

FROM CLASSROOM TO CRIME SCENE: BRINGING FORENSIC SCIENCE INTO PROJECT WORK

Chow Ban Hoe

River Valley High School (Singapore)

Wong Teck Hee

River Valley High School (Singapore)

ABSTRACT

As the exciting TV serial Crime Scene Investigation (CSI) continues to entice its audience, teachers are capturing its intrigue in the classroom. Forensic Science is a multi-disciplinary field which draws principles from many branches of Science, ranging from biology, chemistry, pathology, molecular biology and toxicology. In River Valley High School (Singapore), forensic science is used as a topic for a 15-week interdisciplinary project work module in our Construct, Integrate and Differentiate (CID) Programme. Students are taught basic analytical techniques used in forensic science, from fingerprint lifting, blood type determination, footprint casting and drug analyses to DNA fingerprinting. Using role play and a range of other learning activities, the students collected and analysed evidence in their attempt to solve the mystery. At the end of the CID Science Cluster, the culminating project sees Secondary Two students working in teams to solve a mock-up crime case. This CID Science Cluster seeks to develop critical thinking and problem-solving skills, synthesising knowledge and skills learnt and applying them to solve a crime case. It offers an intriguing and authentic learning opportunity which is challenging to all science students, particularly high ability learners, in expanding their interests in science and providing depth in their learning of science.

INTRODUCTION

Consider this project work activity for students at work in crime scene investigation:

Twelve groups of Secondary Two students are brought to a mock-up crime scene of a murder. Their task is to solve a crime case by collecting physical evidence, conducting laboratory tests and applying crime scene investigation skills to analyse the results. This activity captivates the students' attention from the start and keeps them intensely engaged throughout, as they take on the role of sleuths in crime detection. A few students are in gloves picking up fine strands of threads with forceps while others are making a sketch map of the scene, and indicating the locations of evidence. As they examine the fingerprint and blood samples, they discuss and interpret the clues presented by the evidence. In their group report, they conjure up a plausible and logical storyline to account for the crime, and document their analyses in a portfolio. In an oral presentation to the teachers, each group does a show-and-tell of the evidence. Using deductive reasoning, they justify their conclusions based on the study of the evidence collected.

This is the culminating task in the Forensic Science Module offered in the Science Learning Cluster in our Construct, Integrate and Differentiate (CID) Programme (refer to Annex 1) at River Valley High School. It is through this 15-week project work module that students learn scientific inquiry skills and understand fundamental analytical principles in forensic science. Through this project work, they are challenged to apply critical thinking and other skills to solving problems in real-life situations.

Attitude, Skills and Knowledge (ASK)

The CID Programme offered by River Valley High School seeks to deliver project work uniquely by developing each child with the requisite **Attitude, Skills and Knowledge (ASK)**, as the intent of our Integrated Programme. In short, ASK stands for:

- Attitude (Habits of the Mind)
- Skills (critical thinking skills)
- Knowledge (themes of knowledge and modes of inquiry)

Attitude denotes the habits of the minds, as described by Costa and Kallick (2000), referring to the positive and beneficial dispositions displayed by effective people in response to dilemmas and situations that have no apparent answer. By routinely practising these habits, such as metacognition and reflective thinking and the ability to make connections (Annex 2), students are better equipped to think critically, confront problems intelligently and make wise decisions. They also contend that the habits are the foundation for building thoughtful learning communities.

Skills refer to the set of critical thinking skills which Richard Paul interestingly defines as developed through “thinking about one’s thinking” (or metacognition): “Critical thinking is the mode of thinking about any subject, content, or problem whereby the thinker improves the quality of his or her thinking by skilfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them. Such thinking about one’s thinking involves the ability to identify the basic elements of thought (purpose,

question, information, assumption, interpretation, concepts, implications, point of view, See Annex 3) and assess those elements using universal intellectual criteria and standards (clarity, accuracy, precision, relevance, depth, breadth and logicalness) (Paul and Elder, 2002).”

Knowledge is constructed based on a foundation of prior knowledge. A key construct guiding the development of the RVIP is that “knowledge construction is valued as a more important learning outcome than knowledge acquisition”. In constructing knowledge, the students must show a thoughtful understanding of the connections and relationships between various subjects. One way students can explore and construct new knowledge is through scientific inquiry and deductive reasoning.

Construct, Integrate and Differentiate (CID) Programme

The Construct, Integrate and Differentiate (CID) Programme seeks to develop ASK in our students and promotes independent and active learning. It provides our students with opportunities to construct their own learning by integrating knowledge from various disciplines, using modes of inquiry appropriate to the projects that they are working on.

Project Work was introduced by the Ministry of Education (MOE) in Singapore schools as an effort to inculcate critical thinking skills and develop self-directed inquiry and independent learning, through the exploration of inter-relationships and inter-connectedness of subject-specific knowledge. The importance of such thinking skills was

seen in the launch of the “Thinking Schools, Learning Nation” vision in 1997 in Singapore. This vision aims to develop creative and critical thinking skills, which are essential for Singaporeans to thrive in a more global and innovation-driven future (MOE, 1999 and 2004).

The CID Programme delivers project work through a carousel of five Learning Clusters, namely Aesthetics and Language Arts, Chinese, Humanities, Mathematics, and Science and Technology. Three modules are offered under the Science Learning Cluster, based on themes of Electronics, Scents and Fragrances and Forensic Science.

Why Study Forensic Science?

Forensic science is the study of evidence discovered at a crime scene. These evidences provide impartial scientific information for use in the courts of law and in a criminal investigation and trial. It is a multi-disciplinary subject involving the applications of science methods and processes from medicine, toxicology, chemistry, physics and biology, psychology and social science to law (Encyclopaedia Britannica, n.d.). Thus the subject lends its contents neatly to interdisciplinary project work for students.

The module hopes to use forensic science as a body of knowledge with the content to engage the learners in appreciating science through the eyes of a crime scene investigator and a forensic scientist. By stepping into the roles of these crime-fighting experts in interpreting the evidence, students can learn scientific inquiry and process skills, critical thinking and project work skills in authentic real life situations.

FORENSIC SCIENCE MODULE

River Valley High School adopts the Teaching for Understanding (TfU) framework in curriculum design for all academic subjects, including CID. Teaching for Understanding is an educational pedagogy that uses the four key ideas as the foundation for its framework, namely: generative topics, understanding goals, performances of understanding, and ongoing assessment (Blythe *et. al*, 1998).

Throughlines / Overarching Understanding Goals

Throughlines or overarching understanding goals state the essential concepts, processes, and skills which we want students to come to understand over the course or module. The understanding goals for the Forensic Science Module are:

Question : *How can students apply scientific inquiry skills to solving problems in real-life situations?*

Statement : Students will recognise the usefulness and limitations of the scientific inquiry and to appreciate its applicability in other disciplines. They will develop skills that are relevant to the study and practice of Forensic Science.

Question : *What do crime scene investigators and forensic scientists do to solve crimes?*

Statement : Students will appreciate the roles of crime scene investigators in evidence collection and of forensic scientists in the analyses of evidence. Students will understand the scientific principles behind these forensic analytical skills, by putting into practice these procedures and the documentation of evidence and result solve a crime.

Generative Topic

Throughlines focus on the “big ideas” of a generative topic. A generative topic is an issue, theme, concept or idea that provides enough depth, significance, connections, and variety of perspectives to support students' development of powerful understandings. It is central to one or more domains or disciplines, interesting to students and the teacher and offers opportunities for multiple connections. The generative topic of this module:

Question : *Who has done it?*

Statement : Unusual Suspects

Performances of Understanding

Performances of Understanding are the activities, tasks or assignments students will complete in order to learn what we want them to understand hence achieve the goals described in the throughlines and through the exploration of the generative topic. The performances are generally divided into three sequential sections, namely:

- *introductory performances* (performances which come first in a module to allow students to explore the generative topic and for teachers to gauge students' prior understanding of the topic),
- *guided inquiry performances* (performances which let students focus on developing their understanding on specific issues of the generative topic), and
- *culminating performances* (more complex performances which give students a chance to synthesise and demonstrate their understandings learnt from previous performances of understandings).

Introductory Performances

In an introductory lesson, students brainstorm as a class or in groups to complete a K-W-L chart with their ideas of Forensic Science and of the generative topic “Who has done it?”. The K-W-L chart was created by Donna Ogle in the 1980s and stands for what I KNOW, what I WANT to know and what I LEARNED. This helps to check on what they know and list this prior knowledge (K). They set their goals for learning (W). Upon watching a documentary on forensic science, they reflect or evaluate their learning (L) at the end of class. Students generally expressed that they are amazed by the intricacies of crime scene investigation and the meticulous nature of the work of forensic scientists.

Guided Inquiry Performances

Through initial ten weeks of different guided hands-on learning activities, students are introduced to basic forensic evidence collection and analytical techniques. In each session, students explore the underpinning scientific knowledge behind crime scene investigation. They learn basic forensic techniques from fingerprint dusting and lifting, hair and fibre analyses, blood type determination, footprint casting and drug analyses to DNA fingerprinting.

Performances of understanding require students to demonstrate their understanding in an observable way, thus making their thinking visible. In a typical criminal investigation, crime scene investigators will gather physical evidence (such as fingerprints, fabrics, shoeprints and blood stains) from the crime scene, victim and suspect. Forensic scientists will then examine these materials to provide scientific evidence to assist in the

investigation and court proceedings by presenting evidence in court as impartial expert witnesses. The approaches by these crime-fighting experts are systematic, logical and through observations and experimentation. To check on their understanding and how they take on the roles of these experts as described in the throughlines, students are challenged to solve a simple mock-up crime task at the end of each session, such as the identification of the culprit from a sample of lip-prints from five suspects.

In each CID lesson, the performances of understanding are designed to develop the preferred **Attitude** and the required critical thinking **Skills** to help students construct their own **Knowledge**. Students will develop the **Attitude**, i.e. valuable habits of mind found among scientists, such as a *natural curiosity and an enjoyment of problem solving*, *perseverance* and the *ability to make connections*. These habits will be routinely reinforced through the instructions in our course. As described above, students are given many opportunities to practise and demonstrate these habits learnt.

With the inquiry nature of Science, the performances also focus on imparting important cognitive **skills** from three elements of reasoning in critical thinking:

- *Question at issue* (where students ask questions and answer them through scientific investigations, e.g. asking questions and analysing on a shoeprint evidence presented in the mock crime task),
- *Information* (where students gather information with their senses and with the use of scientific instruments, e.g. the dusting and lifting of latent fingerprints, the use of light microscope to scrutinise hair and fabric samples), and

- *Interpretation and Inference* (where students develop their own logical explanations based on observations (evidence) and scientific knowledge, e.g. eliminating suspects by matching ABO blood types, interpreting patterns of shoe-print formations, etc.).

As described earlier, students use scientific inquiry and deductive reasoning to construct their **knowledge**. Scientific inquiry denotes the many ways in which scientists study the natural world and propose explanations based on evidence derived from their work. In 1996, the National Research Council (NRC) in United States, released the National Science Education Standards, which provides a vision for dramatic reforms in instruction and assessment, and describes a way of science learning that reflects how science itself is done – through scientific inquiry. Inquiry refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 2000). When students perform the same activities that all scientists do, they observe, classify, compare, measure, predict, interpret data and draw inferences, or reasonable conclusions. These are essential science process skills as outlined by the American Association for the Advancement of Science (1989). Inquiry-based learning not only sustains curiosity and engages our young minds, but it also helps to develop deeper understanding of scientific concepts rather than shallow memorisation of facts and vocabulary (Shields, 2006).

Such characteristics are also delineated by Joyce VanTassel-Baska (1998) in her description of the appropriate science curriculum and instruction for high ability students

as well as for all students in science. Her proposed ideal science curriculum for talented science learners will possess the essential elements with emphases on:

- learning concepts,
- higher-level thinking,
- inquiry, especially problem-based learning,
- the use of technology as a learning tool, and
- the learning of the scientific process, using experimental design procedures.

This Forensic Science Module offers an inquiry-based and interdisciplinary science programme developed to promote this preferred form of science education, with intellectual rigour for all science students, including the high-ability learners

Each CID lesson is carefully designed to allow students to actively participate in crime scene investigation, by using relevant cognitive and science process skills (e.g. making observations and predictions) associated with the formulation of scientific explanations. They can demonstrate understanding that investigations are guided by concepts and principles of forensic science. Students plan their investigations and select appropriate apparatus and materials in the collection of evidence. They also use the correct forensic techniques to analyse evidences, and explain by draw logical inferences and conclusions.

Culminating Performances

Equipped with the basic principles and skills of forensics analytical work learnt through the guided-inquiry performances, students can then embark on a culminating group

project work in the final five weeks. The Year 2 project assignments involves Crime Scene Investigation task where students are to bust a mock-up crime case by looking for patterns of evidence with systems of forensic analysis and drawing connections between evidence.

Ongoing Assessments

Ongoing assessments form a continual process of providing students with feedback on their work, thus helping them improve their performances of understanding. These assessments inform both teachers and students about what students understand and about how they can proceed with subsequent teaching and learning. The simple mock-up crime tasks which punctuate each session are examples of mini ongoing assessments to check on students' understanding.

As for the culminating performance, the assessment of project assignment takes the format of a “4-P model” which comprises namely:

- Paper (report on collection and analyses of evidence and storyline for the crime),
- Product (portfolio of evidence),
- Process (assessment on the practice of the habits of the mind), and
- Presentation (oral presentation of crime case and forensic investigation).

Individual and group performances are graded with specific rubrics.

Assessment of Project Tasks

Level	Project task	Components in 4-P Model
Year 1	Crime scene investigation (based on physical evidence)	Paper + product: CSI report and portfolio Presentation : Oral communications
Year 2	Crime scene investigation (based on physical as well as DNA evidence)	Paper + product: CSI report and portfolio Presentation : Oral communications
Years 1 & 2	All tasks	Process : Assessment of ASK aspects

FEEDBACK & REVIEW

Students

The quotations below were taken from students' post-module feedback survey. Generally, they felt that they had an eye-opening experience learning about forensic science and enjoyed crime solving. They saw the inter-connections and the transfer of knowledge between the different disciplines, namely physics, chemistry, biology and the law.

“Forensic Science is interesting, as it is different from the normal science I have been learning. C.S.I is fun! I got to use lots of (forensic) skills to investigate and analyse evidence to identify the criminal. Learning about (ABO) blood types help me to understand blood donation better. I learn to use interesting equipments like the UV lamp for fingerprint spotting at the (field trip to the forensic unit of) police station.” – Ang Jia Lun (2007, 2L)

“I learnt that forensic scientists are very meticulous in what they are doing. They are observant while looking for clues and evidence, like fingerprints, hair samples, and conducting analyses. I hope to be more meticulous in my work as well.” – Chia Pei Woon (2007, 2I)

“Different (forensic) techniques are used to analyse and solve different (crime) cases. Making (detailed) observations allow me to train my thought process. I also learnt to draw inferences and make connections between evidence and what happened (in a crime). I can make use of such (process) skills in real life.” – Chng Kah Hoe (2006, 2H)

“I learnt many things which cannot be learnt during any normal lessons in school, like making a shoe-print out of mud, fingerprint lifting and dusting from table-tops and beakers. And boys also had to put on lipstick (to make lip-prints), it was funny!” – Judith Tan (2005, 1G).

“Most memorable part is the hands-on activities. Especially when I am using the PDArtist programme to make the face of the criminal who committed the crime. It was fun! I also learnt to use fingerprint dusting to trace the culprit. Lessons should be longer and I want to watch more C.S.I.!” – Seah Wei Kai (2005, 1E).

Teachers

At a review session of the Forensic Science Module at the end of CID, science teachers unanimously found the lessons to be indeed engaging. This is especially true for the

mock-up crime case, where students were observed to be absolutely focussed in combing for evidence and carefully making analyses of their findings. In some cases, we had new forms of evidences which were not explicitly discussed in our lessons, e.g. handwriting and DNA profile analyses. Yet, students did their own research and came up with novel interpretations to the evidence found.

Into its fourth year of implementation, the teachers have since worked on improvements to the module to cater to the needs of our students. Initially, in 2005 and 2006, the culminating performance for the Year 1 cohort was a forensic science board game, which proved to be too easy for our students. Upon review, the teachers decided to offer crime science investigation as the final assessment task. The tasks for Year 2 are of a higher level difficulty, involving basic DNA analyses, and not just physical evidence as in that of Year 1.

With many rounds of trials, we have also improvised on our teaching resources. For instance, collecting footprint cast on mud is messy and not possible in hotter months. We explored the use of pre-made footprint clay moulds instead of using actual ones on mud. To make crime cases more realistic, we also purchased mannequins with moveable joints to simulate victims in murder cases. Being teachers, we cannot claim to be experts of forensic science. To provide students with the authentic and first-hand experience, we arranged for a special learning journey to the Forensic Science Unit of the Singapore Police Force. . Besides an exclusive introduction to sophisticated instruments and professional analytical techniques, students also get to hear of actual accounts of police

crime scene investigators, who shared their wealth of knowledge and experience on busting of crimes from household break-ins to manslaughter crimes.

The success of the Forensic Science Module was also shared with fellow teachers at various platforms, the “Redesigning Pedagogy: Culture, Knowledge and Understanding Conference”, organised by the National Institute of Education (NIE) in May 2007, as well as the RV Learning Symposium in October 2007. Feedback from teacher participants was positive and most gave credits to our innovative efforts in infusing critical thinking and scientific inquiry to the interdisciplinary project work in science.

The challenges ahead include introducing more rigour and further differentiating the performances, particularly the culminating performances, according to the difficulty of the tasks and the grade level. We are also looking into the actual development of activities and planning of more realistic and challenging crime scenes in collaboration with specialists of the field, e.g. from the Centre of Forensic Science of the Health Science Authority.

CONCLUSION

Our CID programme hopes to offer project work as an enriching and engaging learning experience which aims to provide students with the opportunity to synthesise knowledge from different areas of learning, and critically and creatively apply it to real life situations. This process not only enhances students' knowledge, but also enables them to acquire

skills like collaboration, communication and independent learning, which in the long run prepares them for lifelong learning and the challenges ahead as envisaged in the MOE's Thinking schools, Learning Nation" vision (MOE, 2004). The coursework of Forensic Science Module also supports RV's directions for our Integrated Programme in the nurturance of ASK in students via a process-centred curriculum, designed using the Teaching for Understanding framework.

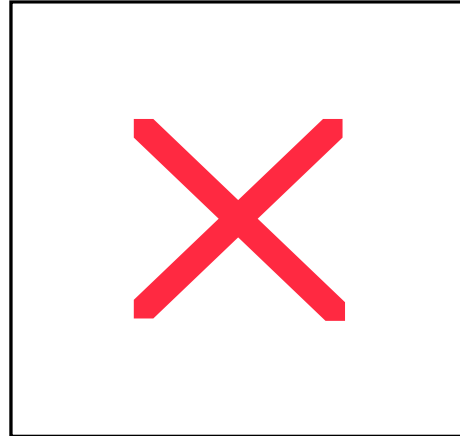
Having a science curriculum that promotes high quality learning is ideal for all learners. Students learn best when they are interested in the topic being presented. Forensic science, which is the application of science methods and processes to the law, presents an exciting body of knowledge for students, as they take on the role of detectives and forensic scientists in busting mock-up crime situations. Learning activities based on scientific inquiry have high impact on students and these may well be the first steps in nurturing our students, especially our high ability learners to become future Marie Curies, James Watsons and Albert Einsteins.

ANNEX 1

Construct, Integrate and Differentiate (CID) Programme

The Integrated Programme offered by River Valley High School seeks to develop each child holistically and equip him with the requisite Attitude, Skills and Knowledge (ASK). ASK is anchored and delivered through a broad-based and rigorous, process-centred curriculum that emphasises both content and process. In short, ASK stands for:

- Attitude (Habits of the Mind)
- Skills (generic thinking skills and critical thinking skills)
- Knowledge (themes of knowledge and modes of inquiry)



The Construct, Integrate and Differentiate (CID) Programme hopes to deliver ASK by promoting independent and active learning, via a carousel of five subject-based Learning Clusters. The Learning Clusters provide opportunities for students to explore the similarities and differences in the construction of knowledge within and beyond the various disciplines. By working on different projects, students construct their own learning by integrating knowledge and using modes of inquiry appropriate to the subject or project.

CID also serves to impart critical thinking and project work skills to students and to guide students in constructing new knowledge using the skills and content learnt. Project work provides them with an alternative mode of assessment that supports inquiry-based learning, data analysis, interpretation and inference, and the honing of presentation skills.

ANNEX 2

Attitude: Habits of the Mind

River Valley High School seeks to develop good habits of minds in our students by encouraging them to move progressively from being a novice thinker to a practising thinker and then to being an advanced thinker. Having a “habit of mind” means a person is disposed to behaving intelligently when confronted with problems, when the answers are not immediately known. According to Arthur Costa, this is the critical attribute of intelligent human beings.

The twelve Habits of the Mind which our school adopts are:

1. Passion for lifelong learning
2. A strong personal belief
3. Natural curiosity and an enjoyment of problem solving
4. Intellectual rigour
5. Openness and diversity
6. Ability to make connections
7. Meta-cognition and reflective thinking
8. Creativity and ingenuity
9. A willingness to embrace new challenges
10. Empathy
11. Perseverance
12. Ability to manage impulsiveness

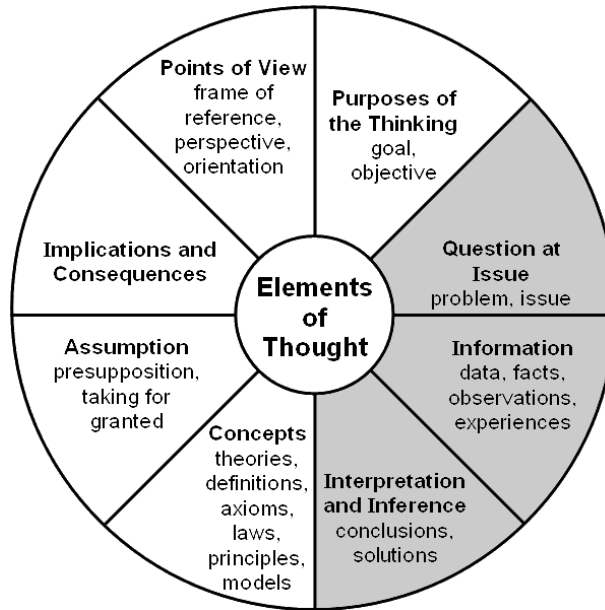
ANNEX 3

Skills: Critical Thinking

Through learning with understanding, River Valley High School also wishes to impart students with critical thinking skills. Critical thinking is the mode of thinking about any subject, content, or problem whereby the thinker improves the quality of his or her thinking by skilfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them. Critical thinking is self-directed, self-disciplined, self-monitoring, and self-corrective in nature.

Critical thinking discusses the element of thought that critical thinkers have. The model used is adapted from Foundation for Critical Thinking (Paul and Elder, 2005). According to Richard Paul, such thinking about one's thinking involves the ability to identify the basic elements of thought (purpose, question, information, assumption, interpretation, concepts, implications, point of view) and assess those elements using universal intellectual criteria and standards (clarity, accuracy, precision, relevance, depth, breadth and logicalness).

Dr Richard Paul's Elements of Thought



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