for other general school with proper content, it would work best by incorporating ethics into the science classroom. It would be a challenge for the researcher to try to implement the results obtained in the survey into a regular science classroom at Mahidol Wittayanusorn School.

As a result, hybrid learning would be an appropriate pedagogical method of learning ethics. This researcher agreed with this because every student at Mahidol Wittayanusorn School is supported with laptop computer and can easily gain access to the internet system. Therefore, it would be helpful for them to learn effectively by using this method of learning. However, for other schools, context and appropriateness of the school needs to be considered in implementing hybrid learning.

In summary, the results from this phase of study were fruitful for analyzing and implementing in the second phase of the study, in regards to the classroom's context. According to the time limitations, not all of obtained results could be used in the second phase. The rest could be used to further conduct future research or help the researchers analyze data more deeply in all details.

Phase II: The incorporation of principle-based learning of ethics into a science classroom

1. Discussion on research objectives

All of research objectives are discussed as follows:

Objective 1: To promote, develop and assess students' understanding of key ethical concepts and principles in science.

According to the questionnaire of students' opinion on ethics in science that students took at the very beginning of the semester, before they learned with principle-based hybrid learning of ethics in science, students responded to a statement "I understand ethics in science well". A mean of 3.54 (S.D. = 0.78) which they agreed in the agree level which is a moderate level was obtained. However, when they were observed in class activities, it seemed that they did not understand all principles well as they thought. For instance, the principle of credit, students were assigned to find out the answers on the

questions in a worksheet without being told that they had to cite or put the resources of answered information (if any). The questions are 1) why does the electron have to move around the nucleus? Why does it not lose energy moving around it? 2) Do electrons ever "fall" into the nucleus of an atom? From the submitted worksheet, it was seen that there were only two students who correctly cited the resources of the information they obtained. Five students made the wrong citations. The rest of them didn't cite at all. Then, it was suggested by the researcher to cite the resources, and also they were provided with two examples of proper citations, both in Thai and English. The Thai example of the description on plagiarism with citations was from a trusted source which was Stang Library website available at http://stanglibrary.wordpress.com/tag/plagiarism/. The English example was brought from the Online Ethics Center for Engineering available at http://www.onlineethics.org. The second assignment on the investigation of quarks, more students made the citations, but still improper form. On the third assignment, it was found that most of students could do better citations.

After learning ethics in science, the mean score was higher with 4.33 (S.D. = 0.7) which showed that their understanding on ethics in science, namely key ethical, concepts and principles in science, was better. Furthermore, it can be seen from the test of understanding ethics in science which the pretest score was quite low with the mean of 6.21 compared to the post test mean score of 13.0. This also can be evidence that the students' understanding on ethics in science was higher.

In this study, all principles were generally applied into class in different ways and did not go in depth in all principles according to the time and content limitations. More details on how these principles were incorporated to the classroom activities are provided below.

1. Honesty: Students learned about this principle through three main case studies which are: the case of Hwang Woo Suk, a Korean scientist who demonstrated misconduct in embryonic stem cell research, the case study of Victor Ninov's discover of element 118, a case of alleged data fabrication at Lawrence Berkeley National Laboratory (LBNL) California, USA and last the case of Millikan's oil drop experiment. In the case studies, the students were required to answer and share their views on the questionable issues they received. Students also learned the principle of honesty through lab reports and experiments. According to the activity they were involved with, it helped them learn that they should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and trustful in all aspects of the research process. Since this is the

most important principle, therefore close attention should be paid to it in the classroom.

2. Carefulness: The main activities involving this principle were labs and final lab exams in which all students had to do experiments. They generally had to be very careful in doing experiments to avoid all kinds of errors and also to save chemicals and time. That means that they had to make careful plans with their peers before doing experiments. More importantly, students learned to be careful for their safety because they used some hazardous chemicals in the labs. According to the activity they were involved with, it helped them learn that they needed avoid errors in research, especially in presenting results. They should minimize experimental, methodological, and human errors and avoid self-deception, bias, and any conflict of interest.

3. Openness: Students mostly learned and practiced this principle through experiments and case study presentations when they had to work in group cooperatively. They had to work together by sharing their ideas or viewpoints with open-mindedness. In fact, not only in their group, but they also had to do so with the rest of the classroom. To be open to criticism from other classmates or teachers, openness is very important to think about. Therefore, they learned from the classroom that they should share data, results, methods, ideas, techniques, and tools. In addition, they should allow other scientists to review their work and be open to criticism and new ideas.

4. Freedom: Students learned that they should be free to do research or science projects. Students applied this idea to another class, Scientific Inquiry and the Nature of Science (SINOS) taught by the researcher, by choosing the topics on their science mini project. From this activity, students were allowed to pursue new ideas on doing a mini project, actually, not only a science mini project, but also Math, psychology and so on. They were totally free to conduct a project on what they really wanted to do. As for the chemistry classroom they were taught, the case studies of Hwang Woo Suk and Dr. Art-Ong Jumsai Na Ayudhya that could help them see the advantages and disadvantages of freedom. From what they learned in the classroom, they would recognize that they should be free to conduct research on any problem or hypothesis. They should be allowed to pursue new ideas and criticize old ones.

5. Credit: This is also one of the most important principles for students to be concerned with today. They should understand and be aware of, especially, plagiarism giving credit appropriately which is really a new idea for them to learn. Mostly, they haven't known before what it is and how important it is. So, in the classroom, this principle was included in assignments as also, discussed earlier. This principle must be highly

incorporated in the classroom because most of students didn't well understand citations. They need to know and be concerned that credit should be given where credit is due but not given when it is not due.

6. Education: In the classroom, they learned this principle through the "ethics before class" for instance, Albert Arnold "Al" Gore, Jr., served as the 45th Vice President of the United States, under President Bill Clinton. He is a well-known environmental activist who has received an award of the Nobel Peace Prize (joint award with the Intergovernmental Panel on Climate Change in 2007). He also starred in the 2006 documentary *An Inconvenient Truth,* which won an Academy Award for Best Documentary in 2007 and wrote the book *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It*, which won a Grammy Award for Best Spoken Word Album in 2009. Also from the case study of Dr. Art-Ong Jumsai Na Ayudhya who participated in NASA's Viking Space Project in the design of the automatic landing device and he expertise in the National Research Council on rockets for use in the Artificial Rain Making Project. He is currently a director of the Institute of Sathya Sai Education, Thailand and also a Chief Administrator of the Sathya Sai School, Thailand. He is an Official Trainer of Teachers for the Ministry of Education in Human Values Education who has been working on training of teachers in Human Values Education around Thailand, and in many other countries as well. This example helped students eventually learn that they should educate prospective scientists and insure that they learn how to conduct science properly. Additionally, scientists should educate and inform the public about science as Dr. Art-Ong Jumsai Na Ayudhya has been doing.

7. Social responsibility: Students learned this principle through case studies, such as Hwang Woo Suk and Dr. Art-Ong Jumsai Na Ayudhya's cases. In case of Hwang Woo Suk, they were supposed to know that they should avoid causing harm to society or other people in the society. On the other hand, in case of Dr. Art-Ong Jumsai Na Ayudhya, students should learn that they should attempt to produce social benefits like what Dr. Art-Ong Jumsai Na Ayudhya or other scientists have been trying to. Furthermore, they should also be responsible for the consequences of their research and they should inform the public about those consequences. It was obvious that this principle is very important, especially when Hwang's case was introduced to the lesson. Students could remember and understand this principle very well. For example, a female student who learned in the class of ethics in science was asked a question on the stage of the the Noppamas Queen contest on Loy Krathong Day. She told the researcher, one of the

judges, after she finished the contest that she used the idea of Hwang Woo Suk's misconduct in social responsibility principle to answer the question. Her answer was very impressive and that made her receive the third runner up award.

8. Legality: The case of Hwang Woo Suk obviously showed the concept of this principle stated in the process of research, scientists should obey the laws pertaining to their work. Since Hwang did not obey the laws so that he was caught and also was dropped from Scientific American 50 for faking research. This is the most popular case for students to recognize about the bad consequence of being illegal in research, and also in classroom.

9. Opportunity: Students also learned about this principle through a case study of Jan Hendrik Schön: World Class Physics Fraud at Bell Labs in New Jersey that he used an opportunity in a wrong and unethical way. Also, students themselves at this school were always cultivated by teachers to keep in mind that they have more opportunity than other students in general school in terms of scholarship, scientific resources and tools such as chemicals and cutting-edge scientific tools available in this school and so forth. Therefore, they should be aware of social responsibility, using resources efficiently, educating other people and trying to inform the public about science as much as they can. More importantly, to lead the nation to be a developed country and also to help Thai citizens have a higher quality of life. Students were introduced to the concept that scientists should not be unfairly denied the opportunity to use scientific resources or advance in the scientific profession. They should be able to apply this concept to their profession in the future.

10. Mutual respect: Students also learned this principle through a case study of Jan Hendrik Schön. They learned to respect each other when they discussed or brainstormed issues or questions related to the case before giving a presentation. Also, through lab reports, which is group work, and they had to respect their friends' ideas. This principle could work well with the principle of openness, also the principle of honesty. It is crucial to be honest with yourself and then to the others in group working. In the classroom, students were encouraged to treat their colleagues with respect in doing experiments and all kinds of activity they have done together. This would help them not ruin other friends' rights or integrity. Therefore, the principle of respect for subjects could be used together with the principle of mutual respect.

11. Efficiency: Students learned this principle through experiment in labs with the concept that scientists should use resources efficiently. At first, when students did

an experiment, shared chemicals always fell on table floor with no one taking care of that. Mostly, students cleaned up when the experiment had done already, not in between. There were a few students who were always taking care of cleaning chemicals during the experiment. The researcher had to tell them about safety in labs, for example, magnesium power can automatically ignite in the air. Also, the cost of chemicals needed to be a concern. The efficiency also included the instruments used in labs, to minimize the glassware, such as beakers, volumetric flasks and so on. This would lead them to think about the minimization of water for cleaning the glassware. Sometimes, they used too much chemicals in the trial and errors without making plan. They were also concerned about make plans before doing labs and this also corresponded to the principle of carefulness. Teachers can incorporate other principles related to the current principle they teach. It is all about connection.

12. Respect for subjects: Students learned this principle through all activities they had to work on in groups in the classroom. They learned that scientists should not violate rights or dignity when using human subjects in experiments. Scientists should treat non-human, animal subjects with appropriate respect and care when using them in experiments. Also, they could also learn for themselves in the website provided with several articles on using animals in labs. Furthermore, they learned from their biology class, mainly animal subjects, and not human subjects. In the case of respect of human subjects, in an interview made in their classroom as a part of this research, the principle of respect for subjects was needed. The researcher had to ask for permission from students, participants as human subjects, which is called “informed consent”. That’s what the students learned in this case. In fact, there are more key tenets of the code of conduct on using human subjects, the Nuremburg Code (1949), which could be taught if time allows. For example, social values, scientific validity, nonmalificence, termination, privacy, vulnerable populations, fairness and monitoring. As for animal subjects, there was a drawing competition on using animals in science research (See Appendix F), hosted by Office of the National Research Council of Thailand (NRCT). To have students participate and understand this principle better, they were encouraged to go for the competition. There were two students engaged in this event. One of them received a reward. Actually, they prepared themselves in a short period of time with some available friends and teachers’ suggestions. This also helped them to realize and understand on the principle of respect for subjects quite well. In 2004, Kempton also presented an article that examines how cartoons and paintings could be used to teach and assess the understanding of ethical

issues in science.

In this study, using case studies in order to help students understand ethical concepts and principles in science in the science classroom was successful. As Barden et.al (1997) discussed the importance of using case method in teaching scientific ethics in a high school which ethical issues are raised in the context of realistic situations. It was concluded that the case method is an effective technique for discussing scientific ethics with high school students. Also, case studies make excellent starting points for ethical discussions and can be found in textbooks, on specialized websites, or can be taken directly from the news (Chowning. 2005: Online). The case studies used in this study were mostly taken from the news in the websites.

According to a group interview, one student raised an important issue that even when they understood the principle of ethics in science, but sometimes teachers always give the priority to the results first. They stated that was the reason why they sometimes had to violate the principle of honesty. Therefore, teachers may have to look back at themselves and consider whether what the students said is correct.

When all things are considered, students' understanding is better, it is necessary to be taught continually as students agreed in the interview that only their class was able to learn by this method and there will probably be no more of this type of learning for their classes in next semester. This also indicated that teaching ethics in senior high school helps students recognize, sharpen, and refine the ability of understanding on moral concepts and principles (Onlineethics. 2006: Online; & Gosling; & Musschenga. 1985).

Objective 2: To develop and assess students' analytical, creative, practical thinking skills along with communicative skills in learning ethics in science.

Each thinking skill is discussed as follows:

1. Analytical thinking skills

This skill was mainly considered by using case studies. For instance, the first case study presentation, Millikan's oil drop experiment, was conducted in the evening, and the second case study consisted of Victor Ninov, Dr. Art-Ong Jumsai Na Ayudhya, Hwang Woo Suk, and Jan Hendrik Schön which were presented in chemistry class. All principles could be used to describe in the case studies. There is no one principle corresponding to each case study, for example, Hwang Woo Suk's case, the principles of honesty, carefulness, openness, credit, mutual respect, respect for subjects, legality, and social responsibility were able utilized. As for interviews, both of the two group interviews

were performed in the evening (approximately one hour and a half per group). It was a hard time for them to respond the interviews. Some of them seemed to stay focused on it; also the interview was not conducted as soon as they finished the lesson because there were some other instruments that need to be measured. Then, before the interviews, the researcher had to summarize and show them what they had learned in this course. This may have helped them recognize about that they have learned for an entire semester and to make sure that they would not forget and would respond well in the interview.

Ethics before class was another method of enhancing students on analytical thinking by using power point presentations to show them examples of related topics of ethics. This was basically used to discuss before getting started on the lesson. For example, the ethics of efficiency; a picture of hunger children from “2008 in photos: 10 biggest science stories of food crisis” were shown to students to stimulate them to think about the reduction of the use of chemicals or lab tools they used in the experiments (See Appendix I).

As stated earlier, a discussion on the principle of social responsibility was conducted. It is also an interesting example of students’ analytical thinking skill from a student who learned in this classroom was that a girl who attended the Noppamas Queen contest held at school on Loy Krathong Day. This was a good example of students’ analytical thinking that could be applied to their daily life.

As for the interview, most of students showed in their opinions that they were promoted to think analytically. For instance, as they said “It was good. It made us analyze better. We can analyze whether an experiment should be conducted by taking ethics in science for granted. For example, taking chemicals to animals, we had to think whether it’s good or not” and “The case study helped much on analytical thinking skill.” Additionally, Lewis (1986) pointed out that the learning process will be more effective the more closely students can be identified with the problems themselves. An ethical problem, which will always promote considerable discussion, which is a part of communication, is the issue of experiments on animals that makes the problem real and personal. This is corresponds to the principle of respect for subjects used in the study and also in the activity of the drawing competition on using animals in science research and case study of Hwang Woo Suk on cloning and embryonic stem cell research. This made the experience real and personal for the students’ aspects of ethical concepts.

In conclusion, students were better able to analyze though the different case studies. This is consistent with the ideas of Barbour (1985) that the teaching objective

of discussing the ethical questions to encourage the recognition of ethical issues and the ability to analyze them better. Furthermore, in order to avoid indoctrination it is helpful to examine diverse views in particular cases in which scientists have confronted moral dilemmas on the job or in their public activities.

2. Creative thinking skill

For this skill, ethics quotes, case study presentations, and drawing were used for discussions. Students were always presented with an ethics quote before class, which was created by former students who took a class of scientific ethics and also from renowned scientists and scholars. Then students had to have their own ethics quote at the end of semester. They had to think creatively and that helped them communicate by writing better. From the researcher's point of view, the students' ethics quotes were impressive. Interestingly, one student said that he did brainstorm with his father to get "the word of blessing" which is also good to have him communicated and acquired guidance from parents.

Creative thinking skill can also be seen from the case study presentations, when students tried to give a presentation creatively. For example, there were some groups that did role playing for their presentation. Other groups also have their own ideas to present differently. As discussed on the principle of respect for subjects, drawings on animal subjects used in the scientific research also helped students to think creatively.

From the interview, students also agreed that this classroom help them to think creatively. As they said "This was a very good help. In case study presentation, we had to think about how to design the power point presentation in order to get friends attracted" and "The painting contest on animal subjects that our friends attended brought art and science together which help greatly in creative thinking."

Creative thinking skills can be enhanced by teachers in the science classroom in some other ways, such as debate, stage drama and so on.

3. Practical thinking skill

The results from TABLE 13, it showed the means of practical thinking skill. The means for the principles of honesty, carefulness, openness, freedom, credit, education, social responsibility, legality, opportunity, mutual respect, efficiency, and respect for subjects before the study of ethics in science were 4.04, 3.73, 3.90, 4.01, 3.03, 3.76, 4.16, 4.21, 4.36, 4.15, 4.00, and 4.19, respectively. The means for the principles of honesty, carefulness, openness, freedom, credit, education, social responsibility, legality, opportunity, mutual respect, efficiency, and respect for subjects after the study of ethics in science were

4.10, 4.11, 4.37, 4.57, 3.04, 4.40, 4.48, 4.54, 4.59, 4.53, 4.21, and 4.61, respectively. From all means of the principles, it showed that the means of all principles after the study ethics in science were higher than before. This indicated that the ability of students to think practically was better.

According to the interviews, students' opinions indicated that they were promoted and developed their practical thinking skills. As they said, for example, "This helped a lot. When we knew ethics in science, eventually we utilized it in the experiments like we use chemicals efficiently and not played in labs.", "This really helped. Like in labs, when we made something wrong and we had to repeat it. This made us more careful" and "This helped us write the references or citations more accurately". Students could be able to take the concepts they learned into action. In fact, there might be more ways for students to practice ethically.

4. Communicative thinking skill

Communicative skills were observed from case studies presentation and interviews. The ability of students to tolerate and deal effectively with ethical ambiguity and to reduce disagreement or conflicts which is more likely to happen in the collaborative group discussion/activities of the ethical principles in science. They must also deal with empathy; being able to express their feelings and ideas on issues, listen to and respect others ideas; the ability to paraphrase another's point of view, the capacity to connect with another person's opinion, and feel able to disagree without fear of reproach and the ability to accept and judge another's point of view fairly (fairness). These communicative skills (both verbal and non-verbal communication) are necessary. Typically, there was not enough time in classroom to discuss because of the limitation of too much content. Therefore, students shared their ideas outside the classroom. What the researcher observed was that when they presented their assignment or oral presentations they could communicate very well with confidence and fluency.

From the interviews, according to the responses from students, for example, "We got this skill from working as a group and also from giving a presentation of the case study" and "Presentation on case study, group working and brainstorming helps in promoting this skill." This indicated that they were promoted to communicative skill. In the real world, social intelligence is very important. According to Peter Thomson, today he is regarded as one of the world's leading strategist on personal and business growth. Skill in communication is what allowed him to get where he is today. It's the most powerful, life-changing skill anyone can learn. That's why he teaches the secrets of the world's greatest

communicators. Therefore, this skill should be further promoted and developed.

In conclusion, the results indicated that students realized the ethical concepts and principles by using analytical thinking skills and communicative skills which is consistent with the ideas of Gosling and Musschenga (1985).

Objective 3: To determine students' opinion on learning ethics in a science classroom.

From the questionnaire students took before and after studying ethics in science, it was found that all statements were agreed to by students at a high level. There was only one statement where the mean after studying was lower than before, but just a little difference (from 4.67 (0.56) to 4.63 (S.D = 0.58)). That statement was "Ethical scientist will help society be prosperous, livable and make everyone live together happily." The mean of before and after studying ethics in science was quite high and the difference of the means was quite small. There were two statements where the means have a large difference (> 0.50), for example, statement 3 which was "I'm interested in and curious about how I will be a good scientist." The means are 3.71 (S.D = 0.81) and 4.38 (S.D = 0.71), respectively. Another statement was "study of behaviors and characteristics of ethical scientist is interesting." With the means of 3.75 (S.D = 0.61) and 4.42 (S.D =0.58), respectively. However, students' opinions on ethics in science or learning ethics in science will be more meaningful if they could put their opinions and beliefs into action, also known as practical thinking skills in this study. This is the ultimate goal of moral education in views of Frazer and Kornhauser (1986) and one way of doing this is through community service out of school. All students at Mahidol Wittayanusorn School are familiar with community services as it is a part of the curricula.

From the interviews, most of students thought that it is a great idea to bring ethics into a science classroom. Because it is crucial to know about the scientist behaviors and misconduct as they found in the case study, Hwang Woo Suk. Students suggested that this type of learning should be available for students in other classes to learn as same as they had. Additionally, it should be continually taught. This is true, because if this learning method will not be further used the students will probably not recognize the ethical issues or principles they have learned. Since the study of ethics principles need time to be cultivated, therefore, longitudinal teaching should be provided.

Students also gave some suggestions on the improvement of effective chemistry class with ethics incorporated. Here is an interesting example; "It was

appropriate but still in a narrow group of students. One who never learns will never know about it so it should be spread out to all general science classes and should be presented in the morning activity in front of the flag in order to show it's important." This showed that students see the importance of learning ethics in science and they also wanted to learn more. Additionally, they wanted other students to have the opportunity to learn about ethics. Therefore, teachers should think about this issue too.

After finishing the collecting of data, the researcher, as a teacher at this school, had a chance to open a new course of "scientific ethics" as an additional course for 25 students. Actually more students wanted to learn but classroom size was limited. This reflects an opinion that a student gave in the interview that teaching ethics in an additional class is not available for all students to take. This issue should be considered to expand the number of students to study.

To summarize, from the students' opinions and a survey study, it demonstrated that learning ethics in science is very important and it should be included in all general science classrooms by including it in science curricula for all science students. This is similar to the study of Lysaght, Rosenberger and Kerridge (2006) which found that undergraduate biotechnology students generally regard ethics education to be important and that ethics should be included in undergraduate biotechnology curricula.

Objective 4: To evaluate the effectiveness of a hybrid learning of ethics in science classroom.

According to the interviews, the effectiveness of a learning approach, hybrid learning, is satisfactory with students. A few suggestions were made by students with the following discussion;

A website used in this study should be more often updated. It seems not to be up-to-dated. There should be an ethics quote every day that appears on the web page, but it doesn't because there were some problems occurring on the that computer creates the website, one of the major problems is a computer virus. Also, some students wanted to have more ethics news and journals in the website, in the ethics media part, even which seems to be enough with example of news and links. The intention of the researcher is to have the students study more themselves on whatever they want to know. So the media on the web are just the important examples. Another issue is the color and appearance should be more attractive and less childish. This can be done by working cooperatively with a professional web creator. This website was created by someone with less experience in web design. Just

following to the workshop of web design hosted by department of computer science which is three part workshop. This website was created by the researcher himself working for almost two months to finish it with a number of problems along the way. In fact, it must be more professional than childish regarding to students' preference because it is on the department website and available to all visitors. However, the websites of other teachers in school are almost at the same level in the quality because all of the science teachers have limitation on web designing.

If hybrid learning was used to study, regardless of other variables, with adequate time and research members, the effectiveness of the hybrid learning might be assessed by another reliable and appropriate instrument. Not just by students' opinions from the interviews as appears in this research. This would probably obtain better results for the evaluation of the effectiveness of hybrid learning in scientific ethics classroom.

As for face-to-face learning, classroom atmosphere, (See APPENDIX E) was one of factors that helped enhance and motivate students to be aware of ethics in science. Therefore, the researcher set up, not only classroom atmosphere, but also the office atmosphere with pictures, posters of animal research and students assignments such as ethics calendar, games, a code of conduct research book, and so on.

The results of the effectiveness of using hybrid learning showed that the students were satisfied with this type of learning. This can be a starting point to further develop the hybrid learning to become a better learning method for students that will also help teachers increase student learning opportunities beyond the school day and school year (Pape. 2006).

Learning ethics is a long-term process. In this study, it was conducted in only one semester by using principle-based learning of ethics in science that was considered by the researcher based on the findings that it was an effective method. Chowning (2005: Online) addressed that principle-based ethics provides a familiar form of reasoning for students and are concrete for teachers as well. The researcher hopes that this study would help students appreciate the learning of ethics in science. It is assumed that students already have moral imagination, therefore, the main aim is to stimulate and bring it from inside out, not to implant it (Jumsai. 2003; & Onlineethics. 2006: Online). Also, as a comment of Helen Sayers on Talking Point (2000: Online) that values exist naturally in every human being – they just need to be reawakened through providing a supportive learning environment, suitable resources, and most importantly, through teachers, parents and other adults who act as role models for such values. One of the critical concerns as

Frazer and Kornhauser (1985) stated is that teaching scientific problems and ethics would be appreciated by young minds and convince them irrespective of whether these young people are going to be scientists or not. Whenever such issues are raised, the young minds are somehow activated. Therefore, we should remember that not all students that we teach are going to be scientists. This is consistent with the real situations of students at Mahidol Wittayanusorn School and other schools. Just as those who take science courses in schools and colleges who are not going to be scientists do not need to know detailed equations of chemistry or physics but they still need to know something about how science works and the total implications of science (Frazer; & Kornhauser. 1985). All of these points should be critically considered in the classroom.

2. Discuss on research procedures

2.1 Discussion on research instruments

First, there should be more research instruments used to gather the data in this research as follows;

2.1.1 Evaluation forms of analytical, creative and practical thinking skills which are defined (based on the theory of successful intelligence defended by Sternberg, 1997) and can be measurable. Another variable which has not been exactly defined is ethical thinking skill, but the researcher would like to add it as a new variable of thinking skills in order to study this research and measured it by using the combined evaluation form of practical thinking skills. For better consequences, as for the analytical, creative and practical thinking skills, there might be a more reliable measurement used to measure individually, instead of only the use of interviews, questionnaires and observations as was done in this research. When it comes to ethical thinking skills, instead of using only the rating scale questionnaire and observations as in this research, more research instruments should probably used. A more reliable description should be proposed and defended; also its measurement should be created. When all things are considered, especially the time limitation of study, all of these variables were administered as best as the researcher could do. All of considered evaluation forms of thinking skills, observation and interviews were used in this research. There might be more proper instruments created to assess these variables if needed regarding to the related conditions.

2.1.2 The classroom observation form was another instrument that would be used. When the researcher looked at the course syllabus it was found that there

was already observation lists to score student's learning behavior called "affective domain evaluation form." This evaluation form is used by observing students' behavior in classroom. The researcher tried to improve it by including all 12 principles of ethics in science in the observation lists as they appeared in the course syllabus. This was one of the reasons why the researcher decided to minimize the research instruments by using the affective domain evaluation form, rather than the classroom observations. Another important reason was to save time and more importantly, to save the materials used especially papers. From the survey study, there was a student who made a comment on the amount of paper used in the survey research. That pointed out an important issue to the researcher to be aware of using materials efficiently which is corresponded to one of 12 principles of ethics in science, efficiency. Additionally, this issue can be employed as an example for students to think about using chemicals and material in laboratory efficiently. On-line survey could be used in order to save paper.

2.2 Discussion on data collection

In process of data collection, the following issues are discussed:

2.2.1 In case study presentations, students were assigned to work in groups of three to present their own case study in front of the class. This activity was done two times for the entire semester. It was normally performed outside the class time, the first presentation was conducted in the evening on a Sunday, after some of students returned to school from home and the second time was on a free double period for the students. The case study presentation generally took time to share the facts and analyze their opinions on cases to their classmates, including a question and answer time. If this activity was conducted in a regular class, it might affect the restricted time of other lessons. Therefore, to do so, the limitation of classrooms should be carefully considered. It would be better if the presentations could be rearranged by videotaping in order to interpret data more correctly. In this research, there was only the researcher and students as audiences. There might be more teachers and students to be in the presentation room as an audience if possible, but it is need to be sure that other teachers and students would be available and willing to take part in this activity. For example, in the first case study presentation, which took place on Sunday evening, it was hard to have more teachers to participate. Also, in the second presentation, other chemistry teachers had their class to teach. This was a little difficult to administer and deal with the more hardworking people like Mahidol Wittayanusorn School personnel. If this could happen, it would be much better on data collection.

2.2.2 Regarding of time limitations, the posttest of students' understanding on the issues, concepts and principles of ethics in science, opinions on learning ethics in science and the evaluation form of thinking skills were exposed to students at the same time. This can possibly affect to the results of the study. The data of the posttest of students' understanding on the issues, concepts and principles of ethics in science should be separated to collect. That means that students will be able to have more time to consider their opinions on learning ethics in science and the evaluation form of thinking skills.

2.2.3 In this study, classroom observations were performed by the researcher only to evaluate students' affective score by using the affective domain evaluation form. To avoid research bias, it might be better to have more teachers help in observing the classroom. However, the researcher doesn't expect that the results would be greatly different because of the fact that ethical ideas need a long time to be cultivated. Furthermore, the researcher just wanted to do what he really set out to do and has always tried to do his best, regardless of the outcomes. However, there should be other teachers observe the students' behavior or ethical aspects in the classroom. On the other hand, they need not to be in the same class with the researcher to observe students' behavior. For instance, in a Scientific Inquiry and Nature of Science (SINOS) class which is the class for all grade 10 students to take and it was taught by the researcher as a leader of team teaching group. Students learned how to write their final paper on mini projects by using the APA citation style. There was a group of students who did a great job on applying the knowledge they obtained in the SINOS class to their assigned writing in an additional class of applied chemistry. One of two teachers of the applied chemistry class who used to be one of SINOS teachers said to the researcher that those students could apply the knowledge from SINOS class to her class very well and they were really impressive for both the students and SINOS class. The idea is to have other teachers in different classes with our students also take time to observe and evaluate their behaviors. In fact, this idea could be used in this study to observe student's behavior outside the classroom, rather than just inside classroom. Moreover, it can help assess student's practical thinking skills as well.

2.2.4 Group interviews were conducted two times with each group of 12 students for approximately one hour each by the researcher and two assistant teachers. Also, regarding of time limitation with condense content, the interviews were performed outside the classroom. It was done in the evening on a Sunday, the same as in the case

study presentations. The first group was interviewed from about 6 p.m. to 7 p.m. and the second group was about 7 p.m. to 8 p.m. From the observations of the researcher, not all students answered the interview questions; even though they were encouraged to participate. Possibly, they didn't focused well on the interviews because the researcher observed that before the meeting time of the interviews, a few students were still in the school soccer field playing soccer with their friends. This could have made them feel tired and hungry. After the interviews were completed, the researcher found that a few of male students went to a school convenience store to get food. This could be one of the reasons why they didn't engage well in the interviews. There might be some other reason behind this, for instance, they are not talkative. Therefore, if possible, the interviews should be performed in the daytime with adequate time. So that if there is any issue not clearly stated in the interviews, there would be more time to collect additional data. Also, students may be more prepared, ready and comfortable to respond in the interviews. This unexpectedly occurred but it should be discussed and considered.

3. Discussion on final thoughts

According to my final thoughts, this study is very important and innovative because it provides a tool for teachers who are searching for ways to incorporate ethics into a science classroom for high school students, particularly science students. What can be seen from this study is that though students may say they are not familiar with the ethical issues or principles in science, yet these students still see many benefits from learning ethics in science. One of the main benefits students describe is that learning ethics helps them get a better understanding in scientific ethics which is very important as a basis for science students to aware of. They also would like other science students to get a chance to learn what they have learned on ethics in the science classroom. It is hoped, introducing ethics in science into a classroom helped the students gain a better understanding of ethical issues and principles. Also that the students will be able to perform better as they progress through higher levels of science classes and also in their future scientific careers, for example, as scientists, the researchers, innovators which are the outcome of the school expectation as stated in the Royal Decree for the establishment of the Mahidol Wittayanusorn School, B.E.2543 [2000].

The researcher has learned several things from conducting this study. First, the researcher learned how to conduct this research. This research study has given the

researcher an opportunity to select an interested topic, do a review of literatures, design instruments and experiments, pilot the research instruments, find human subjects willing to participate in the study, collect and analyze both quantitative and qualitative data, discuss the findings, draw conclusions and make recommendations. As the researcher will soon begin his career as a college science education lecturer, the researcher truly believes that all of the works the researcher have done on this wonderful study has already prepared the researcher to pursue on new research agenda exploring ethics education.

Second, the researcher realized the importance of survey study by asking for teachers and students' opinions on learning approach of ethics in science. They helped the researcher a great deal of designing the classroom in the second phase of the research. Personally, the researcher thinks it is very crucial to know what other people think and express their ideas or opinions on questionable issues. Like an old saying "Our mind is too deep to touch". Therefore, their point of view, when they express it, would be useful opinions in analyzing and constructing new knowledge. In addition, asking students' perspectives by using an interview is also essential for the researcher to gain their understanding and valuable opinions on several topics, for instance, the pedagogical approach on learning ethics in a science classroom. This made the researcher learn how to work on group interview effectively.

Third, the researcher learned that there are many imperative ways to incorporate ethics in science to students, for example, debate on ethical issues. This can be rearranged in both a regular and elective science classroom. Like what the researcher, as a chemistry teacher at MWITS for almost four years, has done after finishing the collecting of data for this study in an elective course called "scientific ethics" which has already included in science curricula at Mahidol Wittayanusorn School. Also this can be done in an extracurricular activity such as science club or stage drama. One more example is that to have students involved in ethics in science through a research study. The researcher conducted the research to give a presentation at the gifted conference 2010 in Australia entitled "On Being a Scientist: Scientifically Gifted Students' Perspective in Thailand". This research focused on students' perspectives and attitudes towards being ethical scientists after reading a well-known book entitled "On Being a Scientist". This research was administered to 12 grade 11th -12th students at MWITS who are advanced-level English students, particularly in reading and comprehension skills. A focus-group interviews and questionnaires were employed to gain students' perspectives and attitudes towards being ethical scientists. The research findings could support implementation of this approach

into both a regular science course and in an additional course of specific ethics focus by using scientific novels or an ethics books to enhance the awareness of the students on the ethical and responsible conduct in scientific research. The researcher strongly believes that this approach can be offered for use by other equivalent schools in Thailand.

Forth, the researcher learned how to get a research paper published internationally in all processes of approximately 5 months. This will lead the researcher to keep publishing research papers in a higher impact factor journal. From the publication of research papers in an international journal, this made the researcher realized that we always can make our dreams come true, just do it and have no fear of failure, fear of nothing indeed.

Fifth, the researcher is so proud of himself for getting so many difficult things done in this research with strong determination and dedication even though the researcher had to take responsibility of both a science teacher and doctoral student working on this dissertation. One of the difficulties the researcher faced is the creation of a website as part of hybrid learning with little knowledge of how to do so and the many problems that occurred, but finally, it was completed and can be further developed. Throughout the research study, there were many problems the researcher had to confront and overcome. This means that it has made the researcher stronger and become more patient. Most importantly, the researcher did learn how to tackle those problems effectively. As Robert Bob, a physics educator at Fermi Lab, Illinois, USA said that science requires dedication, not perfection. The researcher can feel this from this research study. It has been almost 5 years, from pilot study of the first phase until now, on conducting research. But there have been so many unforgettable lessons the researcher has learned from this wonderful time. The most impressive one was the two awards, one of ten outstanding teachers and one of ten teachers' in students' heart, the researcher acquired during working as school teacher and also doctoral student at the same academic year. Most importantly, the researcher was well-known by students and teachers for being an ethicist in the school.

Sixth, the researcher has been spreading the knowledge the researcher had learned from conducting this research as much as he can. One of his future plans is to provide a workshop on teaching ethics in science for high science school teachers who are willing to do the same thing as the researcher has done. Both pre-service and in-service teachers can participate.

Seventh, as the researcher drew this study to a close, the researcher strongly believes that learning ethics should be started as early as possible in appropriate level of

content and other related conditions. The researcher really likes the ideas of the following three comments;

> Most scientists begin their careers by obtaining a doctorate of philosophy (as I did). … Scientists need to be trained in ethics, morals and indeed the philosophy of science to make them better scientists. Science without ethics is like learning to drive without the Highway Code! ***N.A. Gostick, UK***
>
> All French students, in their last year at Lycee (17-18 years old), are taught philosophy - not just morals or ethics which may only represent one view. This is the place, I think, to study the implications of science … ***Pascal Jacquemain, UK (French)***

> I believe that values exist naturally in every human being - they just need to be re-awakened through providing a supportive learning environment, suitable resources and, most importantly, through teachers, parents and other adults that act as role models for such values. ***Helen Sayers, Switzerland***

From the researcher's point of view, the most important feature of good teachers is to be courageous enough to introduce new and helpful ideas to students as a creative leader and good-role model. Like in French, students at Lycee are taught philosophy so the researcher also thinks that at Mahidol Wittayanusorn School students, at 15-18 years old in age, should be able to learn philosophy and ethics as well. Therefore ethics in science should be integrated into their science classroom. There is no need to wait until they enter to gain university degree because they are studying intensive science, mathematics and technology as scientifically gifted students and they will have to deal with science issues in their daily life. That means they are surrounded by science. Eighth, as a science teacher and science educator, it is critical for us to keep in mind that the most important part of our obligation is to our students and we have to be sure we examine every avenue to help them learn and do science activities ethically. We are not supposed to have them learn only the science subjects, but also values and ethics. They will not be expected to not only be smart people, but also good and ethical people. These two essences will make them pure and be able to provide benefits for humankind. The researcher truly believes that smart people without goodness are nothing. It is hoped that this study and the use of learning ethics in science become one such avenue for fellow teachers at Mahidol Wittayanusorn School, the first science school in Thailand and also, for teachers at the 12 Princess Chulabhorn Colleges, regional science schools. More

importantly, for all Thai teachers who are actually interested in teaching ethics in science for science students at all levels.

Ninth, above all, the researcher has learned that we have to be honest to ourselves at all processes of research process like a quote of Mary Trump says “Trust in God and be true to yourself”. Honesty is the most important principle of ethics in science, as ranked in the survey by science teachers and students.

Lastly, above all, this study may not be as perfect as the researcher expected it to be, but the researcher has been very pleased that he could conduct a research project that he is very interested in. The researcher has devoted himself to this wonderful research and also learned many invaluable things from it. Especially, how to ethically conduct research. The researcher is so proud of himself to have been honest at all levels in the process of this research. Even though this is not the best research study as someone may have expected, but the researcher really wanted to tell them that he has done his best.

Limitations of the Study

The results of this study are not without its limitations. One limitation to this study is that time and condensed content. There is also a need to improve research instruments in a more reliable order to get more accurate results. It takes time and is not easy to have students (grade 10) understand and appreciate ethics/moral issues. Hopefully, when they are grown or get older, they will be able to do more. This study aimed to introduce ethics in science to them early as their high potential in science and also involved in all science process would allow. In this study, the researcher is in charge of a teacher who leads the activities in a science classroom.

As a result, it may not be easy to generalize these results to all science classes in Thailand. Science teachers at each stage should carefully think about if they would like to apply these findings to their classes.

Recommendations

There are five major recommendations that should be considered based on the findings of this mixed method study. These recommendations are in the form of: policy recommendations, national-level and school-level policy, recommendations for science researchers/mentors, recommendations for science teachers, and recommendations for

further studies.

1. Policy recommendations

1.1 National-level policy recommendation

Science curriculum developers and educational policy makers should make policies on the continual introduction of scientific ethics into science classroom at all educational levels in Thailand, from the primary school level through graduate school. Ethics should be included in science subjects at all levels based on the survey findings. Scientific ethics should be a part of all professional teaching courses, a diploma degree programs. All pre-service science teachers should be required to take a course on scientific ethics. This means that there must be at least one course on scientific ethics in the science curriculum at all universities. It is unnecessary to wait until graduate school level to learn the ethics of science because students are involved with science at all levels as soon as they enter to school. In addition, in-service science teachers should do the same course on scientific ethics as pre-service teachers do. As Chowning (2005: Online) stated that The National Science Education Standards (NRC 1996) point clearly to the need for teachers to not only provide students with a solid grounding in science content, but also with an understanding of ethical implications of science and the human context in which science occurs. These are the reasons why students need to be taught ethics on a continuing basis, by primary school teachers through university faculty members.

1.2 School-level policy recommendation

Scientific ethics should be established in science curriculum at all schools, either incorporated into a regular course or in an additional course dealing with specific public issues such as energy policy, environmental policy, mineral use policies, food and agricultural policy, pollution and nuclear weapon policies (Davis; & Barbour. 1985) by school policy makers or administrators. This can also be in an extracurricular activity, for example, clubs, community service and so on. Specially, the principles of honesty and credit (plagiarism) must be put in the school curriculum and paid the most attention as two of vitally fundamental principles currently that are being violated. Moreover, school policy makers should develop a fuller image of scientific knowledge and the role of science and technology in society, integration of the discussion of ethical issues and science education at relevant points of the curriculum (Gosling; & Musschenga. 1985).

One of the major school policies should be to encourage all science teachers to attend seminars, workshops, or courses of the ethics in science to gain better understanding of ethical principles and to be able to transfer the knowledge to their

students appropriately. This should be compulsory for all science teachers as a starting point to obtain the best results of ethical development for students. Additionally, schools should also promote and develop science teachers to have positive attitude of introducing ethics into a science classroom by eliminating the factors that play a negative role on their attitudes (Gosling; & Musschenga. 1985). These factors are: 1) overloaded science curricula pressurized by an oppressive examination system, 2) a pedagogical climate in the schools that is not favorable to moral development and 3) Low motivation and a tendency to avoid professional risk.

2. Recommendations for science teachers

The results of the present study provide science teachers with new ideas on how to use hybrid learning as a teaching tool. Hybrid learning has not been addressed before in the research scientific ethics. In addition, the results give a strong indication that hybrid learning is a productive way to teach ethics in science with the time and condensed content limitations. This study also shows that students are interested in learning ethics in science and also thought that it is very important for all science students to learn and understand these concepts, and principles of scientific ethics. Therefore, this study provides strong support for the argument that science teachers can incorporate ethics into the science classroom for high school students at an appropriate level and with several different pedagogies. There should be a course that scientific ethics can be either taught individually or integrated by a team of teachers from different disciplines; physics, biology and chemistry or any other related science subject. Classroom research should be conducted to develop this type of teaching in order to make good use of time for the next generations of students. Gosling and Musschenga (1985) agrees that at the secondary school level, the introduction of ethical aspects in science education depends strongly on the teachers. Therefore, science teachers should be more courageous to bring ethics into the science class even if it seems to be difficult and has many problems at first, but it is essential. To do so, they may have to put more effort on eliminating the factors that have a negative role on their attitude of introducing ethics into a science classroom (Gosling; & Musschenga. 1985). This can be done by: 1) reducing the resistance to change in the classroom, and the fear of losing respect by shifting responsibilities to students when using new teaching methods, 2) having the communication and cooperation between the classroom teachers in different disciplines, 3) having the understanding and awareness of the contemporary nature of science and technology and its social political, economic and

moral context, and 4) minimizing the constraints of traditional teaching models. For the science teachers, who have the experience and are interested in ethics in science, they should develop their skills for creating methods of teaching which take into account the ethical dimensions of science that enable them to work cooperatively with other teachers. Additionally, they should encourage secondary students to participate actively in decision-making processes by avoiding a too early and too rigid division of the complete group of students into two separate groups of 1) pre-scientists, and 2) students without professional aspirations towards science and technology (Gosling; & Musschenga. 1985). More importantly, to do some serious study in ethics or to work closely with a philosopher or theologian interested in ethical theory and application is recommended (Barbour. 1985). From the researcher's point of view, to make connections or a network of science teachers who are interested in ethics in science in different countries in order to share and gain wider information and teaching materials is recommended.

These recommendations for science teachers can be used for both science and non-science schools. In all cases, schools' limitations should be considered. For instance, hybrid learning is more likely to be used in a school with internet accessibility. For non-science schools, science teachers may have to modify some aspects in order to fit the school's context and appropriateness. For example, case studies used in the classroom can be at the surface of scientific ideas, and not go too deep into the scientific details. This issue also depends on the educational level of students, namely, from primary to high school students.

3. Recommendations for science educators

This study shows that students are interested in learning ethics in science and they thought that it is very important for all science students to learn and understand the concepts and principles of scientific ethics. This study also provides strong support for the argument that science teachers can incorporate ethics into science classrooms for high school students at an appropriate level and with several different pedagogies. Therefore, science educators should help motivate science teachers to realize the importance of raising ethical issues in their science classroom. Also, to change their ideas that science is neutral, value-free and isolated from questions of values and ethics. Most importantly, science educators themselves should consider science as being value laden. As Gosling, Musschenga and Eijkelhof (1985) addressed the idea that we should not consider science education in isolation, but in relation to moral education in particular and the moral

development of students must be promoted as an integral part of science education. Science educators could set this in motion by offering workshops or training in moral development for science teachers and for prospective science educators.

Furthermore, science educators should play an essential role in solving problems generally occurring with science teachers as stated by Gosling and Musschenga (1985). These problems are those who are against introducing ethical aspects in science education; who think it is not possible, those who are willing to do so but do not know how to do it and who try but meet with many problems. In addition, they should enhance the ability of teachers to deal with student activities that promote moral development so that students have more opportunity to face the consequences of their moral choices, and so are more challenged; also the ability of teachers to assess progress in moral reasoning. Science educators also have to talk repeatedly of the importance of ethical issues related to science and its creations, the good and the bad, the creative and beautiful aspects of science must of course be taught; and the uncontrolled consequences of science should also be taught (Frazer; & Kornhauser. 1985; & Gosling; & Musschenga. 1985). All science educators should also specifically consider these issues.

4. Recommendations for science researchers/mentors

Today science researchers or mentors play an important role on students' science projects or research. When students are learning about scientific research, they also have to learn about the standards of conduct. Advising and mentoring by more-experienced scientists is essential. They have responsibilities to offer the guidance and advice on matters connected to scientific research to students as younger or beginning researchers. The main role of an adviser or a mentor is to help students to maintain and model the high standard of conduct as well as to build the advancement of science. Scientist can be a good role model for science students to work ethically. At the same time, they can educate students, who will be scientists in the near future, on how to be ethical scientists. Therefore, science researchers themselves have to aware, and pay close attention to these principles of scientific ethics so that they can educate prospective scientists and insure that they learn how to conduct good science. Students can benefit greatly from working together with advisers and mentors.

5. Recommendations for all

As Mehlinger (1986) mentioned that typically, the family is the first and principal instructor for the moral values approved by their custom and traditions. Mothers,

fathers and members of the extended family play key roles. Personally, the researcher thinks that it is absolutely right but, for some reason, our world is changing. Some parents tend not to play the major role of teaching their children about ethical or moral values. Particularly, ethics in science is not easy for parents to teach to their children if they do not have the fundamental ideas or awareness of the ethical issues in science, so how could they cultivate their children appropriately? The researcher truly believes that children should be taught by a teacher who seems to have some characteristics, for example, to have basic ideas of science, to have teaching experience, to be aware or to appreciate, to be willing to do so and more importantly, to know how to teach ethics in science properly. Most importantly, it is recommended that parents, policy makers, science teachers, science educators, scientists, researchers, mentors, community, and everyone in our society or nation work cooperatively in order to improve the ethical development effectively. This would be more effective in not only teaching ethics in science, but also ethics in general.

6. Recommendations for further studies

6.1 There should be longitudinal research conducted where students are exposed to ethics in science for three years consecutively to see whether it will be more beneficial for students to learn and be aware of ethical principles effectively. In addition, there is a need to repeat the present study with fewer variables with the next generations of student at Mahidol Wittayanusorn School as well as in other science schools in Thailand to gain results that are more obvious and to determine the trends of this type of research.

6.2 The present study has provided the useful findings for scientific ethics research with high school students. Yet this research is clearly only a beginning point in Thailand. As a follow-up, to the present study, a deeper look at the important variables such as thinking skills and communicative skills should be taken into account. According to the survey, there are several activities that can be added into class, either a standard or an additional class. Therefore, more research studies of ethics education with different techniques are needed e.g. role playing, drama or debate. In fact, at Mahidol Wittayanusorn School there is a drama club organized by students and teachers together. Each year they have to play, until now, there has been two drama plays which were “Just Understand: The Musical” and “Just Saying “Love”: The Musical” They were very popular for most students. Ethics in science can be incorporated in this creative activity, for example, “On Being a Scientist” which is a name of a book about the responsible conduct of scientific research. It could be “On Being a Scientist: The Musical.” This can

be integrated to promote understanding, awareness of scientific ethics, thinking skills; creative, analytical, and practical thinking skills, and communicative skills. If there is no time limited, like in an additional class or club, students should be able to have their own portfolio which regular writing of ethics is included. Such classes would provide data that could be examined for students over a longer time. This could also be studied for several variables.

6.3 A number of other valuable studies would also naturally follow the present study. This would call upon other scholars to seriously study about student understanding of ethical concept and principles in science at the high school level, at the collegiate level, and even, where possible, at the elementary level throughout Thailand. In addition to looking at student awareness on learning ethics in science, research on workshops for science teachers who are really interested in scientific ethics should be conducted. Such qualitative research would certainly lead to the spread out of meaningful teaching scientific ethics across the nation.

6.4 Future research on the principle of honesty would be a major requirement since it is the core of any other ethical principle. Additionally, other principles should be studied in different ways with time allocation. For instance, the ethics of social responsibility, respect for subjects that can be performed through drama or role- playing. All of these principles generally take time to conduct research and to see the obvious and reliable consequences.

6.5 The Thai students and teachers' ability to use English to discover new knowledge, especially the difficulty on technical terms such as in the field of scientific ethics or philosophy, is still limited. Therefore, students and teachers should have adequate potential to deal with English documents or media, which are very crucial for them to search for the up-to-date knowledge on ethical principles or issues in a changing society. Research on students and teachers' capability to learn scientific ethics by using English media should be performed. So that trusted Thai media, translated books, for example, could be increasingly created by scholars if necessary.

6.6 Some useful research could certainly be done with those students who may resist the idea of learning ethics in science, particularly high achieving science students who overlook this imperative issue. Individual teaching with case studies, followed up by one-on-one interviews could be one of the successful ways to figure this out.

In summary, given the success of the present study the area of ethics education in science will provide a fruitful research agenda not only for schools and researchers, but also for many other science teachers and science educators. The research findings can help to effectively prepare students for being a leaders, scientists or researchers in the near future for the nation and to develop Thai learners to be good, competent (smart) and happy according to the objective of the 1999 National Education Act.

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APPENDIX

Appendix A

ตัวอย่างแผนการจัดการเรียนรู้

แผนการจัดการเรียนรู้ที่ 1 **รายวิชา เคมี 1** **รหัสวิชา ว 40131**
ชั้นมัธยมศึกษาปีที่ 4 **ภาคเรียนที่ 1** **ปีการศึกษา 2552**
บทที่ 1 โครงสร้างอะตอม เรื่อง ปฐมนิเทศและจริยธรรมทางวิทยาศาสตร์ **เวลา 1.0 คาบ**

สาระการเรียนรู้

จริยธรรมทางวิทยาศาสตร์ ประกอบด้วยหลักการ 12 ประการ กล่าวคือ 1) ความซื่อสัตย์ (Honesty) 2) ความระมัดระวัง/ความรอบคอบ (Carefulness) 3) ความใจกว้าง (Openness) 4) ความมีอิสรภาพ (Freedom) 5) ความเชื่อถือ (Credit) 6) การให้การศึกษา (Education) 7) ความถูกต้องตามกฎหมาย (Legality) 8) ความรับผิดชอบต่อสังคม (Social Responsibility) 9) โอกาส (Opportunity) 10) ความเคารพซึ่งกันและกัน (Mutual Respect) 11) ประสิทธิภาพ (Efficiency) และ 12) ความเคารพต่อผู้รับการทดลอง (Respect for Subjects)

ผลการเรียนรู้ที่คาดหวัง

อธิบายความหมายของวิทยาศาสตร์ จริยธรรม และจริยธรรมทางวิทยาศาสตร์ได้
อธิบายความสัมพันธ์ระหว่างวิทยาศาสตร์และจริยธรรมได้
อธิบายแนวคิดพื้นฐานและหลักการของจริยธรรมทางวิทยาศาสตร์ได้
ตระหนักถึงคุณค่าและความสำคัญของจริยธรรมทางวิทยาศาสตร์

เนื้อหาสาระ

จริยธรรมเป็นระบบหนึ่งของสาธารณชน ซึ่งเป็นกฎต่าง ๆที่ใช้เป็นแนวทางในการประพฤติปฏิบัติของมนุษย์ (Gert, 1988) จริยธรรมทางวิทยาศาสตร์ (scientific ethics) เป็นจรรยาบรรณองค์กรที่สะท้อนถึงข้อตระหนักและเป้าหมายต่าง ๆของวิทยาศาสตร์และบรรทัดฐานต่าง ๆทางสังคม

จากนิยาม คำว่า ประพฤติปฏิบัติ (conduct) หมายถึง ลักษณะต่าง ๆทั้งหมดของกิจกรรมต่าง ๆ ทางวิทยาศาสตร์ รวมถึงการทำการทดลอง การทดสอบ การศึกษา การวิเคราะห์ข้อมูล การเก็บข้อมูล การใช้ข้อมูลร่วมกัน การทบทวนระดับเดียวกัน (peer review) การให้เงินทุนโดยรัฐบาล สมาชิกทีมวิจัย เป็นต้น โดยไม่รวมถึงการประพฤติปฏิบัติที่ไม่มีผลโดยตรงต่อวิทยาศาสตร์ และคำว่า วิทยาศาสตร์ หมายถึง ศาสตร์ทางวิชาการ (academic science) ไม่ใช่ศาสตร์ทางการทหารหรือศาสตร์ทางธุรกิจ ถึงแม้ว่าศาสตร์ทั้งสามแขนงจะใช้หลักการพื้นฐานบางอย่างร่วมกัน แต่มีเป้าหมายและข้อตระหนักที่แตกต่างกัน เป้าหมายและข้อตระหนักที่แตกต่างกันเหล่านั้น ทำให้เกิดเป็นจริยธรรมที่แตกต่างกัน ในทางการทหาร การรักษาความปลอดภัยของชาติเป็นเป้าหมายหลักและความลับเป็นสิ่งที่สำคัญและจำเป็นต่อการบรรลุเป้าหมายนั้น ความลับก็ยังเป็นสิ่งที่สำคัญด้วยเช่นกันในศาสตร์ทางธุรกิจเพื่อใช้ในการส่งเสริมเป้าหมายหลักของธุรกิจ นั่นก็คือ การทำกำไรให้ได้มากที่สุด สำหรับศาสตร์ทางวิชาการมีการถกเถียงกันมาเป็นเวลานานในกลุ่มนักปรัชญาเกี่ยวกับเป้าหมายของศาสตร์นั้น แต่ข้อตระหนักเบื้องต้น

สองอย่างที่เห็นได้อย่างชัดเจนก็คือ การแสวงหาความรู้และความเชื่อต่างๆที่เป็นจริงเกี่ยวกับโลก เนื่องจากกฎต่างๆทางจริยธรรมของวิทยาศาสตร์ควรจะส่งเสริมเป้าหมายเหล่านี้ หลักการที่สำคัญที่สุดจำนวนมากจึงได้กำเนิดขึ้นมา เดวิด บี เรสนิค (David B. Resnik, 1998) ได้นำเสนอและปกป้องหลักการจริยธรรมทางวิทยาศาสตร์ 12 ประการ ซึ่งนำไปใช้ในกระบวนการทำงานวิจัยต่างๆ เพื่อไม่ให้ขัดต่อมาตรฐานทางจริยธรรมที่เป็นที่ยอมรับกันโดยทั่วไปและเพื่อส่งเสริมความก้าวหน้าของเป้าหมายต่างๆทางวิทยาศาสตร์ หลักการทั้ง 12 ประการ มีดังนี้

หลักการจริยธรรมทางวิทยาศาสตร์	**คำอธิบาย**
1. ความซื่อสัตย์ (Honesty)	นักวิทยาศาสตร์ไม่ควรสร้างข้อมูล (fabricate) แก้ไขข้อมูล (falsify) หรือนำเสนอข้อมูลหรือผลการทดลองที่ไม่ตรงตามจริง (misrepresent) อีกทั้งควรเป็นคนที่ตัดสินใจบนพื้นฐานของข้อเท็จจริง (objective) ไม่ลำเอียง (unbiased) เป็นที่น่าไว้ใจ (trustful) ในทุกแง่มุมของกระบวนการวิจัย
2. ความระมัดระวัง / ความรอบคอบ (Carefulness)	นักวิทยาศาสตร์ควรหลีกเลี่ยงความคลาดเคลื่อนในการรายงานผลการวิจัยที่ได้ ควรลดความคลาดเคลื่อนจากการทดลอง ความคลาดเคลื่อนจากวิธีการวิจัย และความคลาดเคลื่อนของผู้วิจัยหรือผู้ทดลองให้มากที่สุด รวมทั้งหลีกเลี่ยงการหลอกตัวเอง (self-deception) ความลำเอียง (bias) และการขัดผลประโยชน์ (conflicts of interest)
3. ความใจกว้าง (Openness)	นักวิทยาศาสตร์ควรจะแบ่งปันหรือแลกเปลี่ยนข้อมูล (data) ผลวิจัย (results) วิธีการ (methods) แนวคิด (ideas) เทคนิค (techniques) และเครื่องมือต่างๆ (tools) แก่กันและกัน. และควรจะอนุญาตให้นักวิทยาศาสตร์คนอื่นๆ ทบทวน (review) และวิพากษ์วิจารณ์ งานและแนวคิดใหม่ๆของตนด้วย
4. ความมีอิสรภาพ (Freedom)	นักวิทยาศาสตร์ควรมีความเป็นอิสระในการทำงานวิจัยในปัญหา (problem) หรือข้อสมมติฐาน (hypothesis) ต่างๆ และควรได้รับอนุญาตในการทำงานต่อไปให้สำเร็จสำหรับแนวคิดใหม่ๆและสามารถ วิพากษ์วิจารณ์แนวคิดเดิมๆได้
5. ความเชื่อถือ (Credit)	ความเชื่อถือ (Credit) ควรจะมอบให้กับผู้ที่ได้ลงมือปฏิบัติงานนั้นจริงเป็นผลสำเร็จ
6. การให้การศึกษา (Education)	นักวิทยาศาสตร์ควรจะให้การศึกษาหรือความรู้แก่นักวิทยาศาสตร์ใหม่ๆ และรับประกันว่าพวกเขาได้เรียนรู้ว่าจะปฏิบัติหรือทำการทดลองทางวิทยาศาสตร์ ให้ดีได้อย่างไร รวมถึงแจ้งให้สาธารณชนได้ทราบเกี่ยวกับวิทยาศาสตร์
7. ความรับผิดชอบต่อสังคม (Social Responsibility)	นักวิทยาศาสตร์ควรหลีกเลี่ยงการเป็นสาเหตุของการทำการใดๆที่จะเป็นอันตรายต่อ สังคม ควรพยายามสร้างผลประโยชน์ให้กับสังคม และควรจะแสดงความรับผิดชอบต่อผลงานการวิจัยของตนเอง รวมทั้งควรจะแจ้งให้สาธารณชนทราบเกี่ยวกับผลลัพธ์ที่ได้จากการวิจัยต่างๆ
8. ความถูกต้องตามกฎหมาย (Legality)	ในกระบวนการทำวิจัย นักวิทยาศาสตร์ควรปฏิบัติตามกฎหมายต่างๆที่สัมพันธ์โดยตรงต่องานของตน

หลักการจริยธรรมทางวิทยาศาสตร์	คำอธิบาย
9. โอกาส (Opportunity)	นักวิทยาศาสตร์ควรจะได้รับโอกาสอย่างเป็นธรรมในการใช้ทรัพยากรต่าง ๆทางวิทยา ศาสตร์ หรือโอกาสในความก้าวหน้าของวิชาชีพทางวิทยาศาสตร์
10. ความเคารพซึ่งกันและกัน (Mutual Respect)	นักวิทยาศาสตร์ควรจะปฏิบัติต่อเพื่อนร่วมงานด้วยความเคารพ
11. ประสิทธิผล(Efficiency)	นักวิทยาศาสตร์ควรใช้ทรัพยากรต่าง ๆอย่างรู้คุณค่า มีประสิทธิผลและเกิดประโยชน์สูงสุด
12. ความเคารพต่อผู้รับการทดลอง (Respect for Subjects)	นักวิทยาศาสตร์ไม่ควรละเมิดสิทธิต่าง ๆหรือศักดิ์ศรี (dignity) เมื่อมีการใช้คน (human subjects) ในการทำการทดลองต่าง ๆ และควรปฏิบัติต่อสัตว์ทดลองหรือผู้รับการทดลอง (subject) อื่น ๆที่ไม่ใช่คนอย่างเหมาะสม

หลักการต่าง ๆที่กล่าวถึงทั้งหมดส่งเสริมเป้าหมายและข้อตระหนักต่าง ๆที่สำคัญทางวิทยาศาสตร์ไม่ทางตรงก็ทางอ้อม หลักการต่าง ๆของการวิจัยทางวิทยาศาสตร์ส่วนใหญ่จะเป็นการส่งเสริมเป้าหมายและข้อตระหนักต่าง ๆที่สำคัญทางวิทยาศาสตร์โดยตรง ในขณะที่หลักการจริยธรรมทั่วไปอื่น ๆส่งเสริมโดยทางอ้อม

ท้ายที่สุดแล้ว เราควรจะจดจำไว้ว่าการแสวงหาความรู้และความจริงจะหยุดชะงักลงถ้าหากว่าบรรดานักวิทยาศาสตร์ละเมิดหลักการจริยธรรมทั่วไปอื่น ๆของสังคม เพราะว่าหลักการต่าง ๆเหล่านี้ช่วยดำรงไว้ซึ่งเสถียรภาพ ความมั่นคง และ ความน่าเชื่อถือไว้วางใจในสังคมวิทยาศาสตร์และการสนับสนุนวิทยาศาสตร์จากสาธารณชน

กิจกรรมการเรียนการสอน

4.1 ขั้นนำเข้าสู่บทเรียน

4.1.1 กล่าวต้อนรับนักเรียนสู่โรงเรียนวิทยาศาสตร์ แล้วให้นักเรียนแนะนำตัว แจ้งให้ทราบถึงโครงการสอน หนังสือหรือเว็บไซต์ที่ใช้ประกอบการเรียนรู้ และการประเมินผล รวมถึงสร้างข้อตกลงในการเรียน พร้อมให้นักเรียนซักถามข้อสงสัย

4.1.2 แจ้งให้นักเรียนทราบว่าก่อนเรียนทุกคาบ ครูจะมีคำคมและข้อคิดก่อนเรียนเกี่ยวกับจริยธรรมทางวิทยาศาสตร์มาฝากและเมื่อหมดภาคเรียน นักเรียนจะต้องคิดคำคมหรือข้อคิดก่อนเรียนอย่างน้อยคนละ 1 คำคม แล้วนำมาส่งครู เพื่อเก็บไว้เป็นตัวอย่างให้กับรุ่นน้องต่อไป

4.1.3 ครูยกตัวอย่างคำคม/ข้อคิดก่อนเรียนของนักเรียนที่เคยเรียนรายวิชาเพิ่มเติม ว 40234 จริยธรรมทางวิทยาศาสตร์ ที่ว่า ***“ความคิดของคนเปรียบเสมือนดิน ซึ่งถือเป็นพื้นฐานด้าน ๆ แต่ความคิดที่มีจริยธรรม เปรียบเสมือนดิน ซึ่งกำเนิดชีวิตได้” เตชิต ตริตระการ ม. 5/4*** แล้วให้นักเรียนร่วมกันวิเคราะห์

4.2 ขั้นสอน

4.2.1 ครูยกตัวอย่างหนังสือเรื่อง เปิดพรมแดนวิทยาศาสตร์สู่พรมแดนจริยศาสตร์และแค่เก่งไม่พอให้นักเรียนอ่าน เปิด Power Point ให้เห็นรูปภาพประกอบ ซึ่งนักเรียนสามารถนับเป็น 1 ใน 50 เล่มหนังสือที่โรงเรียนให้นักเรียนอ่านเพื่อจบหลักสูตรได้ จากนั้นสรุปเนื้อหาของหนังสือทั้งสองเรื่องให้นักเรียนฟังอย่างคร่าวๆ

4.2.2 แสดง Ethics before class ตัวอย่างกรณีศึกษาของหวาง วู ซก นักวิทยาศาสตร์ชาวเกาหลีที่ประพฤติผิดหลักจริยธรรมทางวิทยาศาสตร์ ก่อให้เกิดความเสื่อมเสียชื่อเสียงทั้งต่อตนเอง ครอบครัวและประเทศชาติ โดยใช้ Power Point และเว็บไซต์ประกอบ แล้วให้นักเรียนร่วมกันวิเคราะห์และแสดงความคิดเห็นของพฤติกรรมดังกล่าว

4.2.3 จากกรณีดังกล่าว ให้นักเรียนตอบแบบทดสอบก่อนเรียนเกี่ยวกับความรู้ความเข้าใจเรื่องจริยธรรมทางวิทยาศาสตร์และแบบสอบถามความคิดเห็นของนักเรียนเกี่ยวกับความสำคัญของจริยธรรมทางวิทยาศาสตร์ ให้เวลานักเรียนทำชุดละประมาณ 10 นาที

4.2.4 ครูนำเสนอหลักการจริยธรรมทางวิทยาศาสตร์ 12 ประการพร้อมทั้งอธิบายเพิ่มเติม พร้อมทั้งให้นักเรียนซักถามข้อสงสัย และแจ้งให้นักเรียนทราบว่าเราจะค่อยๆเรียนรู้แต่ละหลักการเพิ่มเติมไปตลอดทั้งภาคเรียน

4.3 ขั้นสรุป

ร่วมกันสรุปความสำคัญของจริยธรรมทางวิทยาศาสตร์ แล้วมอบหมายให้นักเรียนไปอ่านบทความเรื่อง จริยธรรมทางวิทยาศาสตร์ของ ศ.ดร.ยงยุทธ ยุทธวงศ์ ซึ่งอยู่ในเว็บไซต์ประกอบการสอนของครู แล้วสรุปความเพื่อเตรียมนำมาอภิปรายในคาบเรียนถัดไป พร้อมทั้งรับใบงานกรณีศึกษาของมิลลิแกนไปศึกษา เพื่อเตรียมนำเสนอหลังจากเรียนเรื่องการทดลองของมิลลิแกนแล้ว

5. สื่อการเรียนการสอน / แหล่งเรียนรู้

5.1 Power Point

5.2 เว็บไซต์ประกอบการสอน

5.3 หนังสือแค่เก่งไม่พอ (Talent is never enough)

5.4 หนังสือเคมีของ Raymond Chang 8th edition

5.5 ใบงาน กรณีศึกษา การทดลองหยดน้ำมันของมิลลิแกน

6. การประเมินผล / เครื่องมือ

6.1 แบบทดสอบก่อนเรียน เรื่อง จริยธรรมทางวิทยาศาสตร์

6.2 แบบสอบถามวัดความคิดเห็น เรื่อง จริยธรรมทางวิทยาศาสตร์

6.3 แบบทบทวนไตร่ตรองแผนการจัดการเรียนรู้สำหรับครู

6.4 แบบประเมินใบงานการบ้าน

7. กิจกรรมเสนอแนะ

……

……..……

8. ข้อเสนอแนะของหัวหน้าสถานศึกษาหรือผู้ที่ได้รับมอบหมาย

……..……

……..

ลงชื่อ……

(นายวชิรศรณ์ แสงสุวรรณ)

ครูวิชาการ สาขาวิชาเคมี

วันที่……เดือน……พ.ศ……

9. บันทึกหลังการสอน:

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แผนการจัดการเรียนรู้ที่ 3 **รายวิชา เคมี 1** **รหัสวิชา ว 40131**
ชั้นมัธยมศึกษาปีที่ 4 **ภาคเรียนที่ 1** **ปีการศึกษา 2552**
บทที่ 1 โครงสร้างอะตอม **เรื่อง แบบจำลองอะตอม** **เวลา 2 คาบ**

1. สาระการเรียนรู้

แบบจำลองอะตอม

1. ดาลตัน เสนอแบบจำลองอะตอมว่าอะตอมมีลักษณะเป็นทรงกลม มีขนาดเล็กที่สุดไม่สามารถแบ่งแยกได้
2. ทอมสัน เสนอว่าอะตอมประกอบด้วย อนุภาคบวกและอิเล็กตรอนจำนวนเท่ากันกระจายอยู่ทั่วไปในอะตอม
3. รัทเทอร์ฟอร์ด เสนอว่าอะตอมประกอบด้วย นิวเคลียสซึ่งมีขนาดเล็กอยู่ตรงกลางและมีอิเล็กตรอนเคลื่อนที่อยู่รอบ ๆ

2. ผลการเรียนรู้ที่คาดหวัง

อธิบายและเปรียบเทียบแบบจำลองอะตอมของดาลตัน ทอมสัน รัทเทอร์ฟอร์ดได้

3. เนื้อหาสาระ

แบบจำลองอะตอมของดาลตัน

จอห์น ดาลตัน นักวิทยาศาสตร์ชาวอังกฤษได้รวบรวมเรื่องเกี่ยวกับอะตอมและตั้งเป็นทฤษฎีขึ้นเรียกว่า ทฤษฎีอะตอมของดาลตัน ซึ่งนับเป็นก้าวแรกที่ทำให้เกิดความเข้าใจเกี่ยวกับอะตอมมากขึ้น ทฤษฎีอะตอมของดาลตันมีใจความสำคัญดังนี้

1. สสารทุกชนิดประกอบด้วยอนุภาคที่เล็กที่สุดเรียกว่า อะตอม ซึ่งไม่สามารถแบ่งแยกต่อไปได้อีก
2. อะตอมไม่สามารถสร้างขึ้นใหม่หรือทำให้สูญหายไปได้
3. อะตอมของธาตุชนิดเดียวกันย่อมเหมือนกัน กล่าวคือมีสมบัติเหมือนกันทั้งทางกายภาพและทางเคมี
4. อะตอมของธาตุชนิดเดียวกันย่อมมีมวลหรือน้ำหนักเท่ากัน
5. สารประกอบเกิดจากการรวมตัวทางเคมีระหว่างอะตอมของธาตุต่างชนิดกันด้วยอัตราส่วนของจำนวนอะตอมเป็นเลขลงตัวน้อยๆ
6. อะตอมของธาตุสองชนิดขึ้นไปอาจรวมกันเป็นสารประกอบด้วยอัตราส่วนที่มากกว่าหนึ่งอย่างเพื่อเกิดสารประกอบมากกว่า 1 ชนิด

ดาลตัน (Dalton)

1803-1805

รูป 1-1 แบบจำลองอะตอมของดาลตัน

(ที่มา: http://pages.uoregon.edu/ch111/L5.htm)

แบบจำลองอะตอมของทอมสัน

1) หลอดรังสีคาโทด เป็นเครื่องมือที่ใช้ในการทดลองเกี่ยวกับการนำไฟฟ้าของก๊าซและใช้ศึกษาสมบัติของรังสีคาโทด

2) การค้นพบอิเล็กตรอน

ทอมสัน นักวิทยาศาสตร์ชาวอังกฤษ ได้ศึกษาจากหลอดรังสีคาโทด โดยให้รังสีคาโทดผ่านช่องเล็ก ๆ ที่มีทั้งสนามแม่เหล็ก และสนามไฟฟ้า อยู่ในแนวตั้งฉากกับทิศทางของรังสี ผลการทดลองพบว่ารังสีคาโทดจะเบี่ยงเบนไปจากฉากเรืองแสง โดยเบนออกจากขั้วลบเข้าหาขั้วบวกของสนามไฟฟ้า จึงสรุปว่ารังสีคาโทดนี้มีประจุเป็นลบ เรียกว่าอิเล็กตรอน เมื่อเปลี่ยนก๊าซชนิดต่าง ๆ รวมทั้งเปลี่ยนชนิดของโลหะที่ใช้เป็นคาโทด ทอมสันศึกษาสมบัติของรังสีคาโทด และคำนวณอัตราส่วนของประจุต่อมวล (e/m) ของอนุภาค พบว่ารังสีคาโทดไม่ว่าจะใช้ก๊าซหรือโลหะใด ๆ ก็ตามมีสมบัติเหมือนกันทุกประการ และมีค่าประจุต่อมวลคงที่ คือมีค่า e/m = 1.7×10^{8} คูลอมบ์/กรัม ซึ่งจากผลการทดลองและผลการคำนวณนี้แสดงว่าอะตอมทุกชนิดมีอิเล็กตรอนเหมือนกัน ดังนั้นการทดลองของทอมสันจึงเป็นการค้นพบอิเล็กตรอน

3) การค้นพบโปรตอน

โกลด์ชไตน์ ได้ดัดแปลงหลอดรังสีคาโทด โดยให้ขั้วคาโทดและอาโนดเลื่อนมาไว้เกือบตรงกลางและเพิ่มฉากเรืองแสงทั้งสองด้านของหลอดเจาะรูตรงกลางขั้วทั้งสอง เมื่อผ่านกระแสไฟฟ้าศักย์สูงเข้าไปจะมีจุดสว่างขึ้นที่ฉากเรืองแสงทั้งสอง และเบี่ยงเบนในสนามแม่เหล็กเข้าหาขั้วลบ ซึ่งตรงข้ามกับรังสีคาโทด แสดงว่ารังสีที่พุ่งมาที่ฉาก B ต้องประกอบด้วยอนุภาคที่มีประจุไฟฟ้าบวก เพราะเคลื่อนที่จากอาโนดไปยังคาโทด ผ่านรูเลยไปยังฉาก B ด้านหลังคาโทดและเบี่ยงเบนเข้าหาขั้วลบ เมื่อเปลี่ยนชนิดก๊าซในหลอด พบว่าอัตราส่วนประจุต่อมวลไม่คงที่ขึ้นกับชนิดของก๊าซ แต่ถ้าใช้ก๊าซชนิดเดียวกันแม้จะเปลี่ยนชนิดของโลหะคาโทดพบว่าผลการทดลองไม่เปลี่ยนแปลง เมื่อใช้ก๊าซไฮโดรเจนบรรจุในหลอดพบว่า อนุภาคบวกที่ได้มีประจุเท่ากับประจุของอิเล็กตรอน เรียกอนุภาคบวกที่เกิดจากก๊าซไฮโดรเจนว่าโปรตอน

การหาประจุของอิเล็กตรอน

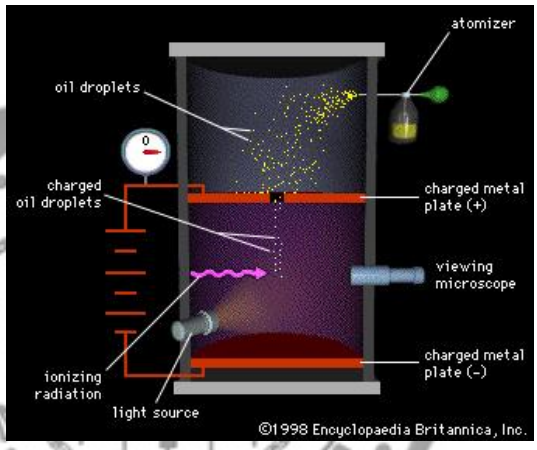
มิลลิแกน นักวิทยาศาสตร์ชาวอเมริกัน เป็นผู้สามารถทำการทดลองหาค่าประจุของอิเล็กตรอน โดยวิธี หยดน้ำมัน (Oil-drop) พบว่าประจุบนเม็ดน้ำมันมีค่าเป็นเลขจำนวนเต็มเป็นจำนวนเท่าของ 1.60×10^{-19} คูลอมบ์ นั่นคือ $Q = ne$ ตัวเลขจำนวนเต็มที่แสดงเป็นจำนวนเท่าของ 1.60×10^{-19} คูลอมบ์ หรือค่า n ใด ๆ คือจำนวนอิเล็กตรอนที่เม็ดน้ำมันจับไว้

จากการทดลองของทอมสัน สามารถหาค่า อัตราส่วนของประจุต่อมวลของอิเล็กตรอนได้

จาก $e/m = 1.7 \times 10^{8}$ คูลอมบ์/กรัม

$e = 1.60 \times 10^{-19}$ คูลอมบ์

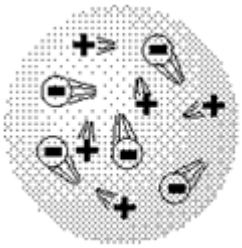
$m = 9.41 \times 10^{-28}$ กรัม



รูป 1-2 การทดลองหาประจุของอิเล็กตรอน

(ที่มา: http://millikan.nbaoh.com/1.htm)

สรุปแบบจำลองอะตอมของทอมสันมีลักษณะเป็นทรงกลมของอนุภาคบวกแล้วมีอิเล็กตรอนกระจายอยู่ภายในทรงกลมนั้นเหมือนกับขนมพุดดิ้งของชาวอังกฤษ



ทอมสัน (Thomson)

1903

รูปที่ 1-3 แบบจำลองอะตอมของทอมสัน

(ที่มา: http://pages.uoregon.edu/ch111/L5.htm)

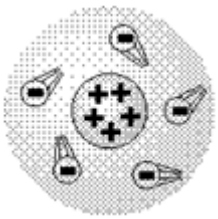
แบบจำลองอะตอมของรัทเทอร์ฟอร์ด

รัทเทอร์ฟอร์ด นักวิทยาศาสตร์ชาวนิวซีแลนด์ได้ทำการทดลองในอังกฤษร่วมกับ เอม ไกเกอร์ และมาร์สเดน โดยทำการยิงอนุภาคแอลฟาผ่านแผ่นโลหะทองคำบาง ๆ พบว่า อนุภาคแอลฟาส่วนใหญ่เดินทางเป็นเส้นตรงทะลุผ่านแผ่นทองคำออกไปได้ แต่มีบางอนุภาคที่เฉออกจากเส้นทางเดิม และบางอนุภาคสะท้อนกลับจากเส้นทางเดิมเมื่อกระทบกับแผ่นทองคำ ซึ่งสรุปว่า การที่อนุภาคแอลฟาซึ่งมีประจุบวกและมีมวลมากสามารถทะลุผ่านแผ่นโลหะบาง ๆ ได้นั้น แสดงว่าอะตอมไม่ใช่ของแข็งทึบตัน นั่นคือ อะตอมจะต้องมีที่ว่างอยู่ภายใน มิฉะนั้นอนุภาคแอลฟาจะต้องออกทุกทิศทางทุกๆ อนุภาคที่ผ่านแผ่นทองคำบางนั้น แสดงว่า ภายในอะตอมจะต้องมีอนุภาคที่มีมวลมาก และมีประจุบวกสูงมีขนาดเล็ก ซึ่งจะมีอยู่ไม่มากนักเมื่อเทียบกับขนาดของอะตอม เพราะเมื่ออนุภาคแอลฟาซึ่งมีประจุบวกผ่านเข้าใกล้อนุภาคนี้ก็จะผลักให้เบนออกจากเส้นทางเดิม การที่อนุภาคแอลฟาหักเหสะท้อนกลับไปทางด้านหน้าของแผ่นทองคำได้นั้น แสดงว่า ภายในอะตอมต้องมีแก่นกลางซึ่งมีมวลมากและมีประจุบวกสูง

การค้นพบนิวตรอน

เจมส์ ชาดวิก นักวิทยาศาสตร์ชาวอังกฤษ ค้นพบอนุภาคที่ไม่มีประจุแต่มีมวลใกล้เคียงเกือบเท่ากับโปรตอน ชาดวิกเรียกอนุภาคนี้ว่านิวตรอน

สรุปแบบจำลองอะตอมของรัทเทอร์ฟอร์ด พบว่าในอะตอมส่วนใหญ่เป็นที่ว่างไม่ได้มีการกระจายตัวของประจุบวก แต่ประจุบวกของอะตอมนั้นน่าจะอยู่รวมกันอย่างหนาแน่นในแกนกลางของอะตอมซึ่งรัทเทอร์ฟอร์ดเรียกว่านิวเคลียส ต่อมาพบว่าอนุภาคบวกในนิวเคลียสนั้นคือโปรตอน โดยแต่ละโปรตอนจะมีประจุเท่ากับอิเล็กตรอนแต่มีเครื่องหมายตรงกันข้ามและมีมวล 1.67×10^{-24} g หรือประมาณ 1840 เท่าของอิเล็กตรอน



รัทเทอร์ฟอร์ด (Rutherford)

1911

รูปที่ 1-4 แบบจำลองอะตอมของรัทเทอร์ฟอร์ด

(ที่มา: http://pages.uoregon.edu/ch111/L5.htm)

4. กิจกรรมการเรียนการสอน

4.1 ขั้นนำเข้าสู่บทเรียน

ครูยกตัวอย่างคำคม/ข้อคิดก่อนเรียนของนักเรียนที่เคยเรียนรายวิชาเพิ่มเติม ว 40234 จริยธรรมทางวิทยาศาสตร์ ที่ว่า ***"หากวิทยาศาสตร์ก่อให้เกิดเทคโนโลยีแล้ว จริยธรรมก็จะก่อให้เกิดการนำเทคโนโลยีมาใช้ให้เกิดประโยชน์ต่อสรรพสิ่ง" (ศรุตย์ กฤษดำ ม. 5/4)*** แล้วให้นักเรียนวิเคราะห์

4.2 ขั้นสอน

4.2.1 นักเรียนแต่ละกลุ่มศึกษาแบบจำลองอะตอมในเอกสารประกอบการเรียน ช่วยกันวิเคราะห์ จากนั้นนักเรียนและครูร่วมกันสรุปแนวคิดจากการดูวิดีทัศน์ เรื่อง หลอดรังสีแคโทด การทดลองหาค่าประจุของอิเล็กตรอนจากหยดน้ำมันของมิลลิแกน แบบจำลองอะตอมของรัทเทอร์ฟอร์ด

4.2.2 ครูยกประเด็นกรณีศึกษาของมิลลิแกน โดยใช้ Power Point ประกอบ และให้ข้อมูลเพิ่มเติมในประเด็นที่เป็นข้อถกเถียงทางจริยธรรมในการทดลองของมิลลิแกน แล้วให้นักเรียนจับคู่กันวิเคราะห์ และขออาสาสมัครออกมาแสดงความคิดเห็นหน้าชั้นเรียน

4.2.3 นักเรียนและครูร่วมกันอภิปราย เปรียบเทียบแบบจำลองต่างๆที่ได้ศึกษา รวมถึงการค้นพบอนุภาคต่างๆด้วย พร้อมทั้งให้นักเรียนซักถามข้อสงสัยและทำแบบฝึกหัดเพิ่มเติม

4.3 ขั้นสรุป

นักเรียนและครูร่วมกันสรุปแนวคิดของแบบจำลองอะตอมของดาลตัน ทอมสันและรัทเทอร์ฟอร์ด พร้อมกระตุ้นให้นักเรียนหาข้อมูลเพิ่มเติมเกี่ยวกับการเปลี่ยนแปลงไปของแบบจำลองอะตอมในปัจจุบัน แล้วแจ้งเรื่องแบบทดสอบย่อยเก็บคะแนน เรื่อง จริยธรรมทางวิทยาศาสตร์: กรณีศึกษาการทดลองหยดน้ำมันของมิลลิแกนเป็นงานกลุ่ม โดยให้ไปศึกษาและ

เตรียมตัวนำเสนอในครั้งถัดไป พร้อมทั้งกระตุ้นให้นักเรียนอ่านหนังสือเรื่องที่จะเรียนในครั้งถัดไปมาล่วงหน้า และหากมีปัญหาเรื่องการเรียนก็สามารถมาพูดคุยปรึกษากับครูได้

5. สื่อการเรียนการสอน / แหล่งเรียนรู้

5.1 Power Point

5.2 เอกสารประกอบการสอน

5.3 เว็บไซต์ประกอบการสอน

5.4 แบบฝึกหัด

5.5 ใบงาน เรื่อง จริยธรรมทางวิทยาศาสตร์ : กรณีศึกษาการทดลองของมิลลิแกน

6. การประเมินผล / เครื่องมือ

6.1 แบบทบทวนไตร่ตรองแผนการจัดการเรียนรู้สำหรับครู

6.2 แบบประเมินการบ้าน/ใบงาน

7. กิจกรรมเสนอแนะ

……

……..

8. ข้อเสนอแนะของหัวหน้าสถานศึกษาหรือผู้ที่ได้รับมอบหมาย

……

……

ลงชื่อ……

(นายวชิรศรณ์ แสงสุวรรณ)

ครูวิชาการ สาขาวิชาเคมี

วันที่……เดือน……พ.ศ……

9. บันทึกหลังการสอน:

……

……

Appendix B

แบบสำรวจความคิดเห็นของนักเรียนวิทยาศาสตร์เกี่ยวกับจริยธรรมทางวิทยาศาสตร์

แบบสำรวจความคิดเห็นของครูวิทยาศาสตร์เกี่ยวกับจริยธรรมทางวิทยาศาสตร์

“Survey of Science Students’ Opinions on Learning Ethics in a Science Classroom”

This study aims to collect preliminary data on science students’ opinions on learning ethics in a science classroom, and to continue preparing for the next phase of research based on the preliminaries. This research is conducted in partial fulfillment of the requirements for the Doctoral of Education degree in Science Education at Srinakharinwirot University.

This questionnaire consists of four major parts:

Part A Personal data of respondent

Part B School’s ethics learning in general

Part C Respondent’s ethics learning in the science classroom

Part D Respondent’s opinion on learning ethics in the science classroom

Your response is voluntary and all information will be kept strictly confidential. The information collected in this questionnaire will be only used for research statistical purposes. Therefore, your participation in this survey provides valuable benefits to my research study and also to scientific ethics education at large.

The researcher is grateful for your cooperation in taking the survey.

Washirasorn Saengsuwan

Researcher

Instruction: Please put √ in the parentheses and specify the answer (if any) that shows the appropriate response(s).

Part A : Personal data of respondent

1. Gender ( ) Male ( ) Female
2. Age ….. years

Part B : School's ethics learning in general

1. Please choose from the following principles of scientific ethics the five that you think are most important and rank them in order of important. Put the No.1-5 in the parentheses in front of the principles (Given: 1 is the most important principle).

Principles of ethics in science	**Descriptions**
( ) Honesty	"Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and trustful in all aspects of the research process."
( ) Carefulness	"Scientists should avoid errors in research, especially in presenting results. They should minimize experimental, methodological, and human errors and avoid self-deception, bias, and conflicts of interest."
( ) Openness	"Scientists should share data, results, methods, ideas, techniques, and tools. They should allow other scientists to review their work and be open to criticism and new ideas."
( ) Freedom	"Scientists should be free to conduct research on any problem or hypothesis. They should be allowed to pursue new ideas and criticize old ones."
( ) Credit	"Credit should be given where credit is due but not where it is not due."
( ) Education	"Scientists should educate prospective scientists and insure that they learn how to conduct good science. Scientists should educate and inform the public about science."
( ) Social Responsibility	"Scientists should avoid causing harm to society and they should attempt to produce social benefits. Scientists should be responsible for the consequences of their research and they should inform the public about those consequences."

Principles of ethics in science	Descriptions
( ) Legality	"In the process of research, scientists should obey the laws pertaining to their work."
( ) Opportunity	"Scientists should not be unfairly denied the opportunity to use scientific resources or advance in the scientific profession."
( ) Mutual Respect	"Scientists should treat colleagues with respect."
( ) Efficiency	"Scientists should use resources efficiently."
( ) Respect for Subjects	"Scientists should not violate rights or dignity when using human subjects in experiments. Scientists should treat non-human, animal subjects with appropriate respect and care when using them in experiments."

2. According to the table above, what level of understanding of ethics in science do you think you have?

( ) Very high ( ) High ( ) Moderate ( ) Low ( ) None at all

3. To what extent do you think ethics in science is important for science students or scientists?

( ) Strongly important ( ) Very important ( ) Somewhat important

( ) Hardly important ( ) Not at all

Why?

……

4. To what extent do you think you are interested in studying ethics in science?

( ) Very high ( ) High ( ) Moderate ( ) Low ( ) None at all

Part C: Respondent's ethics learning in the science classroom

1. Have you ever learned ethics in a science classroom?

( ) Yes

( ) No

If yes, in what way have you learned it? (choose all that apply)	If no, but you're interested in learning ethics in science classes. In what way would you like to learn? (choose all that apply)
( ) Formal lecture ( ) Having a visiting speaker ( ) Open informal discussion/ small-group discussions/debates ( ) Issue-based learning ( ) Inquiry-based learning ( ) Assigned reading and papers ( ) Optional reading ( ) Simulation/ Role-playing / Drama project ( ) Case study analysis ( ) Narrative pedagogy/ journal/ essay writing/stories written ( ) Watching/ editing TV news video ( ) Painting and cartoons ( ) Small group research and seminar presentations ( ) Science fiction ( ) Games ( ) Other (please specify):	( ) Formal lecture ( ) Having a visiting speaker) ( ) Open informal discussion/ small-group discussions/debates) ( ) Issue-based learning ( ) Inquiry-based learning ( ) Assigned reading and papers ( ) Optional reading ( ) Simulation/ Role-playing / Drama project ( ) Case study analysis ( ) Narrative pedagogy/ journal/ essay writing/stories written ( ) Watching/ editing TV news video ( ) Painting and cartoons ( ) Small group research and seminar presentations ( ) Science fiction ( ) Games ( ) Other (please specify): ....

Again, if yes, how satisfied were you with your learning of ethics in the class?

( ) Very satisfied ( ) Moderately satisfied ( ) Satisfied

( ) Dissatisfied ( ) Very dissatisfied

2. Have you ever learned about the following issues in your class? (Choose all that apply)

( ) A variety of prominent ethical principles

( ) General consequences of research on the individual or society

( ) Consideration for diversity of values and beliefs

( ) Awareness of the foundations for personal opinions (biases)

( ) Defending one's personal stance on issues

( ) Your own personal beliefs

( ) None at all

Part D: Respondent's opinion on learning ethics in the science classroom

1. Do you think there should be an academic requirement of ethics for science students?

( ) Yes

( ) No

If Yes, it should be

( ) In the core curriculum requirements for all students

( ) In the elective courses for the students who are interested in it

( ) Other (please specify):

2. What kind of pedagogical methods of ethics are you interested in? (Choose all that apply)

( ) Group discussion

( ) Web-based instruction

( ) Inside and outside classroom

( ) Several different kinds of activity

( ) Other (please specify): .....

3. Do you think the combination of face-to-face and web-based instruction would be an appropriate pedagogical method for learning ethics?

( ) Appropriate ( ) Inappropriate ( ) Not sure

If appropriate, what should the website look like and what should the components be?

The website should (choose all that apply);

( ) Look fashionable and interesting

( ) Have various components

( ) Be easy to access and use

( ) Be easy to learn anywhere anytime

( ) Other (please specify): .....

The components of the website should be (choose all that apply)

( ) Course syllabus

( ) Lesson plans

( ) Learning materials

( ) Roster

( ) Assignments

( ) Grade book

( ) News and announcements

( ) Resources or related websites

( ) Web board or chat room

( ) Moral music or songs

( ) Other (please specify): .....

4. Do you think there should be enhancement of any skills for students? (choose all that apply)

( ) Analytical thinking skills ( ) Creative thinking skills

( ) Practical thinking skills ( ) Ethical thinking skills

( ) Other (please specify):

Thank you for completing the questionnaire.

Thank you for taking your valuable time to complete this questionnaire. **Please return the completed form in the envelope provided.**

If you have any questions or comments about this survey, please contact me at 086-6016816 or by e-mail at washi15@live.com

Comments or suggestions about this survey

1. The questionnaire collected **should be returned to me by March7, 2008**.
2. Results of the survey can be found on SWU Science Education Center's website at http://sciedcenter.swu.ac.th/content/index_th.html

My mailing address is:

Washirasorn Saengsuwan
Science Education Center
Srinakharinwirot University
Sukhumvit 23, Wattana
Bangkok, 1011

“Survey of Science Teachers’ Opinions on Teaching Ethics in a Science Classroom”

This study aims to collect preliminary data on science teachers’ opinions on teaching ethics in a science classroom, and to continue preparing for the next phase of research based on the preliminaries. This research is conducted in partial fulfillment of the requirements for the Doctoral of Education degree in Science Education at Srinakarinwirot University.

This questionnaire consists of four major parts:

Part A Personal data of respondent

Part B School’s ethics learning in general

Part C Respondent’s ethics learning in the science classroom

Part D Respondent’s opinion on learning ethics in the science classroom

Your response is voluntary and all information will be kept strictly confidential. The information collected in this questionnaire will be only used for research statistical purposes. Therefore, your participation in this survey provides valuable benefits to my research study and also to scientific ethics education at large.

The researcher is grateful for your cooperation in taking the survey.

Washirasorn Saengsuwan

Researcher

Instruction: Please put √ in the parentheses and specify the answer (if any) that shows the appropriate response(s).

Part A : Personal data of respondent

1. Gender ( ) Male ( ) Female
2. Age ( ) 20-25 ( ) 26-30
   ( ) 30-35 ( ) 36-40
   ( ) More than 40
3. Level of education
   ( ) Bachelor's degree
   ( ) Master's degree
   ( ) Doctoral degree
   ( ) Others (please specify): .....
4. Years of teaching experience
   ( ) 1-5
   ( ) 6-10
   ( ) More than 10
5. Field of subject
   ( ) Chemistry
   ( ) Biology
   ( ) Physics
6. Grade of teaching
   ( ) MS. 4 (Grade 9)
   ( ) MS.5 (Grade 10)
   ( ) MS. 6 (Grade 11)
7. Have you ever studied/ been trained/ attended a seminar or conference on ethics in science before?
   ( ) Yes, I have
   ( ) Never

   If yes,

   How many times, (approximately)?

   ( ) 1-5 ( ) 5-10 ( ) More than 10

Overall, how satisfied were you with the activities you attended?

( ) Very satisfied ( ) Moderately satisfied

( ) Satisfied ( ) Dissatisfied ( ) Very dissatisfied

Part B: School's ethics learning in general

1. Does your school offer courses in ethics to students?

( ) Yes, including one course focusing on science and ethics.

( ) Yes, but not including any that focus on science and ethics.

( ) No, it does not offer any.

2. Does the school have core requirements that include some ethical component for all students?

( ) Yes, the students are required to take a specific course(s) relating to ethics.

( ) Yes, the students have a choice of specific courses related to ethics.

( ) Yes, the students have a choice of many courses that fulfill a broad requirement

( ) Yes, the students are required to attend some non-classroom activity.

( ) No

( ) Others (please specify) : ……..

Part C: Respondent's ethics learning in the science classroom

1. Do you incorporate ethics into the science classroom?

( ) Yes

( ) No

If yes, how do you introduce it to the class? (choose all that apply)	If no, but you're interested in doing so, how would you introduce it to the class? (choose all that apply)
( ) Formal lecture	( ) Formal lecture
( ) Having a visiting speaker	( ) Having a visiting speaker
( ) Open informal discussion/ small-group discussions/debates	( ) Open informal discussion/ small-group discussions/debates
( ) Issue-based learning	( ) Issue-based learning
( ) Inquiry-based learning	( ) Inquiry-based learning
( ) Assigned reading and papers	( ) Assigned reading and papers
( ) Optional reading	( ) Optional reading
( ) Simulation/ Role-playing / Drama Project	( ) Simulation/ Role-playing / Drama project
( ) Case study analysis	( ) Case study analysis
( ) Narrative pedagogy/ journal/ essay writing/stories written	( ) Narrative pedagogy/ journal/ essay writing/stories written
( ) Watching/ editing TV news video	( ) Watching/ editing TV news video
( ) Painting and cartoons	( ) Painting and cartoons
( ) Small group research and seminar presentations	( ) Small group research and seminar presentations
( ) Science fiction	( ) Science fiction
( ) Games	( ) Games
( ) Other (please specify):	( ) Other (please specify): .....

Again, if yes, how satisfied were you with your introduction of ethics in the class?

( ) Very satisfied ( ) Moderately satisfied ( ) Satisfied

( ) Dissatisfied ( ) Very dissatisfied

2. Does the main assigned textbook(s) for your class include ethical issues?

( ) Yes, in the main body of the text.

( ) Yes, in a special section separated from the main body of the text

( ) No, not at all

( ) Other (please specify): .....

3. Do you incorporate extra materials into the lesson aside from the assigned textbook that specifically focus on ethical issues?

( ) Yes

( ) No

4. Do you cover any of the following issues in your class? (choose all that apply)

( ) A variety of prominent ethical principles

( ) General consequences of research on the individual or society

( ) Consideration for diversity of values and beliefs

( ) Awareness of the foundations for personal opinions (biases)

( ) Defending one's personal stance on issues

( ) Your own personal beliefs

( ) None

5. Approximately what percentage of your class time is devoted to ethical issues?

( ) None

( ) < 1%

( ) 1-5%

( ) 6-20%

( ) > 20%

6. Do ethics components of the class count towards the students' grades?

( ) Yes

( ) No

If Yes, what are those grades based on (choose all that apply)?

( ) Exams

( ) Participation in discussion

( ) Papers/assignments

( ) Other (please specify): .....

7. Do you include as much coverage of ethical issues in your course as you think should be included?

( ) Yes ( ) No

If Yes, what level do you think that is?

( ) Very high ( ) High ( ) Intermediate ( ) Low ( ) Very low

If No, why do you think that is? (Choose all that apply)

( ) Lack of class time for ethical issues

( ) Lack of preparing time for ethical issues

( ) Uncomfortable, lack of knowledge and resources on the subject

( ) Not interested in it and it's not necessary to teach

( ) Other (please specify): .....

Part D: Respondent's opinion on learning ethics in the science classroom

1. Do you think science students should be exposed to ethical issues?

( ) Yes, in the science classroom

( ) Yes, in a class with a specific science and ethics focus

( ) Yes, in unrelated ethics courses offered by the school

( ) Yes, but in some other way (please specify)

( ) No, not at all

2. Do you think there should be an academic requirement of ethics for science students?

( ) Yes

( ) No

If Yes, it should be

( ) In the core curriculum requirements for all students

( ) In the elective courses for the students who are interested in it

( ) Other (please specify): .....

3. Do you think there should be enhancement of any skills for students? (choose all that apply)

( ) Analytical thinking skills ( ) Creative thinking skills

( ) Practical thinking skills ( ) Ethical thinking skills

( ) Other (please specify): .....

4. Please choose from the following principles of scientific ethics the five that you think are most important, and rank them in order of importance. Put the No.1-5 in the parentheses in front of the principles (Given: 1 is the most important principle).

Principles of ethics in science	Descriptions
( ) Honesty	“Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and trustful in all aspects of the research process.”
( ) Carefulness	“Scientists should avoid errors in research, especially in presenting results. They should minimize experimental, methodological, and human errors and avoid self-deception, bias, and conflicts of interest.”
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( ) Social Responsibility	“Scientists should avoid causing harm to society and they should attempt to produce social benefits. Scientists should be responsible for the consequences of their research and they should inform the public about those consequences.”
( ) Legality	“In the process of research, scientists should obey the laws pertaining to their work.”
( ) Opportunity	“Scientists should not be unfairly denied the opportunity to use scientific resources or advance in the scientific profession.”
( ) Mutual Respect	“Scientists should treat colleagues with respect.”
( ) Efficiency	“Scientists should use resources efficiently.”
( ) Respect for Subjects	“Scientists should not violate rights or dignity when using human subjects in experiments. Scientists should treat non-human, animal subjects with appropriate respect and care when using them in experiments.”

5. What kind of pedagogical methods for teaching ethics are you interested in? (Choose all that apply)

( ) Group discussion

( ) Web-based instruction

( ) Inside and outside classroom

( ) Several different kinds of activity

( ) Other (please specify): .....

6. Do you think the combination of face-to-face and web-based instruction would be an appropriate pedagogical method of ethics?

( ) Appropriate ( ) Inappropriate ( ) Not sure

If appropriate, what should the website look like and what should the components be?

The website should (choose all that apply);

( ) Look fashionable and interesting

( ) Have various components

( ) Be easy to access and use

( ) Be easy to learn anywhere anytime

( ) Other (please specify): .....

The components of the website should be (choose all that apply)

( ) Course syllabus

( ) Lesson plans

( ) Learning materials

( ) Roster

( ) Assignments

( ) Grade book

( ) News and announcements

( ) Resources or related websites

( ) Web board or chat room

( ) Moral music or songs

( ) Other (please specify): .....

7. If there will be a training workshop or seminar on pedagogical methods of ethics for science teachers, will you be participating?

( ) Yes

Why? (Please specify):

.....

( ) No

Why not? (Please specify):

.....

Thank you for completing the questionnaire.

Thank you for taking your valuable time to complete this questionnaire. **Please return the completed form in the envelope provided.**

If you have any questions or comments about this survey, please contact me at 086-6016816 or by e-mail at washi15@live.com

1. The questionnaire collected **should be returned to me by March7, 2008**.
2. Results of the survey can be found on SWU Science Education Center's website at http://sciedcenter.swu.ac.th/content/index_th.html

My mailing address is:

Washirasorn Saengsuwan
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Bangkok, 10110

APPENDIX C

แบบทดสอบวัดความรู้และความเข้าใจเรื่องจริยธรรมทางวิทยาศาสตร์ (ก่อนเรียนและหลังเรียน)

แบบสอบถามความคิดเห็นของนักเรียนต่อจริยธรรมทางวิทยาศาสตร์

แบบประเมินทักษะการคิดเชิงปฏิบัติของนักเรียน (ก่อนเรียนและหลังเรียน)

Ethics in Science

Fundamental Chemistry (SC 40131) Grade 10

1st Semester, Academic year 2009

Name ..... No. .....

Instruction

1. Answer all questions completely
2. This is an five-essay exam with 15 points
3. Time allotted for this exam is approximately 20 minutes
4. The answers can be written in this exam paper

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1. What is scientific ethics? Please explain (2)

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2. How many principles of scientific ethics are there? Please specify (6)

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3. According to the logo given below, how do you think science and ethics are related? (1)

.....

.....

.....

.....

.....

From: Mr. Katika Akkasilk M. 4/9 award-winning logo in an elective course, scientific ethics

4. Using human and animals as subjects in testing chemicals or drugs in medication should be performed correspond to the principle of ethics in science. Explain and give two examples both of the principle of conduct on human and animals. (2)

.....

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.....

.....

5. Co-discovery is the situation in which two or more of scientists came up with the same ideas at the same time or accidentally. This occurs quite often in science and it's not plagiarism. Even though co-discoverers may be accused as an intellectual theft to each other, for example, Darwin knew that Wallace also came up with the theory of natural selection as he did. They both agreed to announce the theory together as co-discovery.

5.1 Do you think which principle of scientific ethics is best correspond to this story? (1)

.....

.....

5.2 Do you agree with the action of both scientists? Please explain. (1)

.....

.....

5.3 Assuming that you and your friend have discovered a new element which is element No. 130. Your friend claimed that he was the first one to discover the element. What should you do? And why you made that decision? (2)

.....

.....

.....

The questionnaire of students' opinions on ethics in science

Name ..... Room .... No. .....

Instruction:

This questionnaire is designed to help researcher gain some insight on how students express their opinion on ethics in science. Please consider the statements given below, and then put / in the blank on the right side of table that best describes your feeling or opinions about the statement. Your answers are not either right or wrong and will not affect to your grade in this course.

Level of evaluation on each statement as follows,

5 : You strongly agree with the statement

4 : You agree with the statement

3 : You neutral with the statement

2 : You disagree with the statement

1 : You strongly disagree with the statement

Example of evaluation

Item	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
I	I always like studying science in new perspectives.		/			

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
1	I always like studying science in new perspectives.					
2	I think that science and ethics are related.					
3	I'm interested in and curious about how I will be a good scientist.					
4	I understand ethics in science well.					
5	I think that study ethics in science would be the basis of becoming a good scientist.					
6	I would like to be a good, ethical, and role model scientist to other ones.					
7	Study of behaviors and characteristics of ethical scientist is interesting.					
8	I think that all science students should study about ethics in science as a basis for studying other science subjects.					
9	I think ethics in science is difficult and boring to study.					
10	Studying ethics in science helps me open up my point of view on another side of science that I have never known before.					

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
11	Studying ethics in science is useful for me to live my daily life, further education and professional job.					
12	Studying ethics in science makes me aware and appreciate in the importance and value of way of life.					
13	Studying ethics in science teaches me that I have to make more social responsibility.					
14	I'm interested in pursuing my career on ethics in science.					
15	Ethics in science is very important for science student, also scientists in different fields of interest.					
16	I would like all schools to provide ethics in science in science curriculum.					
17	Ethical scientist will help society be prosperous, livable and make everyone live together happily.					

The questionnaire of students' evaluation on ethics in science

(Practical thinking skill)

Name ..... Room ..... No. .....

Instruction:

This questionnaire is designed to help researcher gain some insight on how students' feeling or acting on ethics in science. Please consider the statements given below, and then put / in the blank on the right side of table that best describes your feeling or acting about the statement. Your answers are not either right or wrong and will not affect to your grade in this course.

Level of evaluation on each statement as follows,

5 : You strongly agree with the statement

4 : You agree with the statement

3 : You neutral with the statement

2 : You disagree with the statement

1 : You strongly disagree with the statement

Example of Evaluation

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
I	Honesty I draw a conclusion and report my result as its real data as obtained from an experiment.		/			
II	Carefulness I conduct an experiment and present results by minimizing experimental and human error.		/			
III	Openness I usually would like to share data, results, methods or ideas with peers.	/				

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
IV	Freedom I like to be free to conduct research on any problem or hypothesis.	/				
V	Credit I put my friend's names who are not involved in the experiments or group work in the report or assignment.		/			
VI	Education I always teach or explain my friend on the topics or experiments they don't understand.		/			
VII	Social Responsibility I will definitely not do any science experiment that harm school or society.		/			
VIII	Legality I always do my experiments or science project under the code of conduct or related standard.	/				
IX	Opportunity I'm not satisfied if It is unfair for me in using resources in doing science experiment or project.		/			
X	Mutual Respect I don't want my peers to harm me both physically and mentally.		/			

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
XI	Efficiency I always use materials and chemicals in experiments efficiently. (worth, value, and most effective).		/			
XII	Respect for Subjects I will treat animal subjects with care and respect.	/				

No.	**Statement**	**Strongly agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly disagree (1)**
1	Honesty I draw a conclusion and report my result as its real data as obtained from an experiment.					
2	I don't fabricate or falsify data from experiment in order to get the expected result.					
3	I ask or copy my friends' exams.					
4	Carefulness I conduct an experiment and present results by minimizing experimental and human error.					
5	I avoid self-deception and bias in experiments.					
6	Openness I usually would like to share data, results, methods or ideas with peers.					
7	I would like my peers to be able to review my experimental results or science project.					

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
8	I am open to criticism and new ideas on my experimental results or science project.					
9	I don't want anybody know important data of my results or science project that I am doing, and not completely finish yet					
10	I don't want to perceive new ideas, methods, or peers.					
11	I like working cooperatively and trust the others.					
12	Freedom I like to be free to conduct research on any problem or hypothesis.					
13	I like to be free in doing inquiry in science for my experiment or science project.					
14	If I had a freedom in doing an experiment that may harm the others, I would do it.					
15	Credit I put my friend's names who are not involved in the experiments or group work in the report or assignment.					
16	I agree on the punishment for students who copy other students' assignment or plagiarize					
17	Education I always teach or explain my friend on the topics or experiments they don't understand.					

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
18	I want to make sure that my friends always do the good and proper experiment.					
19	If you had a change to educate or give a seminar or workshop in science to community or public, I'm willing to do it.					
20	Social Responsibility I will definitely not do any science experiment that harm school or society.					
21	I will try to bring scientific knowledge to make best benefit to society.					
22	I will take my responsibility on my science experiment or project I have conducted.					
23	I will inform public or society knows about the scientific results or findings.					
24	Legality I always do my experiments or science project under the code of conduct or related standard.					
25	I will conduct an experiment with high get paid regardless of legality.					
26	I do not use hazardous and prohibited chemicals, human and animals in experiment if I am not legally allowed.					
27	Opportunity I'm not satisfied if It is unfair for me in using resources in doing science experiment or project.					

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
28	I think female scientists should get the equal opportunity as well as male scientists in doing scientific work.					
29	<u>Mutual Respect</u> I don't want my peers to harm me both physically and mentally.					
30	I respect the privacy of all group members.					
31	I won't get involved in my peers' experiment which can cause danger, if not allowed.					
32	<u>Efficiency</u> I always use materials and chemicals in experiments efficiently. (Worth, value, and most effective).					
33	I will minimize animals in lab and most efficient or I will use other subjects instead of animals if possible.					
34	I will use resources that can be reused.					
35	<u>Respect for Subjects</u> I will treat animal subjects with care and respect.					
36	I will take good care of animal subjects regarding of their welfare such as enough space place to live, sterile, enough food and water, and no torturing.					

No.	Statement	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
37	I don’t think animal subjects should be take care much because they eventually will be killed.					
38	Subjects have their own rights to stop or withdraw from experiment anytime if they feel that they will be harm or killed.					

Interview on Learning Ethics in Science

Place: ……

Interviewer: ……

Interview assistant: ……

Interviewee: M. 4/7 (Grade 10)

Introduction:

In the first semester (2009) you have learned a general chemistry which was incorporated ethics in science based on the 12 principles of scientific ethics which is proposed and defended by David B. Resnik. I would like to interview all of you in order to collect data about your opinion on learning ethics in the science classroom. The data obtained will be used only for research purposes. This interview does not affect any of your scores in class. You can stop providing information for the interview at anytime you want.

This group interview will take approximately 60 minutes. To get additional data I would like to videotape the interview as well.

We 1. …… 2. ……

3. …… 4. ……

5. …… 6. ……

7. …… 8. ……

9. …… 10. ……

11. …… 12. ……

Agree to be interviewed and videotaped. M. 4/7 students

Questions for Group Interview on Learning Ethics in Science

1. How important do you think ethics in science is for science students?

   ☐ Most important ☐ Very important ☐ Important ☐ Not important

   ☐ Less important

   Why?

2. Do you think science students should learn about scientifically and socially questionable issues (this means conflicts or questionable issues of science in society) (for example, scientists' honesty, animal experimental subjects, illegal research or experiments)? Why?

3. Do you agree that all science students should be taught about concepts and principles of ethics in science in order to use it as a guideline or regulation in learning or doing experiments ethically?

   ☐ Agree ☐ Disagree

   Why?

4. If there would be a course of having students understand the concepts and principles of ethics in science for all science students, what would you think it should be?

   ☐ Taught in incorporated in a general science course

   ☐ Taught in an additional course

   Why?

5. According to chemistry class you have learned in this semester, what do you think about the understanding of the concepts and principles of ethics in science?

6. Do you think whether learning science incorporated with ethics helps promote and develop the following skills? Explain

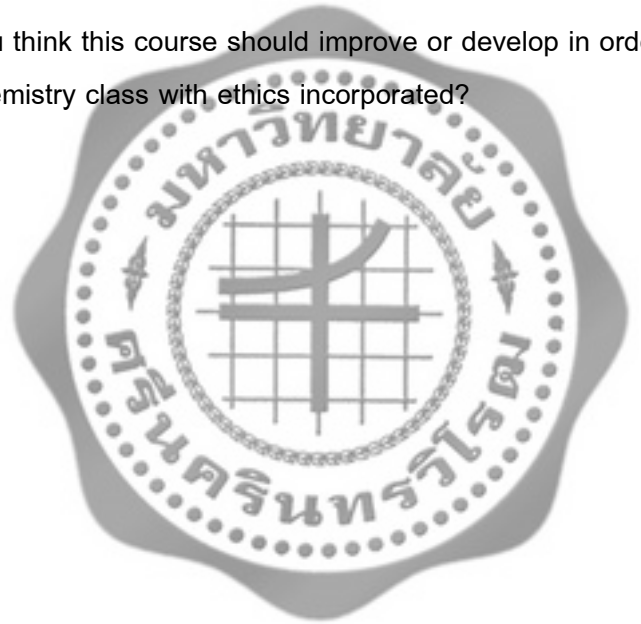
   ☐ Practical Thinking Skill ☐ Analytical Thinking Skill

   ☐ Creative Thinking Skill ☐ Communicative Skill

7. Do you think whether learning ethics in science class with the combination of face to face and web-based learning is appropriate? How?

8. How do you think about the website corporately used in the chemistry class this semester?

9. What do you think this course should improve or develop in order to have more effective chemistry class with ethics incorporated?



.....

Thank you for your cooperation on the group interview. The information received will be used only for research purpose.

แบบประเมินพฤติกรรมการเข้าร่วมกิจกรรมของนักเรียน

ครั้งที่ ..... ชื่อกลุ่มจริยธรรม ..... วันที่ .....

หัวข้อการประเมิน	ผลการประเมิน				
	ดีเยี่ยม (5)	ดีมาก (4)	ดี (3)	ปานกลาง (2)	ควรปรับปรุง (1)
1. ความซื่อสัตย์					
2. ความรับผิดชอบ					
3. ความสนใจใฝ่รู้ สืบค้นข้อมูลอย่างถูกต้อง					
4. ความรอบคอบ ระมัดระวังและใช้สารเคมีอย่างประหยัด					
5. การปฏิบัติตามกฎระเบียบในห้องเรียนและห้องทดลอง					
6. ความใจกว้างและมีอิสรภาพทางความคิด					
7. การช่วยเหลือและการแบ่งปันความรู้ให้ผู้อื่น					
8. ความสามารถในการสื่อสารและความอดทนต่อข้อขัดแย้ง					
9. โอกาสการมีส่วนร่วมในการแสดง/เคารพ และรับฟังความคิด ความคิดเห็นของผู้อื่น					
10. ความมีเหตุผลและความสามารถในการตัดสินใจอย่างถูกต้อง					
คะแนนรวม (50 คะแนน)					
คิดเป็นคะแนนจิตพิสัย (10 คะแนน)					

หมายเหตุ กลุ่มจริยธรรมเป็นกลุ่มเดียวกับกลุ่มทำการทดลอง เพื่อให้สามารถสังเกตพฤติกรรมของนักเรียนได้อย่างต่อเนื่องและใช้คะแนนจากแบบสังเกตพฤติกรรมนี้เป็นคะแนนจิตพิสัย โดยการประเมินของผู้สอนและนักเรียนประเมินตัวเอง แล้วนำมาหาค่าเฉลี่ย คิดเป็น 10 คะแนน

เกณฑ์การประเมิน

0-19 คะแนน หมายถึง ต้องปรับปรุง

20-29 คะแนน หมายถึง ปานกลาง

30-39 คะแนน หมายถึง ดี

40-50 คะแนน หมายถึง ดีมาก

ข้อเสนอแนะ

.....

.....

(นายวชิรศรณ์ แสงสุวรรณ)

ผู้สังเกต/บันทึก

Appendix D

ตัวอย่างกรณีศึกษา ใบงานและผลงานนักเรียน

แบบทดสอบย่อยเก็บคะแนนครั้งที่ 1 (Q2)

โรงเรียนมหิดลวิทยานุสรณ์ (องค์การมหาชน)

รายวิชา เคมีพื้นฐาน ว 30131

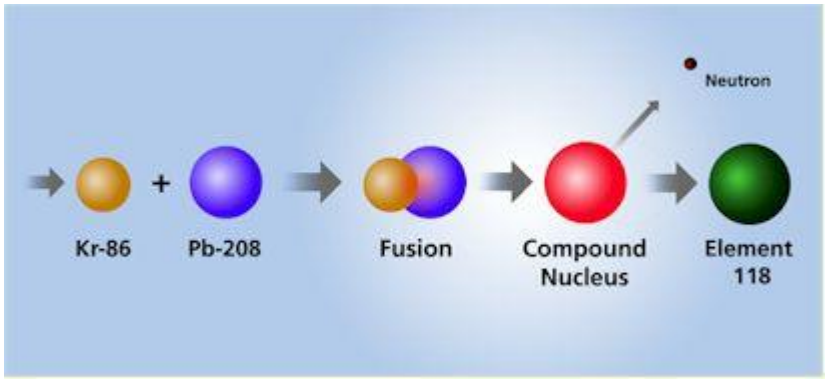
ชื่อ-นามสกุล สมาชิกในกลุ่ม

1. …… เลขที่ …….. ม. 4/7
2. …… เลขที่ …….. ม. 4/7
3. …… เลขที่ …….. ม. 4/7

คำชี้แจง

1. ให้นักเรียนในกลุ่มร่วมกันศึกษา กรณีศึกษาเกี่ยวกับเรื่องราวของวิกเตอร์ นินอฟ (Victor Ninov) จากบทความ เรื่อง Scientific Misconduct และ เรื่องอื้อฉาวลวงโลกวิทยาศาสตร์ ที่กำหนดให้
2. วิเคราะห์กรณีศึกษาแล้วตอบคำถามลงในใบงานที่กำหนดให้
3. นำเสนอผลงานหน้าชั้นเรียน (10 คะแนน) ด้วยรูปแบบการนำเสนอแบบใดก็ได้ โดยใช้เวลากลุ่มละประมาณ 5 นาที และแลกเปลี่ยนความคิดเห็นอีกกลุ่มละประมาณ 5 นาที

ใบงาน



ที่มา

http://www.aip.org/png/html/element118.html

จากการวิเคราะห์กรณีของวิกเตอร์ นินอฟ ให้นักเรียนเตรียมนำเสนอโดยการตอบคำถามต่อไปนี้

1. ให้นักเรียนสรุปเรื่องราวที่เกิดขึ้นที่ห้องปฏิบัติการแห่งชาติลอว์เรนซ์ เบิร์คลีย์ (Lawrence Berkeley National Laboratory)

2. ให้นักเรียนวิเคราะห์การกระทำของ วิกเตอร์ นินอฟ ว่าถูกต้องตามหลักจริยธรรมทางวิทยาศาสตร์หรือไม่

3. ถ้าหากนักเรียนเป็นเพื่อนร่วมทีมวิจัยกับวิกเตอร์ นินอฟ นักเรียนจะมีความรู้สึกอย่างไรต่อสิ่งที่เกิดขึ้น

4. สมมติว่าเหตุการณ์นี้ เกิดขึ้นโดยนักเรียนวิทยาศาสตร์ของโรงเรียนมหิดลวิทยานุสรณ์ นักเรียนคิดว่าจะมีผลกระทบอะไรเกิดขึ้นตามมาบ้าง

5. ให้นักเรียนวิเคราะห์ข้อดีและข้อด้อยของการทำงานวิจัยหรือการทำงานเป็นกลุ่ม

6. ประเด็นหรือหลักการทางจริยธรรมที่เกิดขึ้นจากกรณีศึกษานี้ มีอะไรบ้าง จงอธิบาย

เรื่องอื้อฉาวลวงโลกวิทยาศาสตร์

ชัยวัฒน์ คุประตกุล kshaiwat@hotmail.com

การค้นพบธาตุที่ 116 และ 118 ที่ไม่ใช่

การแข่งขันที่หนักหน่วง และนำชื่อเสียงมาให้แก่นักวิทยาศาสตร์ ผู้เป็นคนแรกที่ทำได้อย่างแน่นอน คือการค้นพบธาตุใหม่ ปี 1999 คณะนักฟิสิกส์ที่ ห้องปฏิบัติการแห่งชาติลอว์เรนซ์ เบิร์คลีย์ ในแคลิฟอร์เนีย (Lawrence Berkeley National Laboratory in California) ประกาศความสำเร็จในการผลิตธาตุใหม่ และหนักที่สุดที่เคยผลิตกันได้มาก่อน คือธาตุมีเลขอะตอม (Atomic Number) หรือจำนวนโปรตอนในนิวเคลียสของอะตอม 116 และ 118 โดยวิธียิงธาตุตะกั่วด้วยอะตอมของธาตุคริปทอน (Krypton) มีพลังงานสูง ลำพังเพียงการผลิตธาตุที่ 116 ได้ ก็เป็นผลงานยิ่งกว่าโบว์แดงอยู่แล้ว แต่คณะนักฟิสิกส์ก็แถมร่องรอยหลักฐานของธาตุที่ 118 อีกด้วย

วงการวิทยาศาสตร์ตื่นเต้นกับความสำเร็จนี้ รัฐมนตรีว่าการกระทรวงพลังงานของสหรัฐอเมริกา บิล ริชาร์ดสัน (Bill Richardson) ถึงกับกล่าวว่า “การค้นพบที่น่าทึ่งนี้ เปิดประตูสู่ความเข้าใจที่ลึกซึ้งถึงอีกระดับหนึ่ง ต่อเรื่องโครงสร้างนิวเคลียสของอะตอม แต่แล้วในปี 2002 การค้นพบธาตุใหม่หนักที่สุด คือธาตุที่ 116 และ 118 ก็ถูกจับผิดได้ว่า เป็นการค้นพบหรือการผลิตธาตุใหม่ที่เป็นเท็จ แล้วใครเป็นผู้ร้ายเรื่องนี้?

ในที่สุด ผู้ร้ายตัวจริงก็ถูกจับได้ เขาคือ วิกเตอร์ นินอฟ (Victor Ninov) นักฟิสิกส์ในคณะผู้มีหน้าที่รับผิดชอบเรื่องการวิเคราะห์ข้อมูล

Victor Ninov

สิ่งที่เขาทำอย่างผิดจรรยาบรรณร้ายแรง คือสร้างข้อมูลเท็จขึ้นมา เพื่อทำให้เขาและคณะเป็นผู้สร้างธาตุใหม่หนักที่สุดขึ้นมาได้ถึง 2 ธาตุ ในปี 2002 เมื่อความจริงปรากฏการค้นพบธาตุใหม่หนักที่สุด 2 ธาตุ คือธาตุที่ 116 และ 118 ก็ถูกประกาศถอนจากการค้นพบ และตัวนักฟิสิกส์ผู้ก่อเรื่อง คือ วิกเตอร์ นินอฟ ก็ถูกไล่ออก แล้ววิกเตอร์ นินอฟ ถูกจับผิดได้อย่างไร? คำตอบ คือการค้นพบหรือความสำเร็จในการผลิตสิ่งใหม่ใดๆ ขึ้นมาได้ โดยนักวิทยาศาสตร์คนหนึ่ง นักวิทยาศาสตร์คนอื่นๆ ก็จะต้องทำได้เช่นกัน

ที่มา เรื่องอื้อฉาวลวงโลก บาปของนักวิทยาศาสตร์จรรยาบรรณบกพร่อง :, ARTgazine Articles:บทความทั่วไป. สืบค้นเมื่อ 9 สิงหาคม 2551 จาก http://www.artgazine.com/shoutouts/viewtopic.php?t=2455

แบบทดสอบย่อยเก็บคะแนนครั้งที่ 1 (Q2)

โรงเรียนมหิดลวิทยานุสรณ์ (องค์การมหาชน)

รายวิชา เคมีพื้นฐาน ว 30131

ชื่อ-นามสกุล สมาชิกในกลุ่ม

1. …… เลขที่ …….. ม. 4/7
2. …… เลขที่ …….. ม. 4/7
3. …… เลขที่ …….. ม. 4/7

คำชี้แจง

1. ให้นักเรียนในกลุ่มร่วมกันศึกษา เรื่อง “บทสัมภาษณ์ ดร.อาจอง ชุมสาย ณ อยุธยา” ใช้สมาธิช่วยองค์การนาซ่าสำรวจอวกาศ
2. วิเคราะห์บทสัมภาษณ์แล้วตอบคำถามลงในใบงานที่กำหนดให้
3. นำเสนอผลงานหน้าชั้นเรียน (10 คะแนน) ด้วยรูปแบบการนำเสนอแบบใดก็ได้ โดยใช้เวลากลุ่มละประมาณ 5 นาที และแลกเปลี่ยนความคิดเห็นอีกกลุ่มละประมาณ 5 นาที

ใบงาน

จากการศึกษา เรื่อง “บทสัมภาษณ์ ดร.อาจอง ชุมสาย ณ อยุธยา” ใช้สมาธิช่วยองค์การนาซ่าสำรวจอวกาศ ให้นักเรียนตอบคำถามต่อไปนี้

1. จากการให้สัมภาษณ์ดังกล่าว นักเรียนมีข้อคิดเห็นที่แตกต่างหรือขัดแย้งกับของ ดร.อาจอง บ้างหรือไม่ อย่างไร

2. นักเรียนมีคำถามหรือข้อสงสัยอะไรบ้างที่อยากจะถามหรือสัมภาษณ์ ดร.อาจอง เพิ่มเติม จากบทสัมภาษณ์ข้างต้น

3. จริยธรรมที่เกิดขึ้นในตัว ดร.อาจอง ที่นักเรียนสัมผัสได้จากการอ่านบทความนี้ ได้แก่ อะไรบ้าง จงอธิบายและแสดงเหตุผลประกอบ

4. นักเรียนได้รับแนวคิดอะไรบ้างที่สามารถนำไปใช้เป็นแบบอย่างในการพัฒนาตนเองให้เป็นนักวิทยาศาสตร์ที่เก่ง ดีและมีคุณธรรมจริยธรรม

http://pr.ku.ac.th/pr_pic/html/09september50/samati.htm

"บทสัมภาษณ์ ดรอาจอง ชุมสาย ณ . "อยุธยา ใช้สมาธิช่วยองค์การนาซ่าสำรวจอวกาศ

เรื่อง ชุติมา ซุ้นเจริญ :
ภาพ สราวุธ : สุวรรณรักษ์

ระหว่างวิทยาศาสตร์กับศาสนา

ถ้าไม่มีวิกฤติเราก็ไม่เปลี่ยน เราก็อยู่กันอย่างสบายๆ เพราะฉะนั้นช่วงนี้มันจะมีวิกฤติเกิดขึ้นเยอะ และสร้างปัญหาให้กับเรา ทำให้การเปลี่ยนแปลงจะเร่งและรีบด่วน มันจะไม่ใช่ 50 ปีอย่างที่บางคนทำนายหรอก มันจะเกิดขึ้นเร็วมาก สมัยนี้เราอยู่ในยุคของการเปลี่ยนแปลง เราไม่มีเวลากันแล้ว สำหรับบางคน ความสำเร็จในหน้าที่การงานอาจวัดด้วยชื่อเสียง เงินทอง แต่สำหรับบุคคลท่านนี้ สิ่งเหล่านั้นคือของแถมจากการใช้ชีวิตอย่างเต็มศักยภาพในฐานะมนุษย์คนหนึ่ง ถ้าบอกว่า เขาคือ อดีตวิศวกรที่ทำรายได้เป็นหลักล้านต่อเดือนเมื่อหลายสิบปีก่อน เป็นนักธุรกิจผู้เคยรั้งตำแหน่งผู้บริหารมาหลายบริษัท ได้รับการยอมรับในฐานะนักการเมืองน้ำดี เป็นนักการศึกษาที่ได้รับเชิญให้ไปบรรยายมาแล้วทั่วโลก รวมถึงเคยเป็นนักแสดงประกอบในภาพยนตร์เรื่อง 'ข้างหลังภาพ' ...หลายคนอาจนึกไม่ออก แต่ถ้าแนะนำว่า ดรอาจอง ชุมสาย ณ อยุธยา ผู้นี้. คือบุคคลที่ถูกกล่าวถึงในโฆษณาชิ้นหนึ่งว่า เป็นผู้คิดค้นระบบลงจอดบนดาวอังคาร คงไม่มีใครมองผ่านไปเฉยๆ ถึงแม้ว่าในทัศนะของผู้เป็นเจ้าของเรื่อง ผลงานชิ้นนี้จะเป็นเพียงเศษเสี้ยวเล็กๆ แห่งบททดสอบพลังการหยั่งรู้ของมนุษย์คนหนึ่งเท่านั้น

อยากให้อาจารย์ช่วยเล่าถึงเรื่องราวที่ปรากฏในโฆษณาชิ้นนี้ค่ะ

มีบริษัทโฆษณาเขามาติดต่อผม เขาเพียงแต่บอกว่าเขาต้องการยกย่องคนดีในสังคม ผมก็บอกว่าการที่จะยกย่องคนดีนั้นก็เป็นสิทธิของทุกคนอยู่แล้วไม่ต้องมาขออนุญาตอะไร ผมเพียงแต่บอกว่าขออย่างเดียวอย่าให้เกี่ยวข้องกับการโฆษณาสินค้าอะไรต่างๆ ก็ได้บอกเขาไว้อย่างนั้น เขาก็สัญญาว่าในช่วงของผมจะไม่มีอะไรที่เกี่ยวข้องกับผลิตภัณฑ์ แต่เสร็จแล้วเขาก็ไปเสริมเติมตอนท้าย ก็เลยเป็นการทำให้คนเข้าใจว่าผมมาโฆษณาเหล้า ซึ่งผมก็ไม่พอใจเหมือนกัน ก็เรียกเขามาคุย เขาก็รับปากว่าจะเพิ่มเติมส่วนที่แบ่งระหว่างเรื่องของผมและสินค้าที่เขาโฆษณา จริงๆ แล้วผมไม่ได้สักบาทหนึ่ง ไม่ถือว่าเป็นการโฆษณาอะไร

แล้วในส่วนของผลงานการคิดค้นล่ะคะ มีที่มาที่ไปอย่างไร

ตอนนั้นผมเป็นอาจารย์อยู่ที่คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย พอสอนไปได้สัก 2 ปี รู้สึกว่าวิทยาการมันก้าวล้ำไปแล้ว ความรู้ ประสบการณ์ของเรามันล้าสมัย ผมก็เดินทางไปต่างประเทศ ส่วนใหญ่แล้วไปที่สหรัฐอเมริกา เพื่อที่จะได้ไปหาข้อมูลเรียนรู้อะไรต่างๆ เพิ่มเติม เพื่อกลับมาสอนนิสิตนักศึกษาในประเทศไทย ผมก็ลาราชการไป บังเอิญเขาประกาศเกี่ยวกับยานอวกาศขององค์การนาซาที่จะไปสำรวจดาวอังคาร ก็

พยายามสมัครเข้าไป คือเสนอโครงการเข้าไป ตอนแรกๆ เขาก็จะไม่รับคนต่างชาติ เพราะว่าเป็นความลับทางเทคโนโลยี แต่ผมก็เห็นว่ามันมีช่องโหว่ในกฎหมายที่เขาจะรับคนต่างชาติได้ โดยเฉพาะกรณีที่เขาขาดแคลนคนที่มีความรู้ทางด้านนั้น ผมก็เลยดูว่ามีอะไรที่ทางอเมริกาเขาขาด ทำไม่สำเร็จ ผมดูแล้วก็มีอยู่อย่างเดียว คือ ช่วงนั้นปี พ.ศ.1971 อเมริกาและรัสเซียก็พยายามส่งยานอวกาศไปลงที่ดาวเคราะห์ โดยเฉพาะดาวอังคาร ดาวพุธ กับดาวศุกร์ แต่ปรากฏว่าล้มเหลวทุกครั้ง พอเขาส่งไปถึงมันจะตกลงไป มันจะกระแทกพื้นดิน พังใช้การไม่ได้ เพราะว่ามันอยู่ห่างไกลจากโลก ไม่สามารถควบคุมการร่อนลงได้จากโลกของเรา ฉะนั้นต้องเป็นระบบที่มันควบคุมตัวเองโดยอัตโนมัติ ซึ่งอันนี้ทางอเมริกายังไม่ประสบผลสำเร็จ ผมก็เลยเสนอโครงการเข้าไปว่าผมจะช่วยสร้างชิ้นส่วนอันหนึ่งที่จะบังคับยานอวกาศให้ร่อนลงโดยอัตโนมัติลงสู่พื้นดินของดาวอังคารอย่างปลอดภัย ตรงนี้เองที่ทำให้เขาสนใจและทำให้ผมเข้าไปร่วมในโครงการยานอวกาศได้ โดยเริ่มไปทำงาน ไม่ใช่กับองค์การนาซาโดยตรง เพราะนาซาเขาจะไม่สร้างอะไรเอง เขาจะให้บริษัทต่างๆ เป็นผู้ผลิต ฉะนั้นผมก็ต้องไปทำงานกับบริษัทในสหรัฐอเมริกา โดยอยู่ในโครงการอันนี้ที่ผมเสนอไป ตอนแรกทางสหรัฐอเมริกาเขาเช็คประวัติของผมก่อนว่าผมมีแนวโน้มเอียงไปทางซ้ายหรือเปล่า เขาระมัดระวังมาก เขาจะส่งคนไปสืบดูในทุกๆ แห่งที่ผมเคยอาศัยอยู่ รวมถึงที่ปารีสซึ่งเคยอยู่ 2 ปี ปรากฏว่าผ่านทุกอย่างไม่มีปัญหาอะไร เขาเลยให้ทำงานทำวิจัยไปประมาณ 1 ปี สร้างต้นแบบมาหลายต้นแบบ แต่ปรากฏว่าไม่ประสบผลสำเร็จ ใช้การไม่ได้ แต่หลังจาก 1 ปี ผมก็คิดขึ้นมาว่าวิธีการหาความรู้แบบตะวันตก มันใช้ไม่ได้ เพราะเราต้องอาศัยข้อมูลของคนอื่น เราต้องทำวิจัย เราต้องมาเปลี่ยนแปลงวิเคราะห์ ผมคิดว่าใช้วิธีของทางตะวันออกดีกว่าก็คือไปนั่งสมาธิเพื่อให้เกิดปัญญา ผมก็ปีนขึ้นไปอยู่บนภูเขาในรัฐแคลิฟอร์เนีย ใกล้ๆ เมืองลอสแองเจลิส และนั่งสมาธิอยู่ตามลำพังจนกระทั่งจิตนิ่ง สงบ ปัญญามันก็เกิด ผมอยู่ 4 คืน 5 วัน วันที่ 5 กำลังนั่งอยู่เฉยๆ สงบนิ่ง ไม่คิดถึงโครงการยานอวกาศเลย อยู่ๆ มันก็แวบเข้ามา แล้วเราก็ได้คำตอบ เราก็ อ๋อ รู้แล้ว เข้าใจแล้ว แค่นี้ คือในการฝึกสมาธิจนปัญญาเกิด โดยที่เราไม่ต้องคิด มันจะไม่ผ่านระบบความคิดอะไร

เมื่อไม่ได้ผ่านกระบวนการทางวิทยาศาสตร์ การคิดคำนวณ แล้วนำไปสร้างได้อย่างไรคะ

ผมสร้างต้นแบบให้เขา และเขาก็ทดสอบ โดยใช้เครื่องคอมพิวเตอร์ สมมติตอนที่ร่อนลง ปรากฏว่ามันค่อยๆ ร่อนลงและไปแตะพื้นดินของดาวอังคารอย่างปลอดภัย เขาก็ดีอกดีใจก็เลยให้ผมสร้างให้เขา 3 ชุด ไปไว้ในยานไวกิ้ง 1 ไวกิ้ง 2 และยานไวกิ้ง 3 สามลำด้วยกัน เขาส่งขึ้นไป 2 ลำ เดินทางไปใช้เวลา 11 เดือน พอไปถึงดาวอังคารก็สำรวจว่าจะลงตรงไหน แล้วก็ส่งสัญญาณไปกระตุ้นเครื่องที่ผมสร้างไว้ และมันค่อยๆ ควบคุมยานอวกาศให้ร่อนลงไปโดยอัตโนมัติสู่พื้นดินของดาวอังคาร ประสบความสำเร็จ ยานทั้ง 2 ลำแตะพื้นเบาๆ ไม่มีปัญหาอะไร และสามารถส่งข้อมูลกลับมาที่โลกของเราเป็นเวลาเกือบ 7 ปี

ถือเป็นครั้งแรก?

ครั้งแรกในประวัติศาสตร์ของมนุษย์ ก่อนหน้านั้นยังไม่เคยมียานอวกาศลำไหนลงไปบนพื้นดินของดาวเคราะห์ได้สำเร็จ แต่ตอนนั้นได้ลงไปที่ดวงจันทร์แล้ว แต่ดาวเคราะห์ยังไม่เคย

อาจารย์สนใจเรื่องสมาธิมาตั้งแต่ก่อนจะไปทำงานตรงนั้นหรือเปล่า
ผมเริ่มฝึกปฏิบัติตั้งแต่อายุ 15 ปี ตอนนั้นศึกษาอยู่ที่ประเทศอังกฤษ เป็นโรงเรียนประจำ แล้วก็ฝึกมาเรื่อยๆ จนถึงทุกวันนี้

ทำไมถึงได้สนใจเรื่องสมาธิ

เหตุที่เป็นแรงจูงใจก็เพราะว่าช่วงนั้นผมเป็นเด็กเกเรพอสมควร ชอบชก ชอบต่อย ชอบอาละวาด เป็นคนที่อารมณ์รุนแรง แล้วมันเกิดเหตุการณ์ที่ค่อนข้างจะมหัศจรรย์กับตัวเอง คือนอนอยู่ในห้องนอนรวม เป็นหอพักของนักเรียน อยู่กัน 50 คน อยู่ๆ วันหนึ่งก็ตกใจตื่นขึ้นมากลางดึก เพราะเหมือนกับมีเสียงคุยกับผมอยู่ เสียงนั้นแค่เรียกชื่อผม 3 ครั้ง อาจอง อาจอง อาจอง ทำไมถึงทำอย่างนี้ ตั้งคำถามไว้ให้กับผม ผมก็มานั่งคิด ตอนแรกก็ตกใจนึกว่าเป็นผีมาหลอก ก็ไม่สนใจ นอนหลับไป พร้อมกับเสียงนั้นมันจะมีแสงสว่างอยู่รอบๆ บริเวณนั้นด้วย ผมมองซ้าย มองขวา ดูเพื่อน ทุกคนก็นอนหลับไม่มีใครได้ยินอะไร และมันก็เกิดขึ้นสามคืนติดต่อกัน คืนที่สามก็เลยต้องมานั่งคิดใหญ่เลยว่า เอมันเรื่องอะไร.. คิดไปคิดมาอาจเป็นการเตือนตัวเราเองว่า สิ่งที่เราทำมันไม่ถูกต้อง ก็เลยหาทางออก พยายามคิดว่าเราจะปรับปรุงตัวอย่างไร ตอนแรกไม่รู้จะไปปรึกษาหารือกับใครเลยไปปรึกษากับนักบวชในศาสนาคริสต์ ท่านก็บอกว่าให้ไปสวดมนต์ภาวนา เข้าโบสถ์ด้วยกัน ผมก็เข้าไป แต่แล้วท่านก็ไม่ได้ให้คำตอบอะไรกับผม ท่านบอกว่าต้องไปศึกษาพระคัมภีร์ต่อ ผมก็ไปศึกษาพระคัมภีร์จนกระทั่งวันหนึ่งท่านสอนเกี่ยวกับเรื่องการสวดมนต์ท่านบอกว่าเมื่อสวดมนต์จะต้องมาพร้อมกัน เปร่งเสียงดังพร้อมกัน เข้ามาอยู่ในโบสถ์พร้อมกัน ผมเถียงท่าน บอกว่าไม่จำเป็น เราสวดมนต์ในมุมเงียบๆ ในห้องของเราก็ได้ ไม่จำเป็นต้องไปสวดในโบสถ์ อันนี้ท่านโกรธมากเลย ไล่ผมออกจากห้อง ผมก็เสียใจมาก ก็พยายามคิดว่าจะทำยังไง เลยไปเข้าห้องสมุด แล้วบอกตัวเองว่าเราเกิดมาเป็นชาวพุทธ น่าจะมีอะไรดีๆ ทางพุทธศาสนา ก็เลยไปค้นหนังสือเจอบทความเกี่ยวกับการฝึกสมาธิ พออ่านแล้วมันประทับใจมาก ก็เลยเริ่มฝึกตั้งแต่ตอนนั้นเป็นต้นมา พอฝึกไปได้เดือนหนึ่งมันรู้สึกสงบ สบาย อารมณ์โกรธ โมโห อะไรก็ค่อยๆ หายไป เลยฝึกต่อ พอฝึกไปได้ปีหนึ่ง ก่อนหน้านั้นเรียนหนังสือไม่ค่อยได้ดี ปรากฏว่าความจำดีขึ้น การเรียนดีขึ้น พอสอบปีถัดมาก็สอบได้ที่ 1 ของทุกวิชา จากนั้นชีวิตก็เปลี่ยน เป็นคนใจเย็น ความรู้เกิดขึ้น
บางครั้งเราเรียนหนังสือก็ไม่ต้องเรียนหนัก ความจำดีขึ้น ได้รับรางวัลจากประเทศอังกฤษเยอะแยะไปหมด ได้รับรางวัลจากนายกรัฐมนตรีของประเทศอังกฤษด้วย ทางด้านวิทยาศาสตร์และทางด้านศาสนา นี่คือการทำควบคู่กันไปทั้งสองอย่างพร้อมกัน

แต่คนส่วนใหญ่มักจะคิดว่าวิทยาศาสตร์กับศาสนาเป็นคนละเรื่องกัน?

ผมมองดูตัวเองย้อนหลังกลับไป จริงๆ วิทยาศาสตร์กับศาสนาไม่แตกต่างกัน ทั้งสองอย่างพยายามแสวงหาความจริง แต่วิทยาศาสตร์มุ่งไปในสิ่งแวดล้อมรอบๆ ตัวเรา แต่ศาสนามุ่งเข้าไปในตัวเรา ฉะนั้นอันหนึ่งเป็นเรื่องภายใน อีกอันเป็นเรื่องภายนอก สองอย่างมาประกอบกันก็ทำให้เกิดความเข้าใจที่สมบูรณ์แบบ แล้วผมก็วิเคราะห์ดูตั้งแต่ตอนนั้นว่า ผมจะไม่หากินกับเรื่องของจิตใจ เรื่องของการฝึกสมาธิ ตรงนั้นจะทำอะไรก็เป็นการบริการช่วยเหลือคนอื่น ถ้าเผื่อไปหากินก็คิดว่าใช้วิทยาศาสตร์ ผมก็เลยเลือกเรียนทางด้านวิศวกรรมศาสตร์เพื่อใช้เป็นอาชีพ

ในแวดวงของคนที่เรียนด้านวิทยาศาสตร์ อาจารย์คิดว่าตัวเองแปลกแยกจากคนอื่นมั้ยคะ

คือผมเข้าใจเขา แนวความคิดของเขาเป็นอย่างไร ขั้นตอนของการคิดแบบนักวิทยาศาสตร์เป็นอย่างไร ทีนี้ผมพยายามดึงเขาเข้ามาให้เข้าใจด้วยว่าเรามีญาณวิเศษอยู่ในตัวของเราทุกคน เพราะถ้าเกิดเราย้อนหลังกลับไปดูในประวัติศาสตร์อย่าง เซอร์ไอแซค นิวตัน ซึ่งก็เป็นนักวิทยาศาสตร์ที่สำคัญของโลก ตั้งแต่เล็กๆ เขาชอบนั่งอยู่ใต้ต้นแอปเปิลตามลำพัง โดยที่เขาไม่คิดอะไร และเขาทำอย่างนี้เป็นประจำ พอโตขึ้นมาเขาคิดถึงดาวหางแฮรี่ว่ามันจะกลับมาเยี่ยมโลกทุกๆ กี่ปี การหาคำตอบของเขาไม่ได้จากการทดลอง ไม่ได้จากการคำนวณ เขาไปนั่งอยู่ใต้ต้นแอปเปิล พอมันตกลงมาตอนนั้นเองมันก็แวบเข้ามา แล้วเขาก็ได้รับคำตอบ ซึ่งนอกจากจะตอบว่า นอกจากดาวหางแฮรี่จะมาทุก 76 ปี ซึ่งก็ถูกต้อง เขายังได้กฎเกณฑ์ของฮิวตันซึ่งเป็นพื้นฐานของฟิสิกส์ที่เราใช้อยู่ทุกวันนี้

ไอน์สไตน์ก็เหมือนกัน เขาก็บอกว่า เขาได้อะไรต่ออะไรจากการตอนที่เขาสงบนิ่ง แล้วเขาพูดออกมาชัดเจนเลยว่าการหยั่งรู้ด้วยตนเองไม่ได้มาจากการศึกษา ไม่ได้มาจากความพยายาม แต่มันมาจากใจโดยตรง ถ้าเราเข้าถึงใจของเราได้ สมาธิก็จะเกิด ความรู้เกิดขึ้น ปัญญาก็เกิดขึ้น

อธิบายสิ่งที่เรียกว่าการหยั่งรู้นี้อย่างเป็นวิทยาศาสตร์อย่างไรคะ

พอเราฝึกสมาธิ ความรู้สึกของเรามันจะขยายตัวออกไปกว้างใหญ่ พอเป็นอย่างนี้เท่ากับว่ามันขยายไปที่ไหนเราก็รู้ตรงนั้น ถ้าเราอยากจะรู้ว่าข้างหนึ่งของโลกเรากำลังเกิดอะไรขึ้น เรานั่งสมาธิขยายความรู้สึกของเราออกไป มันเป็นจิตใจที่เราขยายออกไปได้ แล้วจะรู้เรื่องอะไรก็ได้ ฉะนั้นจิตเหนือสำนึกก็คือ ผู้รู้ ผู้ตื่น ที่อยู่ในตัวเรา มันไม่มีขอบเขต จิตเหนือสำนึกมันกว้างออกไป และทำให้เราสามารถรู้เรื่องอะไรก็ได้ เกี่ยวข้องกับอะไรก็ได้

ถ้าอย่างนั้นจะเรียกว่าอาจารย์เป็นผู้หยั่งรู้ได้มั้ยคะ

ผมถือว่าทุกคนสามารถที่จะหยั่งรู้ได้ บางทีพวกเราสังเกตกับเหตุการณ์ที่จะเกิดขึ้นในอนาคต อันนั้นก็เป็นการหยั่งรู้ บางทีเรามีปัญหาเยอะแยะ เราคิดอะไรไม่ออก เรานอนหลับไป และช่วงที่เราตื่น อ๋อ! รู้แล้ว คำตอบมันมา เพราะระหว่างที่เรานอนหลับกับตอนที่เราตื่นตอนนั้นจิตใจเราสงบ เรายังไม่ฟุ้งซ่าน เรายังไม่คิดอะไรมาก พอจิตใจสงบในช่วงนั้นการหยั่งรู้ด้วยตนเองก็จะเกิดขึ้น สภาวะจิตใจที่สงบนิ่ง ทางพุทธเราก็เรียกว่าศีล สมาธิ ปัญญา เมื่อเรามีศีล มีสมาธิเกิดขึ้น จิตใจมันสงบ ปัญญามันก็เกิด

หลังจากที่ประสบความสำเร็จในการคิดค้นวิธีลงจอดแล้วอาจารย์ไปทำงานอะไรต่อ

ก็เป็นอาจารย์ต่อที่จุฬาฯ เริ่มสอนนิสิตนักศึกษาเรื่องสมาธิ และอบรมครูในเรื่องการฝึกสมาธิ

ช่วงหนึ่งได้มีโอกาสทำงานในแวดวงการเมืองด้วย?

คือหลังจากที่เป็นอาจารย์อยู่สัก 7 ปี ผมรู้สึกว่าเราน่าจะมีประสบการณ์ที่กว้างออกไป และให้เข้ากับทุกกลุ่ม คือสังคมต่างๆ ตอนนั้นก็ออกมาเป็นนักธุรกิจก่อน ประสบความสำเร็จได้เป็นกรรมการผู้จัดการหลายบริษัท พอเริ่มเข้าใจแล้วว่านักธุรกิจเป็นอย่างไรก็ตัดสินใจว่าถึงเวลาที่เราจะต้องรู้เรื่องเกี่ยวกับการเมืองบ้าง เลยไปลงสมัครเป็นสมาชิกสภาผู้แทนราษฎร ประสบความสำเร็จตอนที่สังกัดพรรคพลังธรรม ได้รับเลือก 3-4 สมัย ตอนนั้นเข้าไปอยู่ในงานที่เกี่ยวข้องกับการศึกษาเป็นหลัก เป็นกรรมาธิการการศึกษา กรรมาธิการวิทยาศาสตร์ กรรมาธิการสิ่งแวดล้อม จะมุ่งไปในทางด้านนั้น จนสุดท้ายได้เป็นเลขารัฐมนตรีว่าการกระทรวงการต่างประเทศ สมัยท่านประสงค์ สุ่นศิริ ได้เดินทางไปรอบโลกพร้อมกับท่าน

ดูเหมือนอาจารย์จะมองการทำงานในตำแหน่งต่าง ๆ เป็นการเรียนรู้มากกว่าการประกอบอาชีพ?

คือทุกอย่างเป็นการเรียนรู้ของผม

ไม่ได้มีเป้าหมายคือ ชื่อเสียง เงินทอง หรืออำนาจ?

ถ้าเราต้องการรวยมันง่ายมาก อย่างผมไปสร้างยานอวกาศที่สหรัฐอเมริกา เงินเดือนที่ได้รับตอนนั้นซื้อรถยนต์ได้ 1 คันต่อเดือน คือต้องเทียบอย่างนั้น เพราะว่าเงินสมัยนั้นมันยังน้อย เงินซื้ออะไรได้เยอะ มูลค่าสูง พอผมสร้างเสร็จแล้วหน้าที่ของผมคือกลับมาเป็นอาจารย์อยู่ที่จุฬาฯ ก็บอกทางโน้นว่าขอกลับแล้ว ตอนแรกเขาก็จะไม่ยอม เพิ่มเงินเดือนให้ผม 20 เท่า ซื้อรถยนต์ได้ 20 คันต่อเดือน และจะโอนสัญชาติให้ผม ผมก็บอกว่าอันนี้ไม่ใช่สิ่งที่ผมต้องการ หน้าที่ของผมคือสอน ที่มาก็มาหาความรู้ ได้ประสบการณ์แล้วก็ขอกลับ ในที่สุดเขาก็ต้องยอม ในชีวิตไม่เคยคิดอยากจะรวย ไม่เคยคิดอยากจะดังอะไร ถ้ามันดังก็ดังโดยธรรมชาติของมันเอง เราไม่ได้ตั้งใจว่าจะต้องทำด้วยความดังหรือชื่อเสียง หรือความร่ำรวยอะไร ตอนนี้ก็กลับมาอยู่ที่โรงเรียน ผมก็ปฏิเสธไม่รับเงินเดือน เพราะว่านี่ไม่ใช่จุดมุ่งหมายของเรา เราต้องการจะให้และช่วยเด็ก

แต่ไม่ว่าจะอยู่ในแวดวงธุรกิจหรือการเมือง คงปฏิเสธไม่ได้ว่าเต็มไปด้วยเรื่องผลประโยชน์และการต่อรอง?

อย่างผมเป็นผู้อำนวยการฝ่ายการตลาดของบริษัทแห่งหนึ่ง ปกติเราต้องเลี้ยงลูกค้า เลี้ยงอาหาร เลี้ยงเหล้าอะไรต่างๆ ผมก็บอกเขาตรงๆ ว่า ผมไม่ดื่มเหล้านะ และผมทานมังสวิรัติด้วย เขาก็ตกใจ แปลกใจ แต่ก็บอกผมว่า ถ้างั้นก็ทานบ้าง เป็นเพื่อนดื่มน้ำชาด้วยกัน เสร็จแล้วก็คุยกันไปคุยกันมา ปรากฏว่าเขาไว้ใจผมมากเลย เขาเชื่อว่าผมทำธุรกิจจะไม่มีวันเอาเปรียบเขา ไม่มีวันที่จะโกงเขา เขาบอกเอาล่ะ ผมพร้อมจะเซ็นสัญญาซื้อขายกับคุณ เซ็นสัญญาทีเป็นพันล้านเพราะเขาไว้วางใจเรา เพราะเราไม่ได้โม้อะไร ไม่ได้ไปแสดงอะไร ไม่ได้ดื่มเหล้าเมายากับเขา ไม่ได้เลี้ยงดูปูเสื่อ ซึ่งนักธุรกิจโดยทั่วไปเขาจะมี แต่ปรากฏว่ากลับไม่ค่อยไว้วางใจกัน แต่นี่เขาไว้ใจเรา เพราะฉะนั้นไม่ใช่ว่าจะต้องใช้วิธีทางโลกในการค้าขาย สู้สร้างความไว้วางใจดีกว่า การเมืองก็เหมือนกัน ผมก็เข้าไปในสภา เอาล่ะ ก็ยอมรับว่ามันมีผลประโยชน์ค่อนข้างจะเยอะ แล้วก็มีคนมาเสนอผลประโยชน์ให้ผมเยอะมาก ตอนที่เป็นเลขานุการรัฐมนตรีว่าการกระทรวงการต่างประเทศ ก็มีคนเสนอว่า พี่ช่วยเซ็นตรงนี้หน่อย พอเซ็นแล้วผมจะได้ 150 ล้าน ผมก็บอกว่าเรื่องอะไรล่ะ ได้เยอะแยะขนาดนี้ เขาบอกว่าเขาจะนำเข้าไม้จากพม่า และเขาเอาหลักฐานให้ผมดูว่าเป็นไม้จากพม่า แต่ผมดูแล้วผมรู้สึกว่ามันเป็นเอกสารปลอม ผมก็เลยเอาเอกสารนี้ไปตรวจ พม่าตรวจแล้วเขาก็บอกว่าเป็นเอกสารปลอม ผมก็เอากลับมาแล้วบอกว่า

ขอโทษนะเซ็นอันนี้ไม่ได้ เพราะว่าเป็นเอกสารปลอม ผมก็พูดตรงไปตรงมากับเขา ใช่ ผมอาจจะไม่ร่วมมือในเรื่องบางเรื่อง แต่ทุกคนก็ยอมรับ และก็ถือว่าผมเป็นคนที่น่าไว้วางใจ ถึงเวลาจะมีการปฏิรูปการศึกษา กรรมาธิการก็ให้ผมร่างในเรื่องคุณธรรม จริยธรรม ถึงเราไม่ได้อยู่ฝ่ายรัฐบาล แต่ไปขอร้องเขา พอถึงเวลาเขาก็ยกมือให้ เขามั่นใจเรา เขารักเรา การทำงานไม่จำเป็นต้องใช้อำนาจ อิทธิพล ไม่ต้องใช้เงินใช้ทอง เราสร้างความไว้วางใจให้กับคนอื่นให้รักเรา

จริงไหมที่เขาบอกว่าคนดี ๆ มักอยู่ในแวดวงการเมืองไม่ได้?

อันนี้ก็จริงเหมือนกัน แต่ทว่าเขาเข้าใจผิด คือยืนหยัดอยู่ในทางของตัวเองแล้วบอกคนอื่นผิดหมด มันไม่ใช่อย่างนั้น ไม่มีใครผิด คือเราต้องเข้าใจว่าทุกคนอยู่ในโลกนี้ก็เพื่อที่จะมีประสบการณ์ บางทีเราต้องหกล้มเราถึงจะรู้ว่าหกล้มแล้วมันเจ็บ แล้วเราน่าจะเปลี่ยนวิธีการใหม่ ตลอดเวลามีการสร้างความแข็งแกร่ง ความเข้าใจเกี่ยวกับชีวิตให้ดีขึ้น ฉะนั้นผมมองนักการเมืองทั้งหลายว่าเขาก็เรียนรู้อยู่ บางทีเขาทำอะไรตัวเองก็เจ็บมาก สร้างปัญหาให้กับตัวเอง ก็คือวิธีการเรียนรู้ ฉะนั้นคนดีบางคนบอกว่าตัวเองดี แล้วก็ไปชี้นิ้วว่าไอ้นี่มันไม่ดี ไอ้นั่นมันเลว แต่เราต้องเข้าใจว่าเมื่อเราชี้นิ้วไป มันจะมีนิ้วสามนิ้วชี้กลับมาที่ตัวเราเสมอ เราบอกว่าคนอื่นเลว แท้ที่จริงเราต้องดูตัวเองว่าเราเลว เราไม่ดีเอง เราคิดไม่ดีเอง ถ้าเผื่อเราเข้าใจอย่างนี้ เราไม่ไปด่าใคร เราไม่ไปว่าใคร

จริง ๆ แล้วการเป็นนักการเมืองก็น่าจะทำอะไรได้เยอะโดยเฉพาะในเชิงนโยบายที่เกี่ยวกับการศึกษา ทำไมถึงตัดสินใจออกมาล่ะคะ

ใช่เราปฏิรูปอะไรได้ ทำอะไรได้เยอะ.. อย่างตอนนั้นเราออกกฎหมายปฏิรูปการศึกษา ซึ่งผมเขียนเรื่องคุณธรรมใส่เข้าไป ก็ไปโดน รสช.ยึดอำนาจพอดี แล้วก็เกิดปัญหาพฤษภาทมิฬอะไรต่างๆ. ผมก็ดูแล้วว่าเราต้องลงไปถึงระดับรากฐานคือไปลงมือสร้างเด็กขึ้นมาเองเลย การปฏิรูปการศึกษาจะมาสั่งคนให้ทำอย่างโน้นอย่างนี้โดยอาศัยกฎหมาย มันไม่ค่อยได้ผล เขาไม่เข้าใจ ไม่รู้จะทำยังไง ผมเลยคิดว่าเราไปสร้างตัวอย่างให้เขาเห็นดีกว่า ไปปฏิรูปของเราเองก่อน วิธีการอย่างนี้จะขยายผลได้เร็ว แล้วอีกอย่างผมก็คิดว่าเราสร้างอะไรต่ออะไร สร้างยานอวกาศ สร้างโน่นสร้างนี่มาเยอะแล้ว ตอนนี้ลองสร้างคนบ้าง ก็เลยหันไปสู่แวดวงการศึกษาของเด็กตั้งโรงเรียนสัตยาไส จลพบุรี. ขณะเดียวกันก็อบรมครู ให้ความรู้เกี่ยวกับเรื่องของการเรียนรู้ เกี่ยวกับการศึกษา และเดินทางไปต่างประเทศตามคำเชิญของประเทศต่างๆ เพื่อไปอบรมครู

แล้วทำไมต้องเป็นโรงเรียนแนวไสบาบา

คืออันนี้เริ่มต้นเมื่อประมาณ 23 ปีที่ผ่านมา ตอนนั้นผมยังไม่ได้มาสนใจเรื่องการศึกษาของเด็ก แต่ก็ได้รับแรงกระตุ้นเมื่อครั้งไปที่ประเทศอินเดีย และไปเจอนักการศึกษา (ท่านสัตยาไสบาบาท่านเป็นอธิการบดี (มหาวิทยาลัยที่มีชื่อเสียงมากในประเทศอินเดีย ขณะเดียวกันท่านก็สอนธรรมะ ผมไปเจอท่าน ท่านก็มองหน้าผมสักพัก แล้วก็บอกว่าในชีวิตที่เหลือขอให้หันมาสนใจการศึกษาทั้งหมดได้ไหม ผมก็ตอบรับทันที เพราะท่านพูดประทับใจมาก เข้าถึงใจผม ผมก็เลยตัดสินใจว่าเราต้องหันมาทางด้านนี้ กลับมาเมืองไทยก็เริ่มต้นจากการทดลองสอนเด็กในแหล่งชุมชนก่อน ดูสิว่าเราสามารถเปลี่ยนชีวิตเขาได้ไหม ปรากฏว่าเด็กพวกนี้เปลี่ยนอย่าง

รวดเร็ว เราก็เริ่มเห็นผล ทีนี้ก็เลยจัดอบรมครู พออบรมไปได้สักหมื่นห้าพันกว่าคน ครูเหล่านี้ก็เรียกร้องว่า วิธีสอนมันดีล่ะ แต่เขาอยากจะเห็นของจริง โรงเรียนที่ปฏิบัติอย่างนั้น ทำอย่างนั้นจริงๆ ผมก็เลยบอกพรรคพวกเรามาสร้างโรงเรียนกันดีกว่า เพื่อจะได้เป็นตัวอย่าง ทุกคนก็เห็นดีด้วย ช่วยกันบริจาค เพราะเราจะไม่เก็บค่าเล่าเรียน ต้องการทำตัวอย่างของการให้ ให้เปล่า ให้ฟรี ไม่ใช่ว่าจะเอากำไร โรงเรียนสัตยาไสก็เริ่มต้นเมื่อ 13 ปีที่แล้ว

อาจารย์ทำงานกับเด็กมาก็พอสมควร มองว่าปัญหาของเด็กยุคนี้คืออะไร

เป็นเรื่องจริงว่าเด็กที่มีปัญหาคือ เด็กที่ขาดความรัก ขาดความอบอุ่นในครอบครัว พอเขาขาดก็จะพยายามแสวงหาความสนใจของคนอื่นเข้ามา ฉะนั้นบางทีเขาก็ใช้วิธีที่เขารู้จัก คือเกเร ทำลายโน่น ทำลายนี่ แกล้งคนโน้น คนนี้ ทันทีเลยผู้ใหญ่ก็จะมาหาเขา จริงอยู่เขาโดนลงโทษ แต่เขาสามารถดึงดูดคนมาหาเขา และนั่นคือสิ่งที่เขาปรารถนา ที่เขาเกเรทุกวันนี้เป็นเพราะเขาขาดความรัก เขาอยากจะได้ความรักจากผู้ใหญ่ เราต้องเข้าใจอย่าไปโทษเด็ก มันมีปัจจัยอีกหลายอย่างที่เสริมเข้ามา ฉะนั้นเป็นหน้าที่ของผู้ปกครองของครูที่จะต้องเติมความรัก ความเมตตา และให้ภูมิคุ้มกันแก่เด็ก

ภายใต้บรรยากาศทางสังคมที่เต็มไปด้วยความรุนแรงอย่างในปัจจุบัน ยังพอมีหวังมั้ยคะ

คือผมเชื่อว่าจะมีเหตุการณ์หลายอย่างที่จะทำให้ทุกอย่างต้องเปลี่ยน มนุษย์เราพอมีความทุกข์มากๆ จะรีบแก้ไข รีบเปลี่ยน รีบหนีความทุกข์ ฉะนั้นมันจะมีเหตุการณ์ที่สร้างปัญหาขึ้นมาเยอะให้กับเรา และปัญหาเหล่านั้นก็คือบทเรียนที่เราจะได้เรียนรู้ และปรับปรุงตัวเราเอง แก้ไขสถานการณ์ให้ดีขึ้น อย่างที่เขาบอกระดับน้ำทะเลจะสูงขึ้น 4 เมตร กรุงเทพฯก็หมดแล้วไม่มีเหลือ อยู่ใต้บาดาลแล้ว ภาคกลางของประเทศไทยก็จะโดนน้ำท่วมหมด พอถึงใกล้ๆ เวลานั้นพวกเราจะตกอกตกใจและรีบเตือนกันอย่างรวดเร็ว เราไม่มีทางเลือกแล้ว เราต้องเปลี่ยน ถ้าเรารู้ว่าอะไรจะเกิดขึ้น จะเกิดแผ่นดินไหว น้ำท่วม มันต้องเปลี่ยนแล้ว คือชีวิตเราจะเปลี่ยนเร็วท่ามกลางวิกฤติต่างๆ ถ้าไม่มีวิกฤติเราก็ไม่เปลี่ยน เราก็อยู่กันอย่างสบายๆ เพราะฉะนั้นช่วงนี้มันจะมีวิกฤติเกิดขึ้นเยอะ และสร้างปัญหาให้กับเรา ทำให้การเปลี่ยนแปลงจะเร่งและรีบด่วน มันจะไม่ใช่ 50 ปีอย่างที่บางคนทำนายหรอก มันจะเกิดขึ้นเร็วมาก สมัยนี้เราอยู่ในยุคของการเปลี่ยนแปลง เราไม่มีเวลากันแล้ว

แต่อาจารย์มองว่าวิกฤติจะนำมาซึ่งการเปลี่ยนแปลงในทางที่ดี?

ผมมั่นใจว่ายุคแห่งความสงบสุขจะเกิดขึ้นในโลกของเราแล้ว

คล้าย ๆ กับแนวคิดทางพุทธศาสนาเรื่องยุคพระศรีอารย์?

มันก็ตรงกับศาสนาต่างๆ ที่เขาทำนายไว้ว่าจะเกิดยุคแห่งความสงบสุขขึ้นมา ผมดูเหตุการณ์ทุกอย่างแล้วก็มุ่งไปทางนั้น แล้วตอนนี้ก็มีคนที่เริ่มคิดในแนวใหม่ เริ่มคิดในทางที่ดี หมอประเวศ วะสี ก็เริ่มคิดแหวกแนวออก

มาแล้ว เพื่อให้เกิดการเปลี่ยนแปลงในสังคมของเรา ฉะนั้นสิ่งเหล่านี้มันจะเกิดขึ้นค่อนข้างจะเร็ว และคนจำนวนมากก็เริ่มจะคิดในแนวเดียวกันมากขึ้นๆ กระแสจะค่อยนำพาทุกฝ่ายไปสู่โลกใหม่ โลกที่เต็มไปด้วยความสงบสุข

ระหว่างวิกฤติทางด้านสังคมกับสิ่งแวดล้อม อาจารย์คิดว่าอะไรน่าจะเป็นจุดเปลี่ยนสำคัญ

ผมคิดว่ามันจะเกิดขึ้นพร้อมๆ กัน จากการที่อุณหภูมิมันสูงขึ้นในโลก ดิน ฟ้า อากาศ ทั่วโลกก็เปลี่ยนแปลง ผมเพิ่งกลับมาจากอาหรับเอมิเรสต์ ปรากฏว่าฝนตกมาตลอดทั้งปี ทั้งๆ ที่ปกติเขาเป็นทะเลทราย ผมเคยบอกเขามานานแล้วว่า ตรงนี้ในที่สุดจะไม่ใช่ทะเลทรายแล้ว ฝนจะเริ่มตกมากขึ้นๆ และมันก็เกิดขึ้นจริงๆ ทะเลทรายจะค่อยๆ เคลื่อนที่ไปทางเหนือมากขึ้น อย่างประเทศสเปนจะแห้งแล้ง ทะเลทรายซาฮาราจะขยับขึ้นไปเรื่อยๆ ทางเหนือ อุณหภูมิในโลกเริ่มจะสูงขึ้นอยู่เรื่อยๆ ผมไปคุยกับนักวิทยาศาสตร์ที่ประเทศจีน มันเกิดจากน้ำทะเล เขายอมรับว่าทุกปีมันจะสูงขึ้นเรื่อยๆ เพราะว่าเมื่ออุณหภูมิสูงขึ้น น้ำแข็งที่ขั้วโลกเหนือ ขั้วโลกใต้ก็เริ่มละลาย ฉะนั้นจึงทำให้ดินฟ้าอากาศเปลี่ยนแปลง ความรุนแรงจะเกิดมากขึ้นๆ พายุไต้ฝุ่นมากขึ้น สึนามิก็จะมีมากขึ้น แผ่นดินไหวมากขึ้น ทุกอย่างมันมากขึ้นไปหมด ขณะเดียวกัน มนุษย์เราก็ยังทะเลาะกัน เถียงกัน ยังทำสงครามกัน ยังฆ่ากันอยู่ โดยเฉพาะแถวๆ อิหร่าน ตะวันออกกลาง จะมีปัญหาอยู่เยอะ และอีกหลายประเทศที่มีการสู้รบกัน ลักษณะแบบนี้มันจะเร่ง ทั้งธรรมชาติ ทั้งวิกฤติในระหว่างมนุษย์ด้วยกันก็จะเป็นตัวเร่ง ทำให้เราต้องยอมรับแล้วว่าถึงเวลาที่มนุษย์จะต้องเปลี่ยนแปลง ชีวิตของผมเองก็เหมือนกัน พอเป็นเด็กเกเรมากๆ ชกต่อยคนโน้น คนนี้ ตัวเราเองก็เจ็บด้วย ไม่ใช่ทำให้คนอื่นเจ็บอย่างเดียว และนั่นคือตัวเร่งที่ทำให้ผมเกิดการเปลี่ยนแปลงในชีวิต เพราะฉะนั้นอันนี้กำลังเกิดขึ้น และผมคิดว่าจะเกิดขึ้นเร็วกว่าที่เราคิด

เร็วแค่ไหนคะ

ผมให้เวลา 12 ปี

ทำไมถึงเป็นตัวเลข 12 ปี

เพราะว่าตัวเร่งมันกำลังเกิดขึ้น ทุกอย่างมันเร่งหมดแล้ว เราไม่เคยมีแผ่นดินไหวที่รุนแรง จนทำให้เกิดคลื่นสึนามิ ไม่เคยมีอย่างนี้มานานทีเดียว แต่ตอนหลังมีตั้งหลายครั้งแล้ว และพอมันเกิดขึ้นตรงนี้ เปลือกโลกมันก็ขยับใช่ไหม มันก็ทำให้เกิดความกดดันอีกจุดหนึ่ง ซึ่งมันก็ต้องขยับตาม ทีนี้มันก็จะไปเรื่อยๆ ไปรอบด้านรอบโลก ซึ่งอันนี้เป็นภัยอันตรายที่พวกเราต้องระมัดระวัง แต่ถ้าพวกเราช่วยเหลือกันตั้งแต่แรก ภัยเหล่านี้ก็จะลดน้อยลง อยู่ที่ความร่วมมือของมนุษย์ สึนามิไม่จำเป็นต้องฆ่าคนจำนวนมาก ถ้าทันทีที่เกิดขึ้นจุดใดจุดหนึ่งก็บอกต่อๆ กันไป

แล้ว 12 ปีนี่ประเมินจากอะไรคะ

ผมลองดูสถานการณ์ต่างๆ ที่เป็นตัวปัจจัยให้เกิดการเปลี่ยนแปลง คือเราก็สังเกตทุกด้านจากเหตุการณ์ที่เกิดขึ้นในโลก อันแรกจากที่มนุษย์เราทะเลาะกันเอง สร้างสงครามกัน สร้างวิกฤติของตัวเองขึ้นมา อีกอันหนึ่งก็

คือความถี่ของธรรมชาติที่มีแผ่นดินไหว น้ำท่วม ดินฟ้าอากาศที่รุนแรง มีพวกพายุมากขึ้น เฮอร์ริเคนทางโน้น มีไซโคลนทางนี้ มีอะไรต่างๆ ที่รุนแรงมากๆ คือพวกนี้เราดูแล้วความถี่มันมากขึ้นๆ ตามหลักวิทยาศาสตร์ผมก็วาดกราฟออกมา การเปลี่ยนแปลงจะเกิดขึ้นแบบไหน ผมคำนวณออกมาแล้วมันจะไม่เป็นเส้นตรง แต่มันจะค่อยๆ ขยับขึ้น ตอนแรกมันดูเหมือนช้ามาก แต่แล้วมันจะค่อยๆ ขยับขึ้น และขึ้นเร็วมาก ผมคำนวณดูก็เห็นว่าจุดวิกฤติต่างๆ มันจะเกิดขึ้นภายใน 10 ปีข้างหน้า หลังจากนั้นก็จะทำให้เกิดการเปลี่ยนแปลง ทั้งทางด้านการศึกษา ทางด้านจิตใจของมนุษย์อะไรต่างๆ เพราะคนเราจะถึงขั้นหนึ่งที่บอกว่าพอแล้ว ไม่เอาแล้ว ความทุกข์มันพอแล้ว เลิกกันดีกว่า เราหันหน้าเข้ามาหากัน คุยกันดีกว่า มันจะถึงขั้นหนึ่ง มากจนต้องหยุดแล้ว

สุดท้ายอาจารย์คิดว่าอะไรจะเป็นเงื่อนไขที่ทำให้มนุษย์ก้าวพ้นวิกฤติเหล่านี้ไปได้

มีอยู่อย่างเดียว ความรัก ความเมตตา คนเราถ้ามีความรัก ความเมตตา ทุกอย่างก็แก้ได้หมด เราให้อภัยซึ่งกันและกัน เราไม่มองในแง่ร้าย มีอะไรเราช่วยเหลือเขา เมื่อมีการช่วยเหลือซึ่งกันและกัน เรามีอาหารเหลือเฟือ เรามีอะไรทุกอย่างเหลือเฟือในโลกนี้ เราไม่ต้องแย่งกันหรอก แต่จะใช้ระบบเศรษฐกิจแบบปัจจุบันไม่ได้ ระบบเศรษฐกิจต้องเปลี่ยน จะเป็นระบบเศรษฐกิจแบบนายทุนไม่ได้แล้ว แต่เป็นเศรษฐกิจของความเอื้อเฟื้อเผื่อแผ่ เศรษฐกิจของในหลวง สิ่งเหล่านี้มันจะต้องเกิดขึ้นโดยอัตโนมัติ

จาก

ผู้หยั่งรู้ ดร อาจอง ชุมสาย ณ อยุธยา

ที่มา : "บทสัมภาษณ์ ดร"อาจอง ชุมสาย ณ อยุธยา. ใช้สมาธิช่วยองค์การนาซ่าสำรวจอวกาศ
สืบค้นเมื่อ 12 สิงหาคม 2551 จากhttp://th.wisdominside.org/index.php?option=com_content&task=view&id=39&Itemid=67

แบบทดสอบย่อยเก็บคะแนนครั้งที่ 1 (Q2)

โรงเรียนมหิดลวิทยานุสรณ์ (องค์การมหาชน)

รายวิชา เคมีพื้นฐาน ว 30131

ชื่อ-นามสกุล สมาชิกในกลุ่ม

1. …… เลขที่ …….. ม. 4/7
2. …… เลขที่ …….. ม. 4/7
3. …… เลขที่ …….. ม. 4/7

คำชี้แจง

1. ให้นักเรียนในกลุ่มร่วมกันศึกษา กรณีศึกษาเกี่ยวกับเรื่องราวของแจน เฮนดริก ชอน (Jan Hendrik Schon) จากบทความ เรื่อง In the Matter of J. Hendrik Schon และ เรื่องอื้อฉาวลวงโลก:บาปของนักวิทยาศาสตร์จรรยาบรรณบกพร่อง ที่กำหนดให้
2. วิเคราะห์กรณีศึกษาแล้วตอบคำถามลงในใบงานที่กำหนดให้
3. นำเสนอผลงานหน้าชั้นเรียน (10 คะแนน) ด้วยรูปแบบการนำเสนอแบบใดก็ได้ โดยใช้เวลากลุ่มละประมาณ 5 นาที และแลกเปลี่ยนความคิดเห็นอีกกลุ่มละประมาณ 5 นาที

ใบงาน

จากการวิเคราะห์กรณีศึกษาของ แจน เฮนดริก ชอน ให้นักเรียนเตรียมนำเสนอผลงานหน้าชั้นเรียน โดยการตอบคำถามต่อไปนี้

1. ให้นักเรียนสรุปเรื่องราวที่เกิดขึ้นที่ห้องปฏิบัติการเบลล์ (Bell Labs)

2. ให้นักเรียนวิเคราะห์การกระทำของ แจน เฮนดริก ชอน ว่าถูกต้องตามหลักจริยธรรมทางวิทยาศาสตร์หรือไม่ อย่างไร

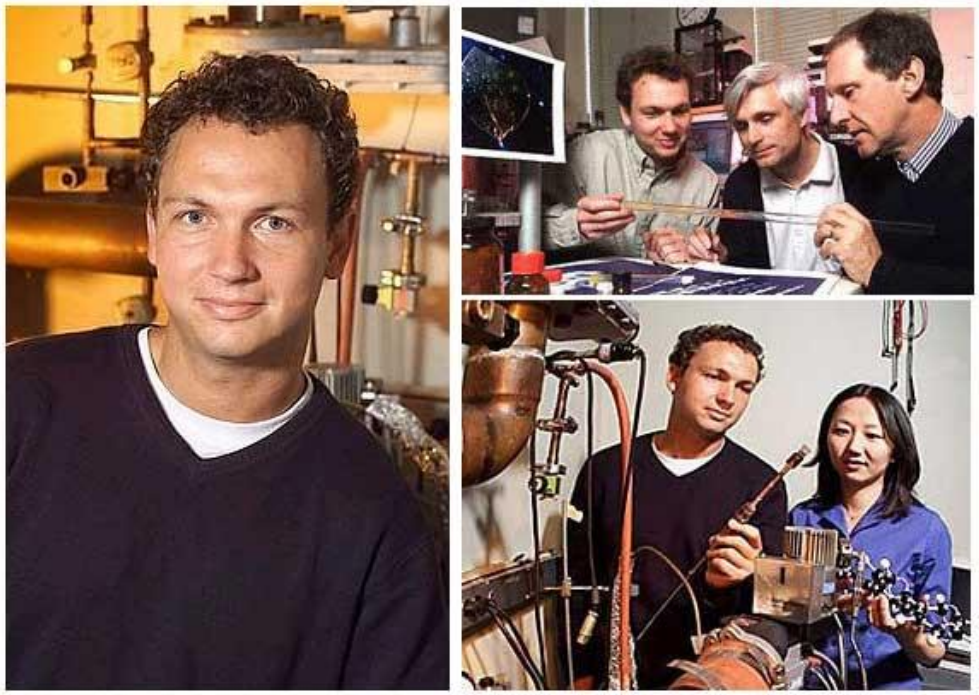
3. ถ้าหากนักเรียนเป็นเพื่อนร่วมทีมวิจัยกับแจน เฮนดริก ชอน นักเรียนจะมีความรู้สึกอย่างไรต่อสิ่งที่เกิดขึ้น

4. สมมติว่าเหตุการณ์นี้ เกิดขึ้นโดยนักเรียนวิทยาศาสตร์ของโรงเรียนมหิดลวิทยานุสรณ์ นักเรียนคิดว่าจะมีผลกระทบอะไรเกิดขึ้นตามมาบ้าง

5. ประเด็นหรือหลักการจริยธรรมทางวิทยาศาสตร์ที่เกิดขึ้นจากกรณีศึกษานี้ มีอะไรบ้าง จงอธิบาย

ใบงาน

นักฟิสิกส์อัจฉริยะขี้โกงที่ห้องปฏิบัติการเบลล์ ห้องปฏิบัติการเบลล์ (Bell Laboratories) เป็นแหล่งรวมนักวิจัยชั้นนำของโลก ในแต่ละปี มีผลงานการวิจัยสำคัญตีพิมพ์มากมาย แต่เมื่อช่วงปลายศตวรรษที่ 20 ไม่มีนักวิทยาศาสตร์คนใดจะเด่นเท่านักฟิสิกส์หนุ่มชื่อ แจน เฮนดริก ชอน (Jan Hendrik Schon) ผู้กำลังแสดงแววอัจฉริยะทางด้านนาโนอิเล็กทรอนิกส์ มีผลงานการวิจัยระดับแนวหน้าตีพิมพ์เฉลี่ยปีละ 40 ฉบับ และเป็นตัวเก็งที่จะได้รับรางวัลโนเบลในไม่ช้า



Jan Hendrik Schon

ทว่า ในที่สุด ความจริงก็ปรากฏจากรายงานการวิจัยจำนวน 5 ฉบับ ตีพิมพ์ในวารสารวิชาการระดับโลก Nature และ 7 ฉบับตีพิมพ์ในวารสาร Science ระหว่างปี 1998 กับ 2001 เขาก็ถูกจับผิดได้ โดยคณะกรรมการที่ถูกตั้งขึ้นมา (โดยห้องปฏิบัติการเบลล์เองเพื่อตรวจสอบรายงานการวิจัยของเขา (ซึ่งผลการตรวจสอบออกมาในปี 2002 ว่า เขาเป็นอัจฉริยะนักฟิสิกส์ขี้โกง เพราะสร้างผลงานเท็จที่เขียนเป็นรายงานการวิจัย ตัวอย่างเช่น ใช้กราฟเดียวกัน ในรายงาน 2 ฉบับ ซึ่งเป็นเรื่องการวิจัยที่ไม่เกี่ยวข้องกันเลย และใช้ข้อมูลที่มีปัญหาถึง 16 แห่ง

แจน เฮนดริค ชอน ขณะถูกจับผิดได้มีอายุเพียง 32 ปี ผลงานอื้อฉาวของเขาสร้างความเสื่อมเสียอย่างหนักแก่ห้องปฏิบัติการเบลล์ สร้างมลทินความน่าเชื่อถือของวารสารวิชาการทางด้านวิทยาศาสตร์ระดับชั้นนำ ของโลกที่มีระบบ Peer Review คือ การตรวจอ่านโดยผู้เชี่ยวชาญ เฉพาะด้านอย่างเข้มข้น (แต่ก็ถูกหลอกจนได้) สำหรับตัวนักวิทยาศาสตร์อื้อฉาวเอง อนาคตความเป็นนักวิทยาศาสตร์ก็ดับวูบลง เป็นแกะดำที่สังคมวิทยาศาสตร์ระดับโลกประนามและรังเกียจ

ที่มา เรื่องอื้อฉาวลวงโลก :บาปของนักวิทยาศาสตร์จรรยาบรรณบกพร่อง, ARTgazine Articles:บทความทั่วไป. สืบค้นเมื่อ 9 สิงหาคม 2551 จาก http://www.artgazine.com/shoutouts/viewtopic.php?t=2455

In the Matter of J. Hendrik Schon

By David Goodstein

Published in Physics World, November, 2002

“The physicists have known sin” J. Robert Oppenheimer is famously said to have said. That was on the occasion of the first nuclear explosion. Sin in the form of faking scientific data seemed to be reserved to biology and related sciences, not physics. I used to think I understood why. “There are three danger factors in scientific misconduct,” I would lecture to my classes in Research Ethics and anyone else who would listen. Not that research misconduct happens whenever these factors are present. They are often present and misconduct in science is very rare. But these factors were present in every case I’ve studied. First, the scientist is under career pressure. That’s not much of a discriminator, because all scientists are under career pressure all the time, but it does point up the fact that this kind of misconduct is not motivated by simple monetary gain. Second, the perpetrators always think they know the right answer. In other words, faking data is never done with the intention of inserting a falsehood into the body of scientific knowledge. The intent is always to insert a truth without bothering to go to the trouble of doing the experiment properly. This kind of misconduct is always a violation of the scientific method, never purposely a violation of scientific truth. And finally, the work is always in a field where reproducibility is not expected to be very precise. For example, if you take two organisms that are as nearly identical as you can make them, say, two transgenic mice, and expose them to the same carcinogenic agent, you don’t expect them to develop the same tumor at the same time in the same place. So, biologists who are otherwise disposed to cheat generally don’t have to fear that someone will quickly prove them wrong merely by repeating the experiment. That, I would conclude, is why faking data occurs in biology, not physics.

Now two high profile cases of cheating in physics have suddenly surfaced. One involves the announcement and later retraction of the discovery of elements 116 and 118 at Lawrence Berkeley National Laboratory (LBNL). The other involves a young researcher at Bell Labs named Jan Hendrik Schon. These cases promise to pose a severe test for my theory. Unfortunately, as in many cases of scientific misconduct, little is known to the outside world about the LBNL case. An investigation took place, and a scientist named Victor Ninov was fired as a result. But the report of the investigation has not been made public. Quite the opposite is true in the Schon case. In a rare instance of openness in the murky field of scientific misconduct, the management of Bell Labs made it clear from the outset that it intended to make public the results of its investigation. It has now done so.

The general outlines of the case have been widely reported [reference previous Physics World reports]. Jan Hendrik Schon seemed to be a brilliant young condensed matter experimentalist zooming straight toward Nobel Prize country. The field was organic or carbon-based semiconductors,

and one after another Schon seemed able to grab every Holy Grail in the business. Many of the samples were fabricated at Bell Labs and prepared for measurements at the University of Konstanz while Schon was waiting for a visa to join Bell Labs. He managed, for example, to use field-effect doping—the use of very large electric fields to change the electron concentration in his samples—to induce such remarkable phenomena as superconductivity and the Quantum Hall effect. Other researchers had been unable to reach high enough fields to detect these miraculous effects because of electrical breakdown in the insulating layers that are essential for such experiments. But Schon, in a humble apparatus in Konstanz, had managed to produce aluminum oxide films of unprecedented resistance to breakdown. In the period from 1998 to the summer of 2001, he produced research papers on the average of one every eight days, together with a total of twenty collaborators. A blazing superstar of physics had been launched. Then the wheels started to come off. The announcement of a single-molecule transistor-- the logical endpoint of Moore's Law—triggered the beginning of an unsuspension of disbelief. Anomalies were pointed out. The data were too perfect. Different experiments had identical noise. And so on. In the Spring of this year, Bell Labs appointed a committee, chaired by Professor Malcolm Beasley of Stanford University to investigate. The committee's report was released to the public, as promised, on September 25. The report detailed some 24 specific allegations the committee had investigated, and found that scientific misconduct by Schon had occurred in at least 16 of them. Schon had done all of his experiments alone, he kept no laboratory notebooks, all his raw data files had been erased from his computer, and all of his original samples had been either destroyed or discarded. With only the slightest of misgivings, the report exonerated all of Schon's collaborators. Schon was immediately fired by Bell Labs.

The case raises a number of issues. To begin with, I find it amazing that when it arose, Bell Labs had no formal policy on how to handle cases of research misconduct. All American universities that accept federal research funds are required to have such policies, but Bell does not have federal funds. The attitude there seems to have been one that was common in the universities a couple of decades ago—it couldn't happen here, so why do we need such a policy? The Beasley committee resolved this dilemma by choosing to follow the federal policy that guides the universities. That, for example, established the level of proof of guilt required. Not, as in a criminal case, beyond a reasonable doubt, but rather a preponderance of the evidence would be sufficient. I would imagine that Bell and other industrial laboratories will now get the message and put appropriate policies in place. A more difficult issue concerns the responsibility of the other authors. The Beasley report defines this as an issue not of scientific misconduct but of professional responsibility, and decides that "…no clear, widely accepted standards of behavior exist", because it is an issue that "the scientific community has not considered carefully." In fact the issue here is trust among scientists. Collaborations take place precisely because different scientists bring different skills to the table. If we are responsible for looking over the shoulders of our collaborators, collaborations will fall apart, and

much damage will be done toscience. Still, it makes one uneasy that there were so many collaborators who never suspected wrongdoing. What about my theory? Those three danger factors I wrote about? In this case they seem to hold up pretty well. Was Schon under career pressure? You bet he was, as is everyone at a place like Bell Labs (or my own Caltech for that matter), perhaps made all the more brutal by the intensely competitive nature of the field he was in, and the unyielding pressure to stay ahead of the curve on Moore's Law (crudely, the continued exponential growth of the number of transistors that can be crammed onto a computer chip). Did he believe he knew the right answer? He still does. In a response attached to the Beasley report, Schon admits having made mistakes, but writes "I have observed experimentally the various physical effects…such as the Quantum Hall effect, superconductivity in various materials…I believe that these results will be reproduced in the future…." Finally, is it a field in which results are not easily reproduced? It is. Results in this field are notoriously sample-specific. That is, they depend crucially on the skill and luck of the person who prepares the sample. Failure to reproduce any given result in any given sample is not considered proof of anything. Nobody could prove Schon had cheated just by demonstrating that a given result he has reported doesn't show up in a particular sample. So, my theory survives to be disproved another day.

The Schon case has put scientific misconduct back on the front pages of the newspapers, and this time it is physics that's on the firing line. Inevitably, there will be much debate and soul-searching about what to do. Whatever we do, we must remember this. Science is a marketplace of ideas, where good ideas must be proven wrong in order to be replaced by better ones. Being wrong, then, is an essential part of progress in science. To the public, it's easy to confuse being wrong with being guilty. We cannot allow that to happen. If scientists start to fear being accused of misconduct when they are wrong, enormous damage will be done to the enterprise of science. In this case, the system worked. Science is self-correcting, as it's supposed to be. But we must not be complacent. If this kind of misconduct were to become commonplace, science would cease to be self correcting and would be no better than any other belief system. Rooting out scientific misconduct in a sensible way will always be a grave responsibility for all of us. Today, September 27, 2002, the stock of once proud Lucent Technologies, the parent company of Bell Labs, closed at 77 cents a share. I bought a thousand shares.

ที่มา : David Goodstein (2002). In the Matter of J.Hendrik Schon. Physics World. Accessed August 12, 2009 from http://www.its.caltech.edu/ ~ dg/The_physicists.pdf

แบบทดสอบย่อยเก็บคะแนนครั้งที่ 1 (Q2)

โรงเรียนมหิดลวิทยานุสรณ์ (องค์การมหาชน)

รายวิชา เคมีพื้นฐาน ว 30131

ชื่อ-นามสกุล สมาชิกในกลุ่ม

1. …… เลขที่ …….. ม. 4/7
2. …… เลขที่ …….. ม. 4/7
3. …… เลขที่ …….. ม. 4/7

คำชี้แจง

1. ให้นักเรียนในกลุ่มร่วมกันศึกษา กรณีศึกษาเกี่ยวกับเรื่องราวของ หวัง วู ซุก (Hwang Woo-Suk) จากบทความที่กำหนดให้ เรื่อง Dr. Hwang Dropped from Scientific American 50 for Faking Research และ “หวัง วู ซุก” คนเก่งที่โลกไม่ต้องการ
2. วิเคราะห์กรณีศึกษาแล้วตอบคำถามลงในใบงานที่กำหนดให้
3. นำเสนอผลงานหน้าชั้นเรียน (10 คะแนน) ด้วยรูปแบบการนำเสนอแบบใดก็ได้ โดยใช้เวลากลุ่มละประมาณ 5 นาที และแลกเปลี่ยนความคิดเห็นอีกกลุ่มละประมาณ 5 นาที

ใบงาน

จากการวิเคราะห์กรณีศึกษาของ หวัง วู ซุก ให้นักเรียนเตรียมนำเสนอผลงานหน้าชั้นเรียนโดยการตอบคำถามต่อไปนี้

1. ให้นักเรียนสรุปเรื่องราวที่เกิดขึ้นกับหวัง วู ซุก (Hwang Woo Suk)

2. ให้นักเรียนวิเคราะห์การกระทำของ หวัง วู ซุก ว่าถูกต้องตามหลักจริยธรรมทางวิทยาศาสตร์หรือไม่ อย่างไร

3. ถ้าหากนักเรียนเป็นเพื่อนร่วมทีมวิจัยกับ หวัง วู ซุก นักเรียนจะมีความรู้สึกอย่างไรต่อสิ่งที่เกิดขึ้น

4. สมมติว่าเหตุการณ์นี้ เกิดขึ้นโดยนักเรียนวิทยาศาสตร์ของโรงเรียนมหิดลวิทยานุสรณ์ นักเรียนคิดว่าจะมีผลกระทบอะไรเกิดขึ้นตามมาบ้าง

5. ประเด็นหรือหลักการจริยธรรมทางวิทยาศาสตร์ที่เกิดขึ้นจากกรณีศึกษานี้ มีอะไรบ้าง จงอธิบาย

News - December 15, 2005

Dr. Hwang Dropped from Scientific American 50 for Faking Research

By The Editors

With considerable disappointment, the editors of *Scientific American* are immediately removing Dr. Woo Suk Hwang from his honored position as Research Leader of the Year on the 2005 Scientific American 50 list.

Dr. Hwang famously announced in *Science* last June that he and his team at Seoul National University in Korea had cloned human embryonic stem cells from 11 patients. Published accounts appearing this morning, however, report that one of his co-authors, Dr. Sung Il Roh, now says that Dr. Hwang admits that much of the evidence in his *Science* paper was faked. He further alleges that Dr. Hwang has asked *Science* to withdraw that paper. Dr. Hwang was not available for comment.

This admission follows the discovery in recent weeks that some of the experiments conducted in Dr. Hwang's laboratory did not meet the highest standards of ethical practice. Specifically, some women were paid to donate eggs for use in the experiments, and some of the eggs came from junior female researchers working in the laboratory.

The allegations of ethical misconduct were very troubling, but *Scientific American¿*s editors felt it was important to give Dr. Hwang the benefit of the doubt until their veracity could be determined. Even when those charges were borne out, we respected that the ethics of accepted practice in this area of science were still somewhat murky, and we declined to judge him too quickly, although his cover-up of those problems was clearly wrong.

However, scientific fraud is an unforgivable offense against the enterprise of research, and in this case, it completely invalidates the selection of Dr. Hwang for inclusion in the Scientific American 50.

Dr. Hwang's deceit misled *Scientific American* along with the international scientific community. We regret, in writing about his work and awarding him a place among key technology leaders, having unknowingly misinformed readers about his actual accomplishments. We are also deeply concerned about the lasting damage that this fraud may do to the reputation of stem cell research, which we continue to regard as a highly worthy endeavor generally pursued by scientists keeping to a far higher standard of honesty and ethics.

ที่มา: Dr. Hwang Dropped from Scientific American 50 for Faking Research สืบค้นเมื่อ 9 สิงหาคม 2551 จาก http://www.scientificamerican.com/article.cfm?id=dr-hwang-dropped-from-sci

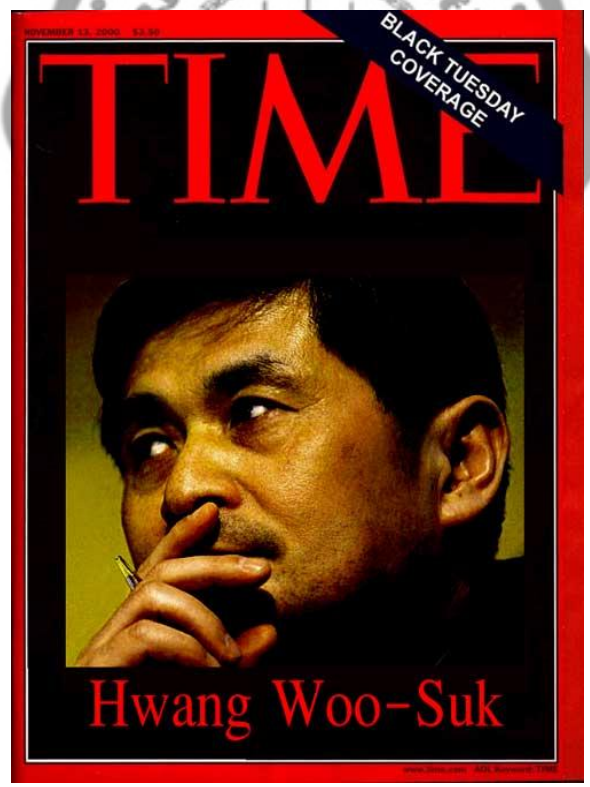
‘หวัง วู ซุก’ คนเก่งที่โลกไม่ต้องการ

เรื่อง : วันพรรษา อภิรัฐนานนท์

อะไรจะเกิดขึ้น เมื่อหนึ่งในมนุษย์โคลนที่ถูกเพาะเลี้ยงขึ้นบนเกาะห่างไกล ออกตามล่าหาตัวมนุษย์ต้นแบบ ภายหลังจากที่ได้รู้ว่าตัวเองที่แท้แล้วเป็นมนุษย์โคลนที่ถูกโคลนนิงหรือ จำลองแบบขึ้น เพื่อใช้เป็นเซลล์หรืออวัยวะสำรองของมนุษย์ต้นแบบ มีชีวิตอยู่เพียงเพื่อใช้เป็นอะไหล่อวัยวะ ที่เมื่อวันหนึ่งมนุษย์เจ้าของเซลล์มีอันล้มป่วย หรือมีเหตุหนึ่งเหตุใดให้ต้องใช้อวัยวะสำรอง ก็จะนำอวัยวะหรือเซลล์จากตัวโคลนมาเพื่อใช้ต่อชีวิตตน เมื่อค้นพบว่าสถานที่สุดท้ายในโลกที่ปลอดภัยจากภัยพิบัติทางระบบนิเวศกลาย เป็นเรื่องหลอกลวง มนุษย์โคลนตัวหนึ่งจึงแหกด่านของศูนย์อำนวยการออกมาสู่โลกภายนอก

นี่คือเรื่องราวของ The Island นิยายวิทยาศาสตร์ที่ถูกหยิบมาสร้างเป็นภาพยนตร์ฮอลลีวูดเมื่อไม่นานนี้ สะท้อนความเป็นไปได้ของโลกอนาคตเรื่องมนุษย์โคลน ที่วันหนึ่งอาจค้นพบว่าทุกสิ่งทุกอย่างเกี่ยวกับการมีชีวิตอยู่เป็นเรื่อง หลอกลวง และเริ่มต้นนับหนึ่งบทแรกของการไล่ล่า แต่ก่อนจะไปถึงบทนั้น คือบทแรกแห่งความลวงของบทวิจัยจอมปลอม “การสร้างสเต็มเซลล์มนุษย์ด้วยวิธีโคลนนิง” ของนักวิจัยชาวเกาหลี “หวัง วู ซุก” ซึ่งเป็นข่าวเกรียวกราวทั่วโลกเมื่อเดือนที่ผ่านมา

นิยายแห่งนิยาย(วิทยาศาสตร์)



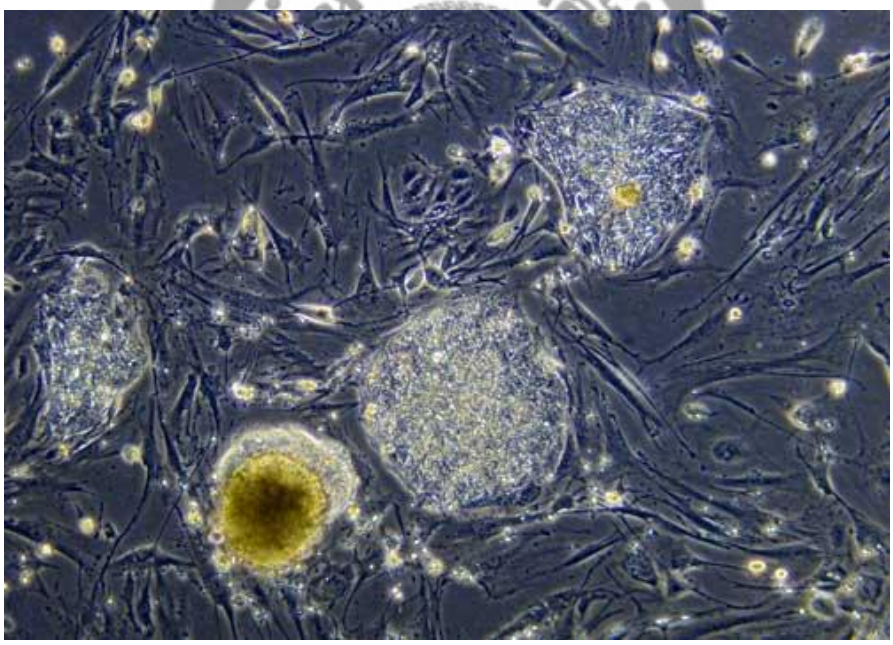
หวัง วู ซุก

หวัง วู ซุก นักวิจัยเกาหลีใต้ เรื่องราวของเขาหากเป็นนิยายก็ต้องเรียกว่าหักมุมตอนจบ จากที่เจิดจรัสเป็นนักวิทยาศาสตร์ดาวรุ่ง ถึงขั้นนิตยสาร Time ยกย่องให้เป็นบุคคลสำคัญแห่งปี (2547) ผลงานการวิจัยของเขาตีพิมพ์ในวารสารวิชาการระดับโลก คือ Nature และนิตยสาร Science ช่วงปี 2547-2548 ซึ่งทำให้

นักวิทยาศาสตร์หนุ่มใหญ่มาดแมนแฮนด์ซัมผู้นี้ กลายเป็นนักวิทยาศาสตร์ที่โด่งดังที่สุดของโลก ในการค้นคว้าวิจัยด้านโคลนนิงและสเต็มเซลล์ แต่เมื่องานวิจัยถูกเปิดโปงว่าไม่สามารถยืนยันผลหรือทำซ้ำได้ ข้อมูลบางส่วน “เมก” ขึ้น และบางส่วนได้มาอย่างไม่ถูกกฎหมาย จากดาวรุ่งก็ร่วงทันที
หวัง วู ซุก เริ่มมีชื่อเสียง เมื่อเขาโคลนนิงวัวได้สำเร็จเป็นรายที่ 5 ของโลกในปี 2542 การวิจัยของเขาได้รับการยกย่องและสนับสนุนอย่างต่อเนื่องจากรัฐบาลและ ประชาชนเกาหลี จนก่อนที่จะเกิดเหตุก็คือการประกาศความสำเร็จการโคลนนิงสุนัขตัวแรกของโลก ในปี 2548 ผลงานของเขา “สนัปปี” (Snuppy) สุนัขพันธุ์อาฟกันฮาวด์ตัวน้อยหน้าแหลม (ใช้เซลล์จากใบหูเป็นเซลล์ต้นแบบ) ยังได้รับการยกย่องจากนิตยสาร Time ให้เป็นสุนัขโคลนนิง-สิ่งประดิษฐ์มหัศจรรย์ยอดเยี่ยมแห่งปี 2548 (The Most Amazing Invention of 2005) ด้วย

ขณะที่ในความคิดของ หวัง วู ซุก แล้ว เจ้าสนัปปีเป็นยิ่งกว่าสิ่งมหัศจรรย์ เพราะมันคือบันไดที่จะนำไปสู่การโคลนมนุษย์ในเวลาต่อมา ทีมงานกว่าครึ่งร้อยของเขาใน “เวิลด์ สเต็มเซลล์ ฮับ” คึกคักและกระตือรือร้นเต็มที่ ท่ามกลางกระแสชาตินิยมของคนเกาหลีผสมกับความเก่งกาจของคุณหมอคนดัง ชื่อเสียง รวมทั้งเงินทองสนับสนุนการวิจัยไหลมาเทมา เกิดเป็นกระแส หวัง วู ซุก ฟีเวอร์ สร้างเกาหลีใต้สู่การเป็นผู้นำด้านสเต็มเซลล์ของโลก

พันธุวิศวกรรมลวงโลก



South Korean research team led by Professor Hwang Woo-suk has created 11 lines of therapeutic human embryonic stem cells using adult cells of diseased and injured patients

ในฐานะวีรบุรุษ หวัง วู ซุก เริ่มโครงการสร้างสเต็มเซลล์มนุษย์จากการโคลนนิงอย่างจริงจัง แต่ความหวังที่ท่วมท้นของคนทั้งชาตินี้ นานวันเข้าก็ได้กลายเป็นแรงเหวี่ยงกลับของกระแสกดดันสู่ตัวเขาเอง อ้างจากหนังสือพิมพ์แมอิลของเกาหลี ซึ่งระบุแหล่งข่าวในเวิลด์ สเต็มเซลล์ ฮับ สถาบันหลักในการผลิตและวิจัยสเต็มเซลล์แห่งชาติเกาหลี ให้ข่าวว่า หวัง วู ซุก ต้องทำงานภายใต้กระแสกดดันอย่างหนัก เมื่อการทดลองแล้วทดลองอีกไม่เป็นผลตามที่หลายฝ่ายเฝ้าหวัง

หวัง วู ซุก จึงตบสายตาคนทั้งโลก ด้วยผลงานพันธุวิศวกรรมจอมปลอมที่ไล่ข้อหาได้ตั้งแต่การใช้ข้อมูลเท็จในกระบวนการวิจัย การเปิดโปงทำโดยวารสารวิชาการ Nature ซึ่งตีพิมพ์งานวิจัยของเขา สืบพบเงื่อนงำน่าสงสัยว่าอาจมีการปิดบังและโกหกที่มาของไข่มนุษย์ที่นำมา วิจัย หวัง วู ซุก สารภาพภายหลังยอมรับว่าไข่บางส่วนได้มาจากนักวิจัยหญิงในทีม และบางส่วนใช้เงินซื้อ ซึ่งผิดจรรยาบรรณและผิดกฎหมายเกาหลีใต้ ที่ไข่มนุษย์เพื่อการวิจัยไม่อนุญาตให้ซื้อขาย และทำได้ด้วยการรับบริจาคจากบุคคลทั่วไปที่ไม่อยู่ในทีมวิจัยเท่านั้น

Editor's note: Hwang Woo-suk has admitted to faking his human cloning and stem cell work, and his published data has been retracted from the journal Science

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ยิ่งไปกว่านั้นคือ การหลอกลวงผลการทดลองที่พบในเวลาต่อมาว่า ไม่สามารถทำซ้ำเพื่อยืนยันผลโดยนักวิทยาศาสตร์อื่นได้ มหาวิทยาลัยแห่งชาติเกาหลีไล่เขาออก หวัง วู ซุก ถูกอายัดทรัพย์และสอบสวนเงินทุนวิจัย ตำแหน่งเกียรติยศทุกตำแหน่ง รวมทั้งใบอนุญาตการวิจัยถูกถอดถอนทั้งหมด ความรักความหวังที่มีต่ออดีตศาสตราจารย์ประจำมหาวิทยาลัยแห่งชาติเกาหลีใต้ ผู้รุ่งโรจน์ถล่มทลายลงบัดเดี๋ยวนั้น

“การทำผิดจริยธรรมของนักวิจัยเป็นเรื่องใหญ่ของสังคม สิ่งที่ หวัง วู ซุก กระทำลงไป ไม่ว่าจะเพราะอยากดัง หรืออยากได้ชื่อเสียงผลประโยชน์ หรือแม้ทำไปเพราะถูกกดดัน ไม่ว่าจะด้วยเหตุใดการกระทำของเขาไม่มีข้อแก้ตัว” นพ.สมศักดิ์ ชุณหรัศมิ์ เลขาธิการมูลนิธิสาธารณสุขแห่งชาติ กล่าว

เรื่องจริงยิ่งกว่า Sci-Fi

“คนเก่งที่โลกไม่ต้องการ” เป็นชื่อนิยายวิทยาศาสตร์ (Sci-Fi) เรื่องหนึ่งที่เขียนไว้ตั้งแต่ปี 2532 ของนักวิทยาศาสตร์และนักเขียน ดร.ชัยวัฒน์ คุประตกุล โดยเป็นเรื่องของนักวิทยาศาสตร์ผู้มองมุมเดียว และค้นคว้าสิ่งประดิษฐ์ที่โลกไม่ต้องการ เรื่องราวของ หวัง วู ซุก แม้จะไม่เหมือนกันเสียทีเดียว แต่ก็สะท้อนให้เห็นการมองมุมเดียวของนักวิทยาศาสตร์ ที่มุ่งแต่จะเอาชนะความท้าทายแห่งองค์ความรู้ มองแต่ในแง่

ความก้าวหน้าทางวิทยาการ จนบกพร่องด้านศีลธรรมและจริยธรรมที่พึงควร

จะเปิดกว้างองศาการมอง ต้องฟังสามัญสำนึกแห่งตัวร่วมกับคนในสังคม เส้นแบ่งของจริยธรรมเกี่ยวกับการค้นคว้าวิจัยสิ่งใหม่ควรทำได้แค่ไหนอย่างไร ต้องช่วยกันคิดขีดตรวจสอบ ก่อนที่ผลผลิตแห่งนักวิทยาศาสตร์โลกอนาคตอย่าง The Island หรือ “คนเก่งที่โลกไม่ต้องการ” จะกลายเป็นเรื่องจริง (ที่จะโหดและเหลือเชื่อกว่าในนิยายเยอะ!!)

ที่มา เรื่องอื้อฉาวลวงโลก บาปของนักวิทยาศาสตร์จรรยาบรรณบกพร่อง :, ARTgazine Articles:บทความทั่วไป. สืบค้นเมื่อ 9 สิงหาคม 2552 จาก http://www.artgazine.com/shoutouts/viewtopic.php?t=2455

“Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and trustful in all aspects of the research process.”

การบ้าน

เรื่อง โครงสร้างอะตอม (2 คะแนน)

ให้นักเรียนสืบค้นข้อมูลเพื่อตอบคำถามต่อไปนี้ โดยระบุที่มาของเอกสาร/แหล่งอ้างอิงด้วย (ถ้ามี)

ชื่อ-นามสกุล ..... ม. 4/7 เลขที่ .....

1. Why does the electron have to move around the nucleus? Why does it not lose energy moving around it?

2. Do electrons ever "fall" into the nucleus of an atom?

“นักวิทยาศาสตร์ไม่ควรสร้างข้อมูล (fabricate) แก้ไขข้อมูล (falsify) หรือนำเสนอข้อมูลหรือผลการทดลองที่ไม่ตรงตามจริง (misrepresent) อีกทั้งควรเป็นคนที่ตัดสินใจบนพื้นฐานของข้อเท็จจริง (objective) ไม่ลำเอียง (unbiased) เป็นที่น่าไว้วางใจ (trustful) ในทุกแง่มุมของกระบวนการวิจัย”

"Credit should be given where credit is due but not where it is not due"

ตัวอย่างการเขียนอ้างอิง

Plagiarism คืออะไร

เรื่องนี้กำลังเป็นเรื่องใหญ่ที่ทุกคนกล่าวขวัญถึง โดยเฉพาะบรรดานักวิชาการ นักวิจัย และนักศึกษาที่ต้องเขียนวิทยานิพนธ์ ...Plagiarism คือ การคัดลอกผลงานหรือขโมยความคิดของคนอื่นโดยไม่อ้างอิงให้ถูกต้อง บางคนเรียกว่า "โจรกรรมทางวิชาการ" หรือ "โจรกรรมทางวรรณกรรม"แต่จะว่าไป สมัยนี้การเขียนบทความทางออนไลน์ ทำให้การ "ตัดแปะ-" (cut & paste) ทำได้ง่ายมาก เด็กนักเรียนบ้านเราก็ชอบมาก ที่จะค้น google แล้ว ตัด แปะ ข้อมูลที่ได้จาก-wikipedia เพื่อทำการบ้านส่งครู ...

เรื่อง Plagiarism ถือเป็นจริยธรรมในการวิจัยที่สำคัญอย่างหนึ่ง และเมื่อเทคโนโลยีเอื้ออำนวย มีการสร้างโปรแกรมประเภท "Digital Detective" ขึ้น จึงทำให้การตรวจจับทำได้ง่ายขึ้นกว่าสมัยก่อนมาก และเป็นประโยชน์อย่างยิ่งต่อบรรดาบรรณาธิการวารสาร ที่จะใช้เป็นเครื่องมือตรวจความซ้ำซ้อนของเนื้อหาบทความ ก่อนรับลงตีพิมพ์ ...

Plagiarism โจรกรรมทางวิชาการ ห้องสมุดสตางค์ มงคลสุข คณะวิทยาศาสตร์ มหาวิทยาลัยมหิดล. [ออนไลน์]. เข้าถึงได้จาก : http://stanglibrary.wordpress.com/tag/plagiarism/.(วันที่ค้นข้อมูล : 15 มิถุนายน 2552).

Cite this page: "Online Ethics Home" Online Ethics Center for Engineering 10/10/2002 2:59:06 PM National Academy of Engineering Accessed: Monday, June 15, 2009 <www.onlineethics.org/>

"ความเชื่อถือ (Credit) ควรจะมอบให้กับผู้ที่ได้ลงมือปฏิบัติงานนั้นจริงเป็นผลสำเร็จ

Appendix E

ภาพบรรยากาศทางจริยธรรมในชั้นเรียนและโต๊ะทำงานผู้วิจัย


SEPTEMBER 2009
Max Planck


Ethics in Science


Ethics in Science
If we stop animal research, who'll stop the real killers!


It's the animals you don't see that really helped her recover.

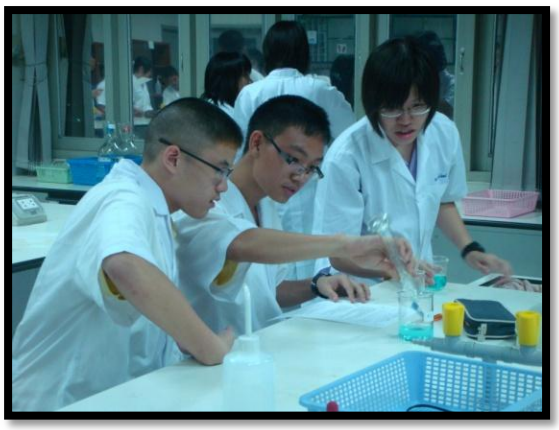

United, we thank research!
and the heroes behind it who...
www.DryErase.com

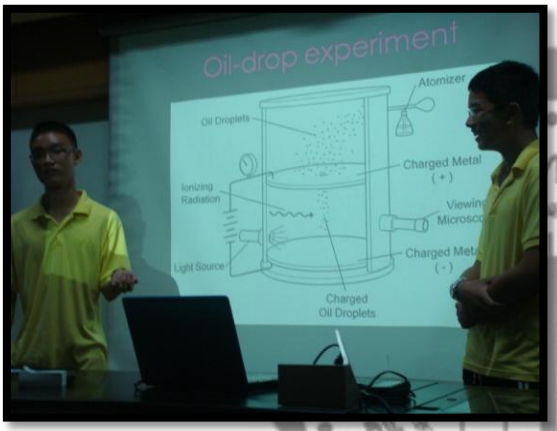
Appendix F

ภาพกิจกรรมต่างๆของนักเรียนในห้องเรียน

ภาพกิจกรรมนอกห้องเรียน (การวาดภาพสัตว์ทดลอง ครั้งที่ 3)


ประเด็นต่างๆ ที่ต้องการศึกษา




Oil-drop experiment
Atomizer
Oil Droplets
Charged Metal
(+)
Ionizing
Radiation
Light Source
Charged
Oil Droplets


Ku-86
Pb-208
Fusion
Compound
Nucleus
Element
118


Jan

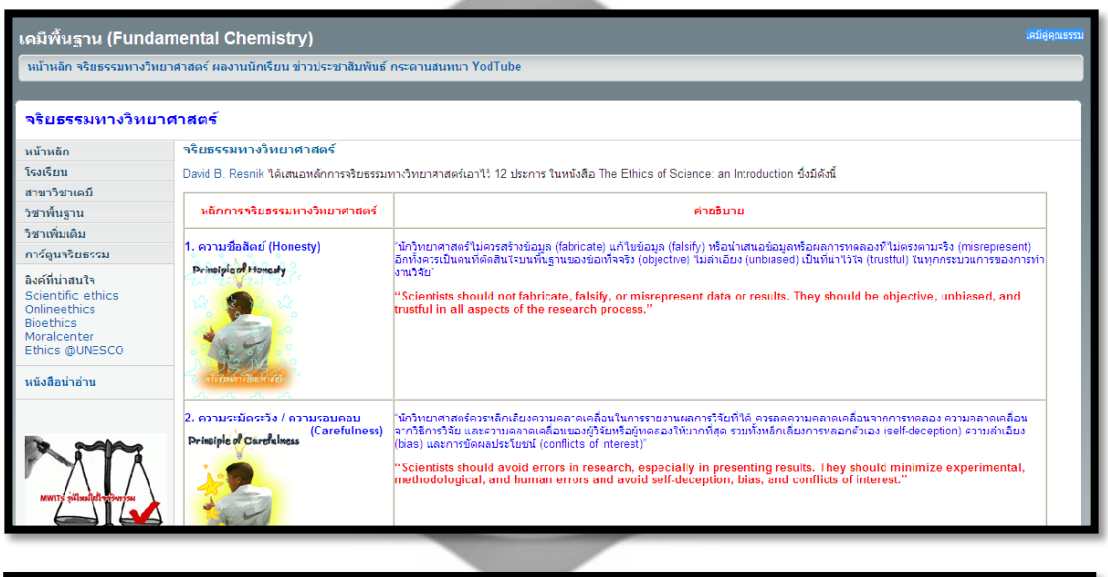

การประกวดผลงานเพื่อพัฒนาการสัตว์ทดลอง
ครั้งที่3
สัตว์ทดลองเพื่อการพัฒนาคุณภาพชีวิตของมนุษย์และสัตว์
26 กันยายน 2552


การประกวดผลงานเพื่อพัฒนาการสัตว์ทดลอง
ครั้งที่3
สัตว์ทดลองเพื่อการพัฒนาคุณภาพชีวิตของมนุษย์และสัตว์
26 กันยายน 2552

Appendix G

ตัวอย่างภาพเว็บไซต์ประกอบการเรียนรู้ เคมีคู่คุณธรรม

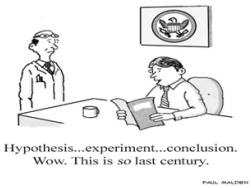

โรงเรียนมหิดลวิทยานุสรณ์ (องค์การมหาชน)
เคมีคู่คุณธรรม
CHEM OXFORD
CHEM HARVARD
YodTube
โรงเรียน
สาขาวิชา
รายวิชาพื้นฐาน
รายวิชาเพิ่มเติม
ภาระงาน
ประวัติ
หนังสือน่าอ่าน
ข่าวประชาสัมพันธ์
Ethics of the Day
"Scientists should share data, results, methods, ideas, techniques, and tools. They should allow other scientists to review their work and be open to criticism and new ideas."
Principle of Openness
สวัสดีครับ


เคมีพื้นฐาน (Fundamental Chemistry)
เคมีคู่คุณธรรม
หน้าหลัก จริยธรรมทางวิทยาศาสตร์ ผลงานนักเรียน ข่าวประชาสัมพันธ์ กระดานสนทนา YodTube
จริยธรรมทางวิทยาศาสตร์
หน้าหลัก
โรงเรียน
สาขาวิชาเคมี
วิชาพื้นฐาน
วิชาเพิ่มเติม
การ์ตูนจริยธรรม
สิ่งที่น่าสนใจ
Scientific ethics
Onlineethics
Bioethics
Moralcenter
Ethics @UNESCO
หนังสือน่าอ่าน
David B. Resnik ได้เสนอหลักการจริยธรรมทางวิทยาศาสตร์เอาไว้ 12 ประการ ในหนังสือ The Ethics of Science: an Introduction ซึ่งมีดังนี้
หลักการจริยธรรมทางวิทยาศาสตร์
คำอธิบาย
1. ความซื่อสัตย์ (Honesty)
Principle of Honesty
นักวิทยาศาสตร์ไม่ควรสร้างข้อมูล (fabricate) แก้ไขข้อมูล (falsify) หรือนำเสนอข้อมูลหรือผลการทดลองที่ไม่ตรงตามจริง (misrepresent) อีกทั้งควรเป็นคนที่ตัดสินใจบนพื้นฐานของข้อเท็จจริง (objective) ไม่ลำเอียง (unbiased) เป็นที่น่าไว้ใจ (trustful) ในทุกกระบวนการของการทำงานวิจัย
"Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and trustful in all aspects of the research process."
2. ความระมัดระวัง / ความรอบคอบ (Carefulness)
Principle of Carefulness
นักวิทยาศาสตร์ควรหลีกเลี่ยงความคลาดเคลื่อนในการรายงานผลการวิจัยที่ได้ ควรลดความคลาดเคลื่อนจากการทดลอง ความคลาดเคลื่อนจากวิธีการวิจัย และความคลาดเคลื่อนของผู้วิจัยหรือผู้ทดลองให้มากที่สุด รวมทั้งหลีกเลี่ยงการหลอกตัวเอง (self-deception) ความลำเอียง (bias) และการขัดผลประโยชน์ (conflicts of interest)"
"Scientists should avoid errors in research, especially in presenting results. They should minimize experimental, methodological, and human errors and avoid self-deception, bias, and conflicts of interest."


บทความทางจริยธรรม
- What is Ethics in Research & Why is It Important?
- Philosophical Foundations of Scientific Ethics
- เปิดพรมแดนวิทยาศาสตร์ สู่พรมแดนแห่งจริยศาสตร์
- จริยธรรมทางวิทยาศาสตร์...ศ.ดร.ยงยุทธ ยุทธวงศ์
- จรรยาบรรณนักวิจัย
งานวิจัยทางจริยธรรม
- Motivatinal Perspectives on Students' Cheating ...
- Students' Perceptions of Academic Dishonesty ...
- Teachers' Practices in and Attitudes Toward Teaching Ethics ...
ข่าวจริยธรรมทางวิทยาศาสตร์
ครูได้รวบรวมข่าวต่างๆที่เกี่ยวข้องกับจริยธรรมทางวิทยาศาสตร์มาให้นักเรียนที่สนใจได้ลองอ่าน ลองศึกษากันดูนะครับ แล้วจะหามาเพิ่มให้อีกแน่นอนครับ
การประพฤติผิดหลักจริยธรรม : หวาง วู ซก
- Dr. Hwang Dropped from Scientific American 50 for Faking Research
- Researcher Faked Evidence of Human Cloning, Koreans Report
- 10 Questions For Dr. Hwang Woo Suk
- S Korea scientist on fraud charge
การใช้สัตว์ทดลอง
- พระราชบัญญัติสัตว์ทดลองไม่คืบ คิดนิยาม "สัตว์"
- ผู้เชี่ยวชาญยังกุญแจเผยใช้ "สัตว์ทดลอง" แต่น้อย มีคุณภาพว่าใช้พร่ำเพรื่อ
- สุราษฎร์ธานีกำเนิดสัตว์ทดลอง
- ตั้งเป้าสร้างมาตรฐานสัตว์ทดลองไทยใน 5 ปี หลังเพื่อนบ้านแซงหลายโค้ง
- ระดมสมองนักวิจัย-ใช้สัตว์ทดลองให้ได้มาตรฐาน
- How do scientists turn genes on and off in living animals?
- Saving Animals and People
ประเด็นจริยธรรม/ทางวิทยาศาสตร์
- Bioethics: Human-animal hybrid embryos
- The Science of Getting It Wrong: How to Deal with False Research Findings
- An Unethical Ethicist?
- Government Fails to Assess Potential Dangers of Nanotechnology
- Breaking Through Editorial: Ethics in the Cold Fusion Controversy
- Water: the Ethics of Efficiency
- Who Gets Credit?
- Bisphenol A
- เครียด หลุมดำ สาวอินเดีย ฆ่าตัวหนีโลกดับ
- CERN ทดลอง LHC หาจุดกำเนิดจักรวาล
- นาโนมาร์ค
- หญิงหม้ายฟ้องวิคตอเรีย'ส ซีเคร็ต ชนิยายโฮเดีย"ยกทรง"ปริมซ่อนสาย
การเรียนรู้จริยธรรมทางวิทยาศาสตร์
- Should schools be teaching science ethics?
ที่มา: http://www.claybennett.com/pages/lab.html

การ์ตูนจริยธรรมทางวิทยาศาสตร์

หน้าหลัก
โรงเรียน
สาขาวิชาเคมี
วิชาพื้นฐาน
วิชาเพิ่มเติม
การ์ตูนจริยธรรม
ลิงค์ที่น่าสนใจ
Scientific ethics
Onlineethics
Bioethics
Moralcenter
Ethics @UNESCO
หนังสือน่าอ่าน



ภาพการ์ตูนที่ครูนำมาทั้งหมดนี้มาจาก http://www.ucsusa.org/scientific_integrity/science_idol/ เพื่อให้นักเรียนได้ตระหนักถึงจริยธรรมทางด้านวิทยาศาสตร์ของนักวิทยาศาสตร์ที่อาจจะเกี่ยวข้องหรือถูกแทรกแซงจากปัจจัยต่างๆ อย่างเช่น การเมือง (ในภาพการ์ตูนทั้งหมด) การทหาร ศาสนา เป็นต้น

นักเรียนคนใดสนใจวาดภาพการ์ตูนเกี่ยวกับจริยธรรมทางวิทยาศาสตร์และต้องการแบ่งปันให้คนอื่นๆ วาดแล้วส่งมาได้นะครับที่ washi15@mwit.ac.th

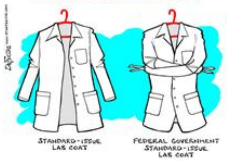
ครูมีเว็บไซต์ภาพการ์ตูนของนักวาดภาพการ์ตูนที่น่าสนใจอย่างเช่น Clay Bennett แวะชมได้ที่ http://www.claybennette.com และผลงานการ์ตูนชิ้นใหม่ๆ ที่ http://www.timesfreepress.com ครับ มีอะไรสงสัยหรือสนใจเกี่ยวกับการวาดภาพการ์ตูน ก็ลองส่งอี-เมล์ ไปคุยกับเขาดูนะครับ

ตัวอย่างภาพการ์ตูนจริยธรรมทางวิทยาศาสตร์จาก Science Idol: The Scientific Integrity Editorial Cartoon Contest

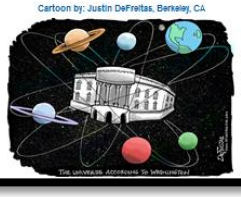
Cartoon by: Paul Malden, Malden, MA

Cartoon by: Eli Zigas, Alexandria, VA, and Kevin Cannon, Minneapolis, MN

Cartoon by: Justin DeFreitas, Berkeley, CA



Cartoon by: Justin DeFreitas, Berkeley, CA



เคมีพื้นฐาน (Fundamental Chemistry) เคมีคู่คุณธรรม
หน้าหลัก จริยธรรมทางวิทยาศาสตร์ ผลงานนักเรียน ข่าวประชาสัมพันธ์ กระดานสนทนา YodTube

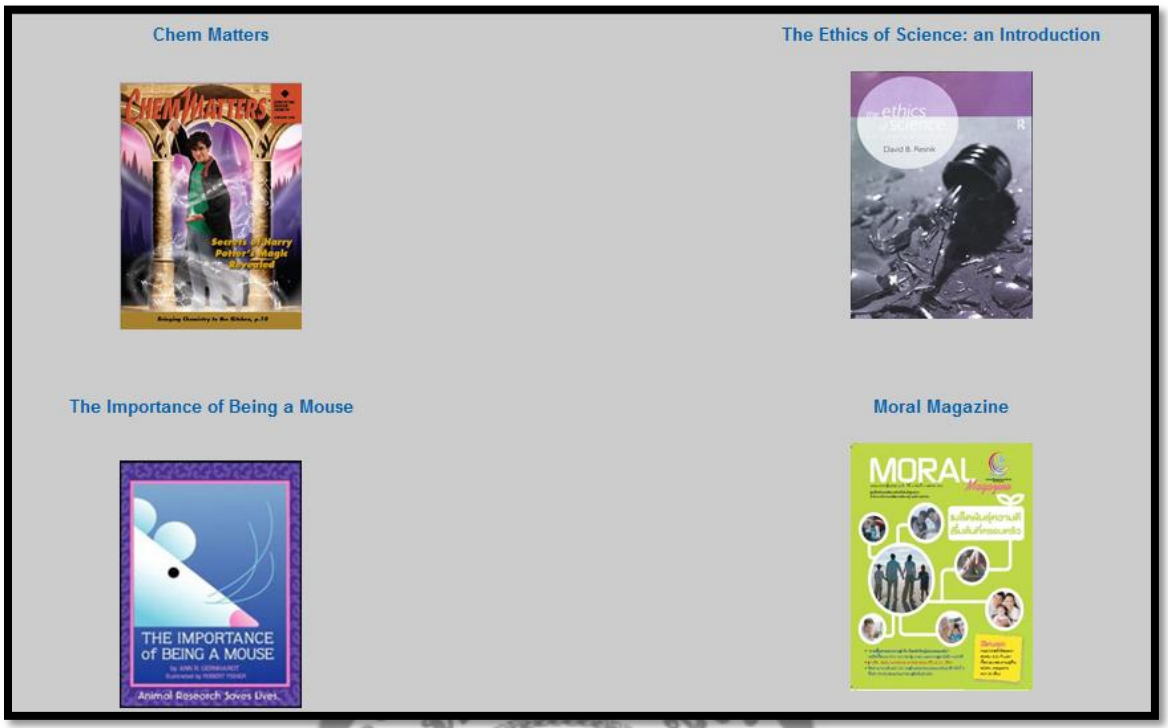
หนังสือน่าอ่าน

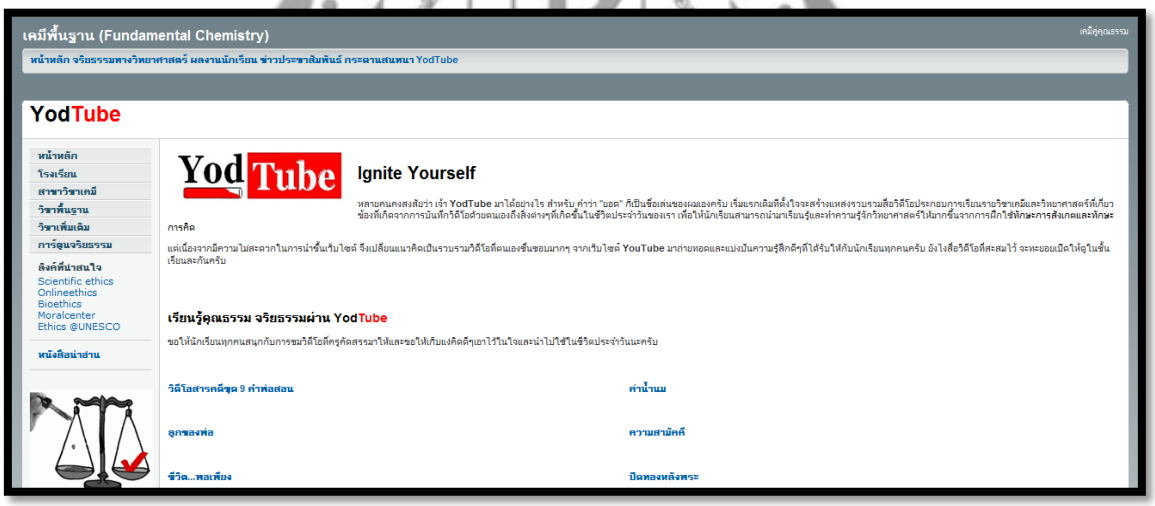
หน้าหลัก
โรงเรียน
สาขาวิชาเคมี
วิชาพื้นฐาน
วิชาเพิ่มเติม
การ์ตูนจริยธรรม
ลิงค์ที่น่าสนใจ
Scientific ethics
Onlineethics
Bioethics
Moralcenter
Ethics @UNESCO
หนังสือน่าอ่าน

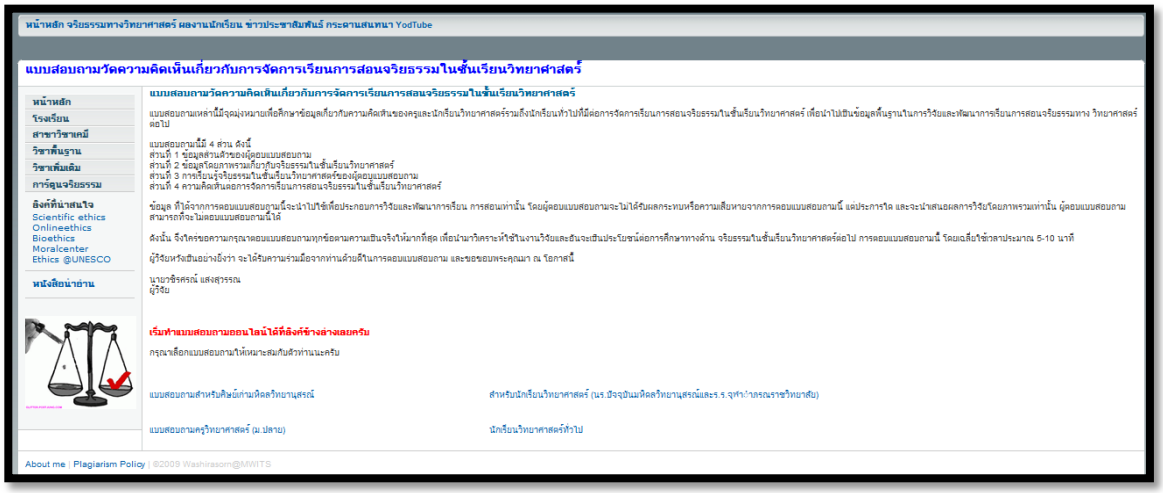
หนังสือที่ครูแนะนำให้อ่านเหล่านี้เป็นเพียงส่วนหนึ่งเท่านั้นของหนังสือดีๆที่ครูได้อ่านและอยากจะแบ่งปันประสบการณ์ดีๆให้นักเรียนได้อ่านบ้าง ยังไงมีเวลาก็ลองหาที่ห้องสมุดมาอ่านดูนะครับ หรือใครจะมายืมที่ครู ก็ยินดีเป็นอย่างยิ่งครับ

ที่มา: http://www.claybennett.com/pages/poli_sci.html

ตัวอย่างหนังสือที่แนะนำให้อ่านครับ


Chem Matters
The Ethics of Science: an Introduction
The Importance of Being a Mouse
Moral Magazine
THE IMPORTANCE of BEING A MOUSE
Animal Research Saves Lives.
MORAL Magazine


เคมีพื้นฐาน (Fundamental Chemistry)
หน้าหลัก จริยธรรมทางวิทยาศาสตร์ ผลงานนักเรียน ข่าวประชาสัมพันธ์ กระดานสนทนา YodTube
YodTube
หน้าหลัก
โรงเรียน
สาขาวิชาเคมี
วิชาพื้นฐาน
วิชาเพิ่มเติม
การ์ตูนจริยธรรม
สิ่งที่น่าสนใจ
Scientific ethics
Onlineethics
Bioethics
Moralcenter
Ethics @UNESCO
หนังสือน่าอ่าน
Ignite Yourself
เรียนรู้คุณธรรม จริยธรรมผ่าน YodTube
วิดีโอสารคดีชุด 9 คำพ่อสอน
ลูกของพ่อ
ชีวิต...พอเพียง
ค่าน้ำนม
ความสามัคคี
ปิดทองหลังพระ


หน้าหลัก จริยธรรมทางวิทยาศาสตร์ ผลงานนักเรียน ข่าวประชาสัมพันธ์ กระดานสนทนา YodTube
แบบสอบถามวัดความคิดเห็นเกี่ยวกับการจัดการเรียนการสอนจริยธรรมในชั้นเรียนวิทยาศาสตร์
หน้าหลัก
โรงเรียน
สาขาวิชาเคมี
วิชาพื้นฐาน
วิชาเพิ่มเติม
การ์ตูนจริยธรรม
สิ่งที่น่าสนใจ
Scientific ethics
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หนังสือน่าอ่าน
แบบสอบถามวัดความคิดเห็นเกี่ยวกับการจัดการเรียนการสอนจริยธรรมในชั้นเรียนวิทยาศาสตร์
แบบสอบถามนี้มี 4 ส่วน คือ
ส่วนที่ 1 ข้อมูลส่วนตัวของผู้ตอบแบบสอบถาม
ส่วนที่ 2 ข้อมูลโดยทั่วไปเกี่ยวกับจริยธรรมในชั้นเรียนวิทยาศาสตร์
ส่วนที่ 3 การเรียนรู้จริยธรรมในชั้นเรียนวิทยาศาสตร์ของผู้ตอบแบบสอบถาม
ส่วนที่ 4 ความคิดเห็นต่อการจัดการเรียนการสอนจริยธรรมในชั้นเรียนวิทยาศาสตร์
ข้อมูล ที่ได้จากการตอบแบบสอบถามนี้จะนำไปใช้เพื่อประกอบการวิจัยและพัฒนาการเรียน การสอนเท่านั้น โดยผู้ตอบแบบสอบถามจะไม่ได้รับผลกระทบหรือความเสียหายจากการตอบแบบสอบถามนี้ แต่ประการใด และจะนำผลผลการวิจัยโดยภาพรวมเท่านั้น ผู้ตอบแบบสอบถามสามารถที่จะไม่ตอบแบบสอบถามนี้ได้
ดังนั้น จึงใคร่ขอความกรุณาตอบแบบสอบถามทุกข้อตามความเป็นจริงให้มากที่สุด เพื่อนำมาวิเคราะห์ใช้ในงานวิจัยและยินจะเป็นประโยชน์ต่อการศึกษาทางด้าน จริยธรรมในชั้นเรียนวิทยาศาสตร์ต่อไป การตอบแบบสอบถามนี้ โดยเฉลี่ยใช้เวลาประมาณ 5-10 นาที
ผู้วิจัยหวังเป็นอย่างยิ่งว่า จะได้รับความร่วมมือจากท่านด้วยดีในการตอบแบบสอบถาม และขอขอบพระคุณมา ณ โอกาสนี้
นายวชิรศรณ์ แสงสุวรรณ
ผู้วิจัย
เริ่มทำแบบสอบถามออนไลน์ได้ที่ลิงค์ข้างล่างเลยครับ
กรุณาคลิกแบบสอบถามให้เหมาะสมกับตัวท่านนะครับ
แบบสอบถามสำหรับนักเรียนวิทยาศาสตร์ (ม.ปลาย)
สำหรับนักเรียนวิทยาศาสตร์ (นร. ปัจจุบันและศิลปวิทยานุสรณ์และร.ร.จุฬาภรณราชวิทยาลัย)
แบบสอบถามครูวิทยาศาสตร์ (ม.ปลาย)
นักเรียนวิทยาศาสตร์ทั่วไป
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Appendix H

ตัวอย่างแบบฝึกหัดและบทปฏิบัติการ

“Scientists should not fabricate, falsify, or misrepresent data or results.
They should be objective, unbiased, and trustful in all aspects of the research process.”

แบบฝึกหัด เรื่อง แรงยึดเหนี่ยวระหว่างโมเลกุลโคเวเลนต์

ชื่อ-นามสกุล ..... เลขที่ ..... ห้อง ม. 4/1

1. จงบอกชนิดของแรงยึดเหนี่ยวระหว่างโมเลกุลที่สำคัญของสารที่กำหนดให้ต่อไปนี้

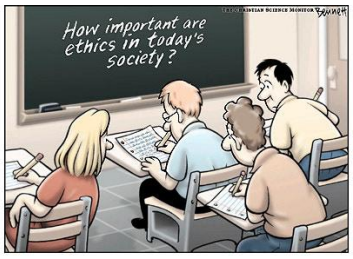
สาร	แรงยึดเหนี่ยวระหว่างโมเลกุล
มีเทน (CH_4)	
ไฮโดรเจนซัลไฟด์ (H_2S)	
กรดไฮโดรคลอริก (HCl)	
น้ำแข็งแห้ง (CO_2)	
กรดแอซีติก (CH_3COOH)	

2. SiH_4 มีมวลโมเลกุลสูงกว่า NH_3 แต่มีจุดเดือดต่ำกว่า เพราะเหตุใด

3. กำหนดตารางแสดงจุดหลอมเหลวและจุดเดือดของสารดังนี้

สาร	จุดหลอมเหลว (°C)	จุดเดือด (°C)
เอทานอล (CH_3CH_2OH)	-114.1	78.3
เมทอกซีมีเทน (CH_3OCH_3)	-138.5	-23.0

สารใดน่าจะมีพันธะไฮโดรเจนยึดเหนี่ยวระหว่างโมเลกุล เพราะเหตุใด



http://www.claybennett.com/images/archivetoons/ethics.jpg

"Scientists should use resources efficiently."

การทดลอง เรื่อง การเกิดปฏิกิริยาของสารประกอบไอออนิก

จุดประสงค์

……

……

……

ชื่อสมาชิกในกลุ่ม

1. …… เลขที่ ..... ห้อง ม. 4/7
2. …… เลขที่ ..... ห้อง ม. 4/7
3. …… เลขที่ ..... ห้อง ม. 4/7

วันที่ทำการทดลอง ……

วิธีทดลอง

1. เลือกสารละลายต่อไปนี้ $Ca(OH)_2$, Na_2SO_4 หรือ KI มา 1 ชนิด ใส่ลงในหลอดทดลองขนาดเล็ก 3 หลอดๆ ละ 1 cm^3
2. เติมสารละลาย Na_2CO_3 NH_4Cl และ $Pb(NO_3)_2$ อย่างละ 1 cm^3 ลงในหลอดที่ 1 2 และ 3 หลอดละชนิด ตามลำดับ สังเกตการเปลี่ยนแปลง และบันทึกผล

ผลการทดลอง

"Scientists should use resources efficiently."

สรุปและอภิปรายผลการทดลอง

คำถามหลังการทดลอง

1. สารละลายที่ผสมกัน คู่ใดบ้างที่เกิดปฏิกิริยาเคมี ทราบได้อย่างไร

2. สมการแสดงปฏิกิริยาที่เกิดขึ้นเป็นอย่างไร

Appendix I

ตัวอย่างสไลด์จริยธรรมก่อนเรียน คำคมทางจริยธรรมและผลงานคำคมทางจริยธรรมของนักเรียน

โรงเรียนมหิดลวิทยานุสรณ์

2008 in Photos--10 Biggest Science Stories

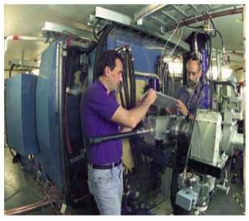
FOOD CRISIS

http://www.sciam.com/slideshow.cfm?id=10-science-stories-2008&thumbs=horizontal&photo_id=2639DC88-BA23-E028-C3B29AAA0A55282F

Ethics of Efficiency

"Scientists should use resources efficiently."

โรงเรียนมหิดลวิทยานุสรณ์



http://www.artgazine.com/shoutouts/viewtopic.php?t=2455

Ethics of Honesty

"Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and trustful in all aspects of the research process."

โรงเรียนมหิดลวิทยานุสรณ์

Dr. Hwang Dropped from Scientific American 50 for Faking Research

http://www.artgazine.com/shoutouts/viewtopic.php?t=2455

Ethics of Legality

"In the process of research, scientists should obey the laws pertaining to their work."

โรงเรียนมหิดลวิทยานุสรณ์

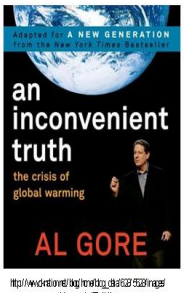
http://yirmumah.com/tag/issac-newton/

http://csmh.pbworks.com/1687+-+Sir+Isaac+Newton

Ethics of Credit

"Credit should be given where credit is due but not where it is not due."

โรงเรียนมหิดลวิทยานุสรณ์



Ethics of Education

"Scientists should educate prospective scientists and insure that they learn how to conduct good science. Scientists should educate and inform the public about science."

คำคมทางจริยธรรม (Ethics Quote)

“ความคิดของคนเปรียบเสมือนดิน ซึ่งถือเป็นพื้นฐานด้านๆ
แต่ความคิดที่มีจริยธรรม เปรียบเสมือนดิน ซึ่งกำเนิดชีวิตได้”

เตชิต ตริตระการ ม.5/5

คำคมทางจริยธรรม (Ethics Quote)

“ความดีทำให้คนมีคุณค่า
ปัญญาทำให้คนเจริญก้าวหน้าต่อไป”

ฉิณณภัค แก้วภักดี ม. ๕/๓

คำคมทางจริยธรรม (Ethics Quote)

“การสอนคนให้มีความรู้เชี่ยวชาญพิเศษอย่างเดียวไม่พอ ถ้าทำเช่นนั้น คนจะกลายเป็นเครื่องจักรที่มีประโยชน์ชนิดหนึ่ง แต่ไม่เป็นบุคลิกภาพที่ได้รับการพัฒนาอย่างประสานกลมกลืน คนที่มีแต่ความรู้ที่เชี่ยวชาญพิเศษ จะคล้ายกับสุนัขที่ฝึกดีแล้วมากกว่าจะเป็นบุคคลเต็มคน”

ไอน์สไตน์

คำคมทางจริยธรรม (Ethics Quote)

“การศึกษาอบรมทุกอย่าง ถ้าปราศจากการฝึกอบรมจิตจะไม่มีประโยชน์เลยและอาจเป็นอันตราย”

คานธี

คำคมจริยธรรมทางวิทยาศาสตร์ของนักเรียน

วิทยาศาสตร์ทำให้เรารู้ที่มาของชีวิต แต่จริยธรรมทำให้เรารู้ว่าต้องทำยังไงกับชีวิตที่ได้มา

Science leads us to the origins of life, ethics teaches us how to live life.

จริยธรรมทางวิทยาศาสตร์ ขาดไปคงไร้ซึ่งอนาคต

A future in science without ethics, is no future at all.

หากนักวิทยาศาสตร์เปรียบเหมือนนาฬิกา ถ้าเดินไม่ตรงเวลา ... จะก่อให้เกิดประโยชน์ได้อย่างไร

If scientists are likened to a clock with inaccurate time, … how then can they be useful?

นักวิทยาศาสตร์ต้องมีปณิธานและอุดมการณ์ที่ดี เพราะพวกเขาสามารถเปลี่ยนแปลงโลกได้ด้วยวิทยาศาสตร์ แต่ปกป้องโลกได้ด้วยคุณธรรม

A scientist with good resolution and vision can change the world, a scientist with ethics and morals protects the world.

วิทยาศาสตร์ก้าวหน้า นักวิทยาศาสตร์ก้าวไกล จริยธรรมรักษาไว้ งานวิจัยพัฒนา

Progressive science, visionary scientists, uphold ethics culminate into progressive research.

เหยี่ยวกับแร้ง เหมือนจะคล้ายแต่ก็ต่าง เฉกเช่นเดียวกับคนที่ไร้จริยธรรมกับคนที่มีจริยธรรม

An eagle and a vulture may seem similar, but are different. The same holds true between an ethical and unethical person.

ถ้าวิทยาศาสตร์เปรียบเสมือนต้นไม้ จริยธรรมก็คงเปรียบเสมือนน้ำที่หล่อเลี้ยงให้ต้นไม้เติบโตได้อย่างงดงาม

If science is a tree, ethics is the water that helps it grow beautifully.

ความกตัญญูเป็นเครื่องหมายของคนดีฉันใด จริยธรรมก็เป็นเครื่องหมายของนักวิทยาศาสตร์ที่ดีฉันนั้น

If gratitude symbolizes good people, then ethics symbolizes good scientists.

ถ้าเปรียบความรู้เป็นลำของต้นไม้ที่แข็งแรงแล้ว ย่อมขาดไม่ได้ซึ่งรากที่แข็งแรงและสมบูรณ์กว่าซึ่งนั่นก็คือจริยธรรมนั่นเอง

If knowledge is the trunk of a tree, then ethics is the root of its very strength.

ถ้านักวิทยาศาสตร์เป็นผู้ที่มีชื่อเสียงโดยทำผิดกฎหมาย ก็เหมือนไม่ประสบความสำเร็จในชีวิต

A successful scientist who achieves fame through unjustifiable means is like an unsuccessful person in life.

นักวิทยาศาสตร์ที่มีคุณธรรม เปรียบเหมือนนักรบที่มีอาวุธครบมือ ส่วนนักวิทยาศาสตร์ที่ไร้คุณธรรมนั้นก็เปรียบเหมือนนักรบที่มีอาวุธครบมือได้เช่นกัน แต่เป็นอาวุธที่มีแต่รอยบิ่น รอยร้าว และพร้อมจะแตกเป็นเสี่ยงๆได้ทุกเมื่อ

An ethical scientist is like a warrior with well-equipped weapons. An unethical scientist is also a warrior with weapons, but ones that are chipped and faulty.

เปรียบนักวิทยาศาสตร์เป็นลูกบอลแล้ว นักวิทยาศาสตร์ที่ไร้คุณธรรมก็เปรียบเสมือนลูกบอลที่ไม่มีลม ย่อมเป็นลูกบอลที่ไม่สามารถนำมาใช้การได้ด้วยประสิทธิภาพที่เต็มที่

If a scientist is likened to an inflated ball, an unethical scientist is a deflated ball that has no use.

นักวิทยาศาสตร์ใช่เพียงรู้ถึงทฤษฎีของจริยธรรมทางวิทยาศาสตร์ แต่นักวิทยาศาสตร์ต้องปฏิบัติให้ได้ตามทฤษฎีของจริยธรรมทางวิทยาศาสตร์ จึงจะได้ชื่อว่า เป็นนักวิทยาศาสตร์อย่างแท้จริง

A true scientist not only understands the theory of ethics, but practices it.

นักวิทยาศาสตร์ที่มีคุณธรรม เปรียบเสมือนแพทย์ที่มีเครื่องมือพร้อมรักษาคนไข้ ส่วน นักวิทยาศาสตร์ที่ไร้คุณธรรม เปรียบเสมือนแพทย์ที่ไร้อุปกรณ์ในการรักษา ถึงแม้จะมีความรู้มากเพียงใด ก็ไม่สามารถรักษาคนไข้ได้

Scientists that uphold ethics are like physicians with tools to cure patients. Unethical scientists are like ill-equipped physicians with knowledge, but no curing skills.

“คำอธิษฐาน” เมื่อได้เกิดมาแล้ว ขออย่าให้ข้าพเจ้าลำบากยากจน หากข้าพเจ้าลำบากยากจน ขออย่าให้ข้าพเจ้าไร้ซึ่งคุณธรรม หากข้าพเจ้าไร้ซึ่งคุณธรรม ขออย่าให้ข้าพเจ้าเป็นคนอกตัญญู หากข้าพเจ้าอกตัญญูเสียแล้ว ขออย่าให้ข้าพเจ้าได้เกิดมาเลย”

“Words of Blessings” Now that I am in this world, pray not let me be poor. If I am poor, pray not let me be unethical. If I am unethical, pray not let me be ungrateful. If I am ungrateful, pray not that I am not born into this world.

แม่พิมพ์คือสิ่งที่หล่อหลอมวัตถุ คุณธรรมคือสิ่งที่หล่อหลอมจิตใจ

If a mold shapes materials, then morality shapes the mind.

จริยธรรมทางวิทยาศาสตร์ อย่าให้ขาดไปในชีวิต ทำอะไรควรหมั่นรู้จักคิด ไม่ทำผิดสุขสมสบายใจ

Do not let science be unethical, think wisely and do no wrong, then happiness follows.

Scientists without ethics are not true scientists. (นักเรียนเขียนมาเป็นภาษาอังกฤษ)

คุณธรรมเปรียบเสมือนหางเสือ ที่ควบคุมหัวเรือของประเทศชาติ

Morality is like an anchor that steers a country ahead.

เราต้องเชื่อในสิ่งที่พิสูจน์ได้ แต่การพิสูจน์นั้นต้องไม่ผิดจริยธรรม

We must believe in what we can prove, but the proven must not be unethical.

วิทยาศาสตร์เปรียบดังหลอดไฟ ถ้าใช้มันผิดวิธี คุณจะมองเห็นแต่ความมืดมิด แต่เมื่อใดที่คุณทำให้มันสว่างขึ้นในความมืด มันจะให้ประโยชน์แก่คุณมหาศาล

Science is like a light bulb, if wrongly used, you will only see darkness. Only when you can make brightness out of darkness, you can fully reap the benefits.

จงวิจัยให้อยู่ในหลักของความดีงาม

Do goodness - based research.

ศาสตร์ทุกศาสตร์ย่อมสะอาดด้วยหลักความดี

All disciplines originate from the purity of goodness.

Appendix J

ตัวอย่างการหาคุณภาพเครื่องมือ

TABLE 15 ITEM-OBJECTIVE CONGRUENCE OF SURVEY OF SCIENCE TEACHERS AND STUDENTS' OPINIONS ON LEARNING ETHICS IN SCIENCE

TEACHERS		STUDENTS	
Items	IOC	Items	IOC
Part A	1.00	Part A	1.00
Part B		Part B	
1	1.00	1	1.00
2	1.00	2	1.00
Part C		3	1.00
1	1.00	4	1.00
2	1.00	Part C	
3	1.00	1	0.67
4	0.67	2	1.00
5	1.00	Part D	
6	1.00	1	1.00
7	1.00	2	1.00
Part D		3	1.00
1	1.00	4	1.00
2	0.67		
3	1.00		
4	1.00		
5	1.00		
6	1.00		
7	1.00		

TABLE 16 ITEM-OBJECTIVE CONGRUENCE OF LESSON PLANS ON TEACHING ETHICS IN SCIENCE

Items	IOC	Items	IOC	Items	IOC
1	1.00	16	1.00	31	0.67
2	1.00	17	0.67	32	1.00
3	0.67	18	1.00	33	1.00
4	1.00	19	1.00	34	1.00
5	1.00	20	1.00	35	0.67
6	1.00	21	0.67	36	1.00
7	1.00	22	1.00	37	0.67
8	0.67	23	1.00	38	1.00
9	0.67	24	0.67	39	1.00
10	1.00	25	1.00	40	0.67
11	1.00	26	1.00	41	1.00
12	1.00	27	1.00	42	1.00
13	1.00	28	0.67	43	1.00
14	0.67	29	1.00		
15	0.67	30	1.00		

TABLE 17 ITEM-OBJECTIVE CONGRUENCE OF WEBSITE (CONTENT & PERFORMANCE)

CONTENT		PERFORMANCE	
Items	IOC	Items	IOC
1	0.67	1	0.67
2	0.67	2	0.67
3	1.00	3	1.00
4	1.00	4	1.00
5	0.67	5	0.67
6	1.00	6	1.00
7	1.00	7	0.67
		8	0.67
		9	0.67
		10	1.00

TABLE 18 ITEM-OBJECTIVE CONGRUENCE OF INTERVIEW QUESTIONS

Items	IOC	Items	IOC
1	1.00	6	1.00
2	1.00	7	1.00
3	1.00	8	1.00
4	1.00	9	1.00
5	1.00		

TABLE 19 ITEM-OBJECTIVE CONGRUENCE OF PRE- POST TEST OF UNDERSTANDING OF ETHICS IN SCIENCE

Items	IOC
1	0.67
2	0.67
3	1.00
4	1.00
5	1.00

TABLE 20 ITEM-OBJECTIVE CONGRUENCE OF OPINIONS ON LEARNING ETHICS IN SCIENCE

Items	IOC	Items	IOC
1	1.00	11	0.67
2	1.00	12	1.00
3	1.00	13	1.00
4	1.00	14	1.00
5	0.67	15	1.00
6	1.00	16	1.00
7	1.00	17	1.00
8	1.00		
9	1.00		
10	0.67		

TABLE 21 ITEM-OBJECTIVE CONGRUENCE OF THINKING SKILLS EVALUATION FORM

Items	IOC	Items	IOC
1	1.00	20	1.00
2	1.00	21	1.00
3	1.00	22	1.00
4	1.00	23	1.00
5	1.00	24	1.00
6	0.67	25	1.00
7	1.00	26	1.00
8	1.00	27	1.00
9	1.00	28	0.67
10	1.00	29	1.00
11	0.67	30	1.00
12	1.00	31	1.00
13	1.00	32	1.00
14	1.00	33	1.00
15	1.00	34	0.67
16	0.67	35	1.00
17	1.00	36	1.00
18	1.00	37	1.00
19	1.00	38	1.00

Appendix K

ตัวอย่างผลการเก็บข้อมูล

TABLE 22 THE COMPARATION OF THE DIFFERENCE BETWEEN PRETEST AND POSTTEST OF ETHICS IN SCIENCE

Ethics in Science Achievement (15 scores)			
Number	Pretest (n=24)	Posttest (n=24)	Difference
1	8.0	15.0	+
2	6.5	14.0	+
3	7.5	12.5	+
4	8.0	14.0	+
5	7.5	13.0	+
6	7.5	11.0	+
7	7.0	15.0	+
8	7.0	12.5	+
9	3.5	10.0	+
10	9.0	14.5	+
11	7.0	12.5	+
12	7.0	9.5	+
13	6.0	13.5	+
14	5.5	14.0	+
15	5.0	13.5	+
16	5.5	11.5	+
17	4.5	13.5	+
18	4.0	14.5	+
19	5.0	12.0	+
20	5.5	12.5	+
21	2.0	13.5	+
22	4.0	14.0	+
23	7.0	11.0	+
24	9.5	15.0	+

+ means the difference of achievement posttest is higher than pretest

TABLE 23 THE FREQUENCY OF THE STUDENTS' OPINION ON LEARNING ETHICS IN SCIENCE (BEFORE STUDYING)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
1	I always like studying science in new perspectives.	8	16	-	-	-	4.33	0.48
2	I think that science and ethics are related.	6	13	5	-	-	4.04	0.69
3	I'm interested in and curious about how I will be a good scientist.	4	10	9	1	-	3.71	0.81
4	I understand ethics in science well.	2	11	9	2	-	3.54	0.78
5	I think that study ethics in science would be the basis of becoming a good scientist.	9	11	3	1	-	4.17	0.82
6	I would like to be a good, ethical, and role model scientist to other ones.	6	14	3	1	-	4.04	0.75
7	Study of behaviors and characteristics of ethical scientist is interesting.	1	17	5	1	-	3.75	0.61
8	I think that all science students should study about ethics in science as a basis for studying other science subjects.	8	13	3	-	-	4.21	0.66
9	I think ethics in science is difficult and boring to study.	1	2	9	9	3	2.54	0.98
10	Studying ethics in science helps me open up my point of view on another side of science that I have never known before.	6	9	9	-	-	3.88	0.80

TABLE 23 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
11	Studying ethics in science is useful for me to live my daily life, further education and professional job.	7	13	4	-	-	4.13	0.68
12	Studying ethics in science makes me aware and appreciate in the importance and value of way of life.	4	14	6	-	-	3.92	0.65
13	Studying ethics in science teaches me that I have to make more social responsibility.	7	15	2	-	-	4.21	0.59
14	I'm interested in pursuing my career on ethics in science.	-	9	12	2	1	3.21	0.78
15	Ethics in science is very important for science student, also scientists in different fields of interest.	9	14	1	-	-	4.33	0.56
16	I would like all schools to provide ethics in science in science curriculum.	6	10	7	-	1	3.83	0.96
17	Ethical scientist will help society be prosperous, livable and make everyone live together happily.	17	6	1	-	-	4.67	0.56

TABLE 24 THE FREQUENCY OF THE STUDENTS' OPINION ON LEARNING ETHICS IN SCIENCE (AFTER STUDYING)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
1	I always like studying science in new perspectives.	10	13	1	-	-	4.38	0.58
2	I think that science and ethics are related.	16	6	2	-	-	4.58	0.65
3	I'm interested in and curious about how I will be a good scientist.	12	9	3	-	-	4.38	0.71
4	I understand ethics in science well.	11	10	3	-	-	4.33	0.70
5	I think that study ethics in science would be the basis of becoming a good scientist.	13	11	-	-	-	4.54	0.51
6	I would like to be a good, ethical, and role model scientist to other ones.	12	11	1	-	-	4.46	0.59
7	Study of behaviors and characteristics of ethical scientist is interesting.	11	12	1	-	-	4.42	0.58
8	I think that all science students should study about ethics in science as a basis for studying other science subjects.	16	7	1	-	-	4.63	0.58
9	I think ethics in science is difficult and boring to study.	1	2	2	11	8	2.04	1.08
10	Studying ethics in science helps me open up my point of view on another side of science that I have never known before.	10	10	4	-	-	4.25	0.74

TABLE 24 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
11	Studying ethics in science is useful for me to live my daily life, further education and professional job.	10	13	1	-	-	4.38	0.58
12	Studying ethics in science makes me aware and appreciate in the importance and value of way of life.	12	11	1	-	-	4.46	0.59
13	Studying ethics in science teaches me that I have to make more social responsibility.	10	13	1	-	-	4.38	0.58
14	I'm interested in pursuing my career on ethics in science.	5	9	9	1	-	3.75	0.85
15	Ethics in science is very important for science student, also scientists in different fields of interest.	15	8	1	-	-	4.58	0.58
16	I would like all schools to provide ethics in science in science curriculum.	10	9	5	-	-	4.21	0.78
17	Ethical scientist will help society be prosperous, livable and make everyone live together happily.	16	7	1	-	-	4.63	0.58

TABLE 25 THE FREQUENCY OF THE STUDENTS' PRACTICAL THINKING SKILL ON LEARNING ETHICS IN SCIENCE (BEFORE STUDYING)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
1	Honesty I draw a conclusion and report my result as its real data as obtained from an experiment.	6	15	3	-	-	4.13	0.61
2	I don't fabricate or falsify data from experiment in order to get the expected result.	1	18	4	1	-	3.79	0.59
3	I ask or copy my friends' exams.	-	1	3	8	12	4.29	0.89
	Mean rating for the principle of honesty						**4.07**	0.72
4	Carefulness I conduct an experiment and present results by minimizing experimental and human error.	4	12	8	-	-	3.83	0.70
5	I avoid self-deception and bias in experiments.	5	13	5	1	-	3.92	0.78
	Mean rating for the principle of carefulness						**3.88**	
6	Openness I usually would like to share data, results, methods or ideas with peers.	7	16	-	1	-	4.21	0.66
7	I would like my peers to be able to review my experimental results or science project.	5	15	4	-	-	4.04	0.62

TABLE 25 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
8	I am open to criticism and new ideas on my experimental results or science project.	8	14	2	-	-	4.25	0.61
9	I don't want anybody know important data of my results or science project that I am doing, and not completely finish yet	-	5	9	10	-	3.21	0.78
10	I don't want to perceive new ideas, methods, or peers.	1	2	4	13	4	3.71	1.00
11	I like working cooperatively and trust the others.	4	16	3	1	-	3.96	0.69
	Mean rating for the principle of openness						**3.90**	
12	Freedom I like to be free to conduct research on any problem or hypothesis.	6	13	5	-	-	4.04	0.69
13	I like to be free in doing inquiry in science for my experiment or science project.	7	12	4	1	-	4.04	0.81
14	If I had a freedom in doing an experiment that may harm the others, I would do it.	-	4	2	9	9	3.96	1.08
	Mean rating for the principle of freedom						**4.01**	

TABLE 25 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
15	Credit I put my friend's names who are not involved in the experiments or group work in the report or assignment.	-	14	6	4	-	2.58	0.78
16	I agree on the punishment for students who copy other students' assignment or plagiarize	3	11	7	1	2	3.50	1.06
	Mean rating for the principle of credit						**3.04**	
17	Education I always teach or explain my friend on the topics or experiments they don't understand.	3	15	5	1	-	3.83	0.70
18	I want to make sure that my friends always do the good and proper experiment.	2	12	8	2	-	3.58	0.78
19	If I had a change to educate or give a seminar or workshop in science to community or public, I am willing to do it.	4	15	3	2	-	3.88	0.80
	Mean rating for the principle of education						**3.76**	
20	Social responsibility I will definitely not do any science experiment that harm school or society.	10	13	1	-	-	4.38	0.58

TABLE 25 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
21	I will try to bring scientific knowledge to make best benefit to society.	9	13	2	-	-	4.29	0.62
22	I will take my responsibility on my science experiment or project I have conducted.	6	15	2	1	-	4.08	0.72
23	I will inform public or society knows about the scientific results or findings.	4	14	5	1	-	3.88	0.74
	Mean rating for the principle of social responsibility						**4.16**	
24	Legality I always do my experiments or science project under the code of conduct or related standard.	9	12	2	-	1	4.17	0.92
25	I will conduct an experiment with high get paid regardless of legality.	-	2	5	8	9	4.00	0.98
26	I do not use hazardous and prohibited chemicals, human and animals in experiment if I am not legally allowed.	14	8	1	1	-	4.46	0.78
	Mean rating for the principle of legality						**4.21**	
27	Opportunity I'm not satisfied if It is unfair for me in using resources in doing science experiment or project.	5	11	7	1	-	3.83	0.82

TABLE 25 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
28	I think female scientists should get the equal opportunity as well as male scientists in doing scientific work.	17	6	1	-	-	4.67	0.56
	Mean rating for the principle of opportunity						**4.25**	
29	Mutual respect I don't want my peers to harm me both physically and mentally.	7	15	1	1	-	4.17	0.70
30	I respect the privacy of all group members.	6	14	4	-	-	4.08	0.65
31	I won't get involved in my peers' experiment which can cause danger, if not allowed.	6	17	1	-	-	4.21	0.51
	Mean rating for the principle of mutual respect						**4.15**	
32	Efficiency I always use materials and chemicals in experiments efficiently. (worth, value, and most effective).	5	13	6	-	-	3.96	0.69
33	I will minimize animals in lab and most efficient or I will use other subjects instead of animals if possible.	10	9	4	1	-	4.17	0.87
34	I will use resources that can be reused.	3	15	6	-	-	3.88	0.61
	Mean rating for the principle of efficiency						**4.00**	

TABLE 25 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
35	Respect for subjects I will treat animal subjects with care and respect.	10	12	2	-	-	4.33	0.64
36	I will take good care of animal subjects regarding of their welfare such as enough space place to live, sterile, enough food and water, and no torturing.	8	15	1	-	-	4.29	0.55
37	I don't think animal subjects should be take care much because they eventually will be killed.	-	1	4	8	11	4.21	0.88
38	Subjects have their own rights to stop or withdraw from experiment anytime if they feel that they will be harm or killed.	13	10	1	-	-	4.50	0.59
	Mean rating for the principle of respect for subjects						**4.33**	

TABLE 26 THE FREQUENCY OF THE STUDENTS' PRACTICAL THINKING SKILL ON LEARNING ETHICS IN SCIENCE (AFTER STUDYING)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
1	Honesty I draw a conclusion and report my result as its real data as obtained from an experiment.	7	16	1	-	-	4.25	0.53
2	I don't fabricate or falsify data from experiment in order to get the expected result.	8	9	7	-	-	4.04	0.81
3	I ask or copy my friends' exams.	-	-	2	9	13	4.46	0.66
	Mean rating for the principle of honesty						**4.25**	
4	Carefulness I conduct an experiment and present results by minimizing experimental and human error.	9	10	3	2	-	4.08	0.93
5	I avoid self-deception and bias in experiments.	8	13	2	1	-	4.17	0.76
	Mean rating for the principle of carefulness						**4.13**	
6	Openness I usually would like to share data, results, methods or ideas with peers.	16	8	-	-	-	4.67	0.48
7	I would like my peers to be able to review my experimental results or science project.	14	9	1	-	-	4.54	0.59

TABLE 26 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
8	I am open to criticism and new ideas on my experimental results or science project.	14	9	1	-	-	4.54	0.59
9	I don't want anybody know important data of my results or science project that I am doing, and not completely finish yet	1	6	1	12	4	3.50	1.18
10	I don't want to perceive new ideas, methods, or peers.	-	-	1	9	14	4.54	0.59
11	I like working cooperatively and trust the others.	11	12	1	-	-	4.42	0.58
	Mean rating for the principle of openness						**4.37**	
12	Freedom I like to be free to conduct research on any problem or hypothesis.	10	11	3	-	-	4.29	0.69
13	I like to be free in doing inquiry in science for my experiment or science project.	17	7	-	-	-	4.71	0.46
14	If I had a freedom in doing an experiment that may harm the others, I would do it.	-	-	-	7	17	4.71	0.46
	Mean rating for the principle of freedom						**4.57**	
15	Credit I put my friend's names who are not involved in the experiments or group work in the report or assignment.	9	4	8	2	1	2.25	1.19

TABLE 26 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
16	I agree on the punishment for students who copy other students' assignment or plagiarize	6	10	6	1	1	3.79	1.02
	Mean rating for the principle of credit						**3.02**	
17	Education I always teach or explain my friend on the topics or experiments they don't understand.	12	10	2	-	-	4.42	0.65
18	I want to make sure that my friends always do the good and proper experiment.	13	10	1	-	-	4.50	0.59
19	If you had a change to educate or give a seminar or workshop in science to community or public, I'm willing to do it.	10	11	3	-	-	4.29	0.69
	Mean rating for the principle of education						**4.40**	
20	Social responsibility I will definitely not do any science experiment that harm school or society.	17	7	-	-	-	4.71	0.46
21	I will try to bring scientific knowledge to make best benefit to society.	13	11	-	-	-	4.54	0.51
22	I will take my responsibility on my science experiment or project I have conducted.	14	9	1	-	-	4.54	0.59

TABLE 26 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
23	I will inform public or society knows about the scientific results or findings.	4	19	1	-	-	4.13	0.45
	Mean rating for the principle of social responsibility						**4.48**	
24	Legality I always do my experiments or science project under the code of conduct or related standard.	13	9	2	-	-	4.46	0.66
25	I will conduct an experiment with high get paid regardless of legality.	-	-	1	12	11	4.42	0.58
26	I do not use hazardous and prohibited chemicals, human and animals in experiment if I am not legally allowed.	18	6	-	-	-	4.75	0.44
	Mean rating for the principle of legality						**4.54**	
27	Opportunity I'm not satisfied if It is unfair for me in using resources in doing science experiment or project.	12	4	7	1	-	4.13	0.99
28	I think female scientists should get the equal opportunity as well as male scientists in doing scientific work.	22	2	-	-	-	4.92	0.28
	Mean rating for the principle of opportunity						**4.53**	

TABLE 26 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
29	Mutual respect I don't want my peers to harm me both physically and mentally.	18	6	-	-	-	4.75	0.44
30	I respect the privacy of all group members.	14	10	-	-	-	4.58	0.50
31	I won't get involved in my peers' experiment which can cause danger, if not allowed.	11	11	2	-	-	4.38	0.65
	Mean rating for the principle of mutual respect						**4.57**	
32	Efficiency I always use materials and chemicals in experiments efficiently. (worth, value, and most effective).	3	15	6	-	-	3.88	0.61
33	I will minimize animals in lab and most efficient or I will use other subjects instead of animals if possible.	15	7	2	-	-	4.54	0.66
34	I will use resources that can be reused.	6	17	1	-	-	4.21	0.51
	Mean rating for the principle of efficiency						**4.21**	
35	Respect for subjects I will treat animal subjects with care and respect.	14	10	-	-	-	4.58	0.50
36	I will take good care of animal subjects regarding of their welfare such as enough space place to live, sterile, enough food and water, and no torturing.	15	9	-	-	-	4.63	0.49

TABLE 26 (continued)

No.	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	S.D
37	I don't think animal subjects should be take care much because they eventually will be killed.	-	1	-	5	18	4.67	0.70
38	Subjects have their own rights to stop or withdraw from experiment anytime if they feel that they will be harm or killed.	18	6	-	-	-	4.75	0.44
	Mean rating for the principle of respect for subjects						**4.66**	

VITAE

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