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Engaging Secondary School Students in Applied Learning through Forensic Science Using the WALES Framework

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Abstract

In this paper, we present details of a forensic science module conducted for 2 batches of secondary three students in Singapore. We formulated the ***WALES*** (***W***orkshops, ***A***uthentic Learning Tasks, ***L***aboratory ***E***xperience, and ***S***haring by Practitioners) framework, a four-pronged approach, to realise the goal of providing students with an applied learning experience in forensic science. The first prong provides students with a comprehensive understanding of key forensic science principles through workshops. The second prong allows students to apply scientific principles that they have learnt in solve authentic problems. The third prong equips students with practical skills through laboratory-based activities. The final prong engages students with first-hand account of what it is like to be a forensic scientist or a law enforcer through guest lectures from investigation agencies. The course culminated in a simulated crime scene that gave students the opportunity to assume the role of an investigator and work collaboratively with their teammates to solve a simulated crime. At the end of the course, students were certified in-house junior forensic science assistants. Students indicated in a post-module survey that they enjoyed the module and the module has enabled them to learn beyond the confine of the syllabuses to acquire useful skills and competencies. As a result, students developed greater interest in science and working with science in an interdisciplinary context. Consequently, the module has inspired many to explore the field of forensic science as future career option. In addition, the module has enabled them to pursue their interest area and to develop 21st Century Competencies.

Keywords:

Secondary School, Interdisciplinary, Inquiry-Based Learning, Applied Learning, Forensic Science

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Introduction

Much of our everyday life revolves around science and the pivotal role that science plays in solving many complex problems around us. As a result, science education has been central to a child's education in many countries. Consequently, the state of science education has received considerable attention from many stakeholders. Tremendous efforts have been dedicated to ensure the relevance of science curriculum to meet the ever-changing need of the society in the future. Equally important, strong emphasis has been placed on how science can be presented in an engaging manner to enable students to acquire scientific knowledge in an effective manner. As a result, new research in pedagogies has constantly surfaced in the research community.

To prepare our students for challenges of a ***V***olatile, ***U***ncertain, ***C***omplex and ***A***mbiguous (***VUCA***) environment, there has been a significant focus placed on the area of applied learning (Lawrence, 2013). Applied learning aims to empower students to create a bridge to connect theoretical knowledge and the application of knowledge from different fields, and thinking skills to solve real-life issues (Rosenbaum & Eric Klopfer, 2007). In 2013, the Ministry of Education (MOE), Singapore announced the implementation of applied learning programme as part of the school curriculum in all Singapore schools. Prior to this announcement, Nan Hua High School has embarked on its journey to provide greater opportunities for students to extend their learning beyond the classroom through its unique modular programme for all secondary 3 students. For this purpose, students get to choose from a variety of modules on contemporary topics offered by the teaching staffs that aims to

stretch their potential. They would spend 10 weeks, of two-hour session each week, outside their curriculum time to explore a specialised subject area.

Forensic science is a big umbrella: almost any science can have forensic applications. It is an integrated field of knowledge that is constantly evolving to include latest technology and innovations. Underlying the ability to solve simple to high profile crimes, law enforcers need to integrate knowledge from multiple fields to unravel the mystery behind every crime. Unfortunately, students often view the 3 main branches (biology, chemistry and physics) of natural science in insolation as they do not have opportunity to be exposed to such interdisciplinary subject area. On the other hand, the popularity of forensic science is rising and fuelled by many well-received television series like CSI: Crime Scene Investigation, many people have been fascinated by forensic science and its applications to solving mind boggling crimes. As such, students acquired certain pre-conception of what forensic science is, but they lack correct theoretical understanding of the various scientific approaches employed to solve crimes due to the simplistic treatment afforded to forensic science through the mass media. Through this module, we seek to extend students' learning curve by showing the relevance of integrating different fields of knowledge and to broaden their scientific horizon by embarking on a journey to experience first-hand how an interdisciplinary approach can be applied in crime scene investigations. To this end, the forensic science module is designed and formulated to create a fun and immersive environment for students to engage in applied learning.

In this paper, we report the details of how an interdisciplinary forensic science module is crafted to provide an applied learning experience for a group of secondary three students in a Singapore school. Capitalising on the strong interest of students in the field, a 10-week

programme provided an unequivocal opportunity for students to dwell deeper in forensic science and apply what they have learnt to solve simulated crime scene case. An account of the framework of the module that guided how the module was run is also described in this paper.

Literature Review

Many unorthodox problems require students to draw knowledge from multiple fields of knowledge to solve them. According to Bransford (2000), interdisciplinary teaching brings about a variety of different perspectives to challenge the conceptions held by individuals to uncover biasness. In doing so, it helps learners to acquire in-depth understanding of an issue and ability to integrate multiple fields of knowledge to analyse the issue at hand. Allen Repko (2009) proposed that interdisciplinary learning helps to develop critical thinking skills and cognitive ability to appreciate different viewpoints. Therefore, to effectively navigate and decipher the solutions to these complex issues, students must be equipped not just with knowledge but with skills to work with limited resources, cross-cultural environment and dealing with unconventional problems (Bereiter, 2002).

As the old saying goes, 'practice makes perfect'. Learning is not complete when a learner does not put into practice what he has learnt. Achieving mastery is therefore not possible if a person does not get his hands dirty. In this regard, many science educators have called for a paradigm shift in science education: a shift from the learning of science to the practice of science to enhance the learning of science (National Science Teachers Association, 2003). To take this one step further, in today's fast changing landscape with complex problems and challenges, it is no longer adequate for students to only practice on mundane problems that do not stimulate their thinking faculty. They must be offered opportunities to engage in solving authentic problems that require them to apply their understanding of science. Many a time,

these authentic problems must be presented in a context that stimulates students' interests. Quite recently, Rosenbaum and Eric Klopfer (2007) assert that authentic problems should mirror the manifold problems that they will potentially face when they step foot into the workforce. Commonly, these problems do not have a single solution and there are multiple ways to approach and resolve them.

Approach of the module

Through this module, students obtained first-hand account of what it is like to be a forensic scientist or a law enforcer through talks offered by the Health Sciences Authority (HSA) and the Singapore Police Force (SPF). With the integration of the sciences, students broadened their scientific horizon and embark on an interdisciplinary course to understand how respective science subjects can go hand-in-hand to be applied in crime scene investigations. Students also applied practical laboratory skills that they have learned in their sciences to aid them in solving mystery behind a crime.

Other than academic-related skills, students had the opportunity to pit their wits against a simulated crime scene whereby they will develop deductive reasoning and problem-solving skills and work collaboratively with their team mates as forensic scientists to solve a crime.

At the end of the course, students were certified in-house basic forensic science assistants and they presented what they have done and learned during the course and assessments to others on a poster while cultivating their presentation skills.

***WALES* Framework**

Workshops, ***A***uthentic Learning Tasks, ***L***earning ***E***xperience and ***S***haring by Practitioners

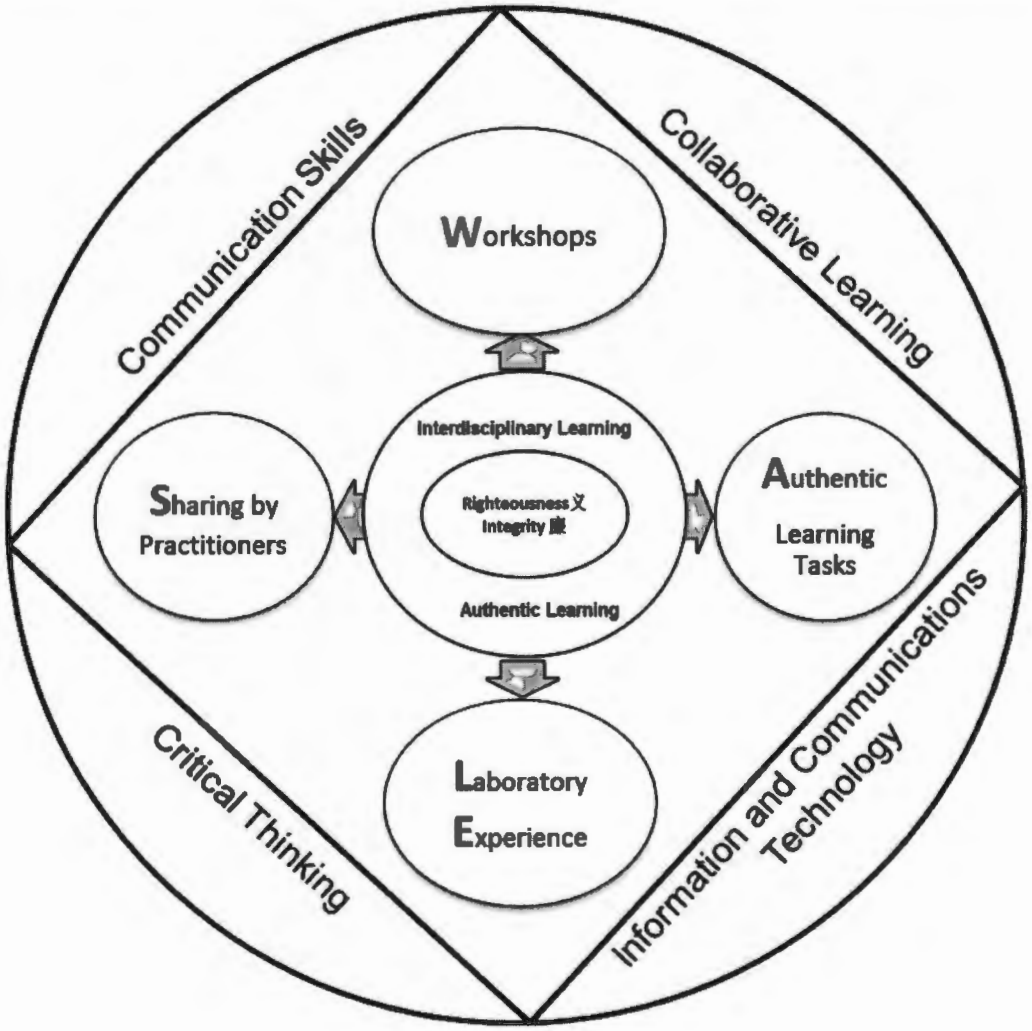

Figure 1: *WALES* Framework

From the beginning, Nan Hua High School was founded on Confucius' values and these values are transmitted to the students through our day to day curriculum. To continue with this rich heritage and to propagate good values in the students, our forensic science module was grounded on two important values, 'Righteousness' and 'Integrity'. Righteousness is a moral compass within a person which guides him to know and do the right thing at the right time, even when no one is looking. It also gives a person the moral courage to stand up for

what is right as he knows that what he is doing is morally justifiable though it may not be popular. Integrity refers to being upright and beyond reproach. These two values fittingly embody the imperative character traits that a crime science investigator should possess. These values were highlighted subtly in appropriate lessons.

Building upon the school values of righteousness and integrity and the knowledge derived from literature research, the content of the module is centred on two premises to meet the learning needs of the students: to present forensic science as an interdisciplinary subject to students and to provide opportunities for students to engage in authentic problem-solving activities. The ***WALES*** framework, provided students with varied learning experience through the following approaches:

(i) ***W***orkshops

Session	Workshop
1	Introduction to Forensic Science
2	Fingerprinting
3	Spectroscopy and Structure of Atom
4	Modern analytical methods used in Forensic Science
5	Forensic Serology
6	DNA in Forensics
7	Forensic Toxicology
8	Analysis of compounds
9	Insights into Crime Scene Investigation
10	Simulated Forensic Case

Table 1: Outline of Forensic Science Workshops

To begin, the forensic science course is often considered a tertiary course as it requires certain advanced concepts. As such, the forensic science workshops were specially crafted for secondary school students of at least average abilities. The duration of each workshop is 2

hours. In view of our audience, we have customised the content of the workshop **(Table 1)** and aligned it to the GCE 'O' Level syllabuses for Biology, Chemistry and Physics. This provided the basis for the construction of the core content of the workshops. Capitalising on the core content, relevant advanced scientific concepts applicable in forensic science were also introduced to expose students to knowledge beyond the syllabuses. For instance, the concepts on emission and absorption spectra, which is not part of the syllabus, were included to provide students with insights on advanced spectroscopic techniques used in crime scene investigations. Trajectory and projectile motion were also introduced, which are part of the GCE 'A' Level syllabus for Physics, to allow students to understand how crime scene investigators differentiate accidental deaths from homicide for falls from great heights.

Next, the running of each workshop is facilitated by a 4-part process modified from the workshop model (Tovani, 2011). Each workshop is designed to focus on a specific topic on forensic science **(Table 1)** and a definite structure. The first part of the workshop is reserved for students to explore the importance of a particular topic in forensic science. This helped to set the stage for the lesson for the day, created buy-in from the students and motivated them to learn. In the second part of the workshop, students were given opportunity to work collaboratively with their peers to acquire key scientific principles on a particular topic. Through discussion with their peers, students assumed ownership in their own learning and developed enduring understanding on the subject area. During this segment, the teachers acted as facilitators to help students in their acquisition of knowledge through facilitating their academic discourses. In the third part of the workshop, students applied what they have learnt to solve problems and/or to conduct experiments. Therefore, this segment is the longest and most important part of the lesson as students worked together to synthesise solutions to the problem set. Finally, in the last part of the workshop, students consolidated their learning

by reflecting on what they have learned for the day. This provided space for students to develop their metacognitive domain as they put everything in perspective.

Lastly, our students today are all digital native and are no strangers to Information Communications and Technology (ICT). To harness the immense power of ICT to encourage collaboration and sharing of ideas, different ICT tools and applications, such as 'Todaysmeet' and 'Socrative', were used throughout the entire duration of the course. The use of ICT in the series of workshops also helped to increase students' participation in discussions as it offered a non-threatening environment for students to express their views. Additionally, the use of ICT shortened the time needed for students to present their ideas and helped students to learn more in the limited time per workshop.

(ii) *A*uthentic Tasks

It has been reported in literature that authentic tasks can effectively engage students in the learning of science (Rosenbaum & Eric Klopfer, 2007). Hence, authentic tasks were incorporated into the module to stimulate students' interests in forensic science. For example, during the workshop on forensic anthropology, students were tasked to derive the relationship size of human foot and height through a series of data. Different tasks were designed to connect theories to applications and strengthened students' grasp of concepts. On the other hand, simulated forensic cases have been reported in the literature to be effective in engaging students (Beussman, 2007; Katharine J. Harmon, 2009). In particular, during the final lesson, a burglar case was set up for students to investigate and to determine the culprit of the crime. The objective of this elaborated activity is to allow students to apply what they have learned throughout the course to solve a simulated crime. Students were tasked to work in groups to survey the simulated crime scene, conduct crime scene sketch and gather crucial evidences

from the simulated crime scene. In addition, they needed to conduct experiments so as to enable them to conclude the culprit of the crime.

(iii) ***L***aboratory ***E***xperience

Practical work is an integral part of the teaching and learning of science (Millar, 2004). Accordingly, to experience the full spectrum of science education, the importance of practical work cannot be undermined. In this module, suitable experiments were designed for students to acquire important practical skills. Practical work is built in for every lesson. Also, students were exposed to experiments that they would not encounter in the conventional syllabus. The learning experience of students would be enriched through such experience.

(iv) ***S***haring by Practitioners

As observed, the curriculum does not provide exchange opportunity for students to interact with professionals from the working world. Through this avenue, crime scene investigators from Singapore Police Force and forensic scientists from Health Sciences Authority were invited to share about their work the students. These experts brought in expert knowledge and wealth of experience of dealing with real-life cases to share with the students. In addition, students were also given the platform to interact and find out more about careers in forensic science.

All in all, students were offered an enriching and holistic learning experience where they were allowed to learn in a collaborative culture and encouraged to apply what they have learned to solve forensic science problems. In addition, it is envisioned in the ***WALES*** framework that students will acquire valuable 21st Century Competencies such as communication skills, critical thinking skills and the ability to work with people.

Results and Discussion

A post-module survey was done and the 34 students' feedback was recorded for analysis. The survey included questions about the perception of students towards the module, structure of the module, benefits that they derived from the module, and so on. The objective of the survey was to elucidate the perception of students' view on the module and to help identify areas for improvement. Quantitative and qualitative analyses were carried out based on two modes of survey – ranking and open-ended questions. From the ranking questions, students were given questions categorised in sections **A, B** and **C**. As shown in **Table 2**, the ranks of 'Strongly Disagree' to 'Strongly Agree' are given scores from 1 to 5. The raw data collected from **Table 2** was then transformed into quantifiable statistics for us to determine the efficacy of the programme in evoking students' interest and promoting learning.

	Forensic Science	1	2	3	4	5		
A	**Choice and Selection Process**	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Blank	Total
i	The modules offered for selection are interesting.	0	2	8	16	8		34
Ii	The module I was offered was one of my 3 choices.	0	0	0	10	24		34
B	**The Programme**							
i	I like what is offered in my module.	0	1	9	18	6		34
Ii	I am able to do the tasks expected in my module.	0	0	10	18	6		34
Iii	The module over one semester is just nice.	1	4	8	16	5		34
Iv	I think the programme of this module should remain the same.	0	7	9	13	5		34
C	**Meeting objectives**							
i	The module has enabled me to learn beyond the school syllabuses.	0	0	4	13	17		34
ii	The module has enabled me to pursue an interest area.	0	0	9	19	6		34
iii	The module has enabled me to develop competencies such teamwork, communication skills, creativity, etc.	0	0	9	20	5		34
iv	I would recommend for this module (as a whole) to be offered again.	0	0	11	12	11		34

Table 2: Ranking survey by students after end of module.

Initially, students were tasked to choose from a list of elective modules which they hoped to embark for the 10 week period. Under section **A** of **Table 2**, about 6% of students from the very beginning felt that the modules offered may not be of their interest. After running the module for ten weeks, about 15% of students reflected in section **B** that the Forensic Science programme should be extended beyond the ten weeks. As such, about 21% of students highlighted that should not remain the same and instead can be extended to a 6-month programme. This is evident in students' feedback to provide 'more practical sessions', 'more hands-on activities' and giving 'longer durations' for the programme. In section **C**, all students enrolled in the module expressed that their expectations for the module were met.

	Forensic Science	**Rank score X number of respondents**						
A	**Choice and Selection Process**	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Blank	Total
i	The modules offered for selection are interesting.	0	4	24	64	40		**132**
Ii	The module I was offered was one of my 3 choices.	0	0	0	40	120		160
B	**The Programme**							
i	I like what is offered in my module.	0	2	27	72	30		**131**
Ii	I am able to do the tasks expected in my module.	0	0	30	72	30		**132**
Iii	The module over one semester is just nice.	1	8	24	64	25		122
Iv	I think the programme of this module should remain the same.	0	14	27	52	25		118
C	**Meeting objectives**							
i	The module has enabled me to learn beyond the school syllabuses.	0	0	12	52	85		**149**
ii	The module has enabled me to pursue an interest area.	0	0	27	76	30		**133**
iii	The module has enabled me to develop competencies such teamwork, communication skills, creativity, etc.	0	0	27	80	25		**132**
iv	I would recommend for this module (as a whole) to be offered again.	0	0	33	48	55		**136**

Table 3: Rank score per rank question in sections **A, B** and **C**.

To obtain a good sense of how the rankings are translated to the students' feel for the module, the rank score of the five different descriptors were multiplied with the number of respondents which chose them as shown in **Table 3**. This preliminary statistics gave us a feel that the module aligned with the students' initial interest for the modules offered. However, the objectives of the modules seemed to have apparent positives than the students' initial interest. Thus, we proceeded with the grouping of the students' rank scores and carried out two-tailed two sample t-test with unequal variances. The null hypothesis was that the mean of the rank scores for group 1 is equal to the mean of the rank scores for group 2, while the alternate hypothesis was that the mean of the rank scores for group 1 is not equal to the mean of the rank scores for group 2. The groups selected were options **Ai), Bi), Bii), Ci), Cii), Ciii)** and **Civ)** which were emphasised and discussed with reference to **Table 3**. Based on the constructed t-test table in **Table 4** with p-value of 0.05 set as the significance level, the students truly felt that the module enabled them to learn beyond the syllabus. This was beyond their initial expectation of the module and their perception of 'liking' for the module. However, there is a need for the module to be reviewed as Forensic Science is still not a well pursued interest for students and they do not feel that their soft skills such as communicative skills were significantly improved during the programme. Still, the students' qualitative feedback suggests that some students felt that they managed to hone their communication skills and they were well introduced as to how they can be a good Singapore Police Force Forensic Officer or Scientist. However, the p-values obtained for students' response to recommend this module to their juniors was seemingly supported with slight confidence that the module had exceeded their expectations and they were satisfied in general.

Options	**Ai**	**Bi**	**Bii**
Ai			
Bi	0.8794		
Bii	1.0000	0.8659	

Ci	**0.0098**	0.0035	**0.0040**
Cii	0.8740	0.7327	0.8584
Ciii	1.0000	0.8618	1.0000
Civ	0.5612	0.4404	0.5223

Table 4: Statistical table computed with two-tailed two sample t-test with unequal variances.

After looking at the quantitative analysis, students' open-ended suggestions and responses were looked into and critically evaluated for three agendas – What they like about the module, what improvements can be made to the module, and what they have learnt from the module. It is noteworthy to highlight that students have listed many things, which are out of the GCE 'O' Level syllabus, as their learning points from the list of feedback they have learnt from the module – 'Learn how **to evaluate a crime scene**', 'Learnt more **DNA**', 'Learnt about **teamwork**', 'Learnt to make use of **blood-splatter patterns** to find out the angle of assault', '**Fingerprints** identification' and '**How sweaty hands have a higher chance of leaving their fingerprints behind**'. Students' ability to learn and retain the advanced knowledge from the module restates the programme's framework ***WALES*** which was only possible by the authentic learning process, workshops, hands-on practical and invaluable sharing from the professionals in the forensic science field.

A number of students made positive comments about the module in the survey. In particular, one student, Jasmine Tan, gave her deep reflective thoughts on the module:

"I learnt how to be critical in thinking and how to see things in a big picture. This course has also taught me to pay closer attention to minute details, and to be meticulous in evaluating situations. I also learnt to work closely with my teammates and to listen with an open mind. I have learnt to better apply science into my daily life. I have gained tremendous interest in the field of forensic science. Throughout the module, I was intrigued by how science is such a vital role in solving crimes. Overall, I feel that this module has enriched me in many ways

and I would certainly like to go through another course like this again." – Jasmine Tan, Class 305

The keywords underlined in the students' reflection highlighted how the ***WALES*** framework employed in this programme had helped to make Jasmine a critical thinker who is able to collaborate with her peers and communicate effectively to convey her thoughts and ideas. At the same time, soft skill such as empathy was built as she was able to listen to others with an open mind. Moreover, she learnt to better apply science in her daily life which emphasised the interdisciplinary learning which lies in the core of the ***WALES*** framework.

In addition to the learning of forensic science in a school environment, a noteworthy aspect of the module is the sharing of real-life work experience by practitioners from governmental agencies. This unique platform provided by the module has allowed students to gain insights into how forensic science is applied in crime scene investigation. Furthermore, students seek clarification on the pre-requisites to work in the forensic field, career opportunities and discuss scientific matters. Consequently, these experts from various fields become mentor for the students in their exploration of future career options. Some students highlighted in the survey that they benefitted from the sharing sessions; one such statement is stated below:

"I enjoyed the interesting sharing session by the Criminal Investigation Department of the Singapore Police Force. It was an interesting and enriching experience that let me gain an insight to the various methods used by the police to solve crimes." – Chew Li Chi, Class 309

Conclusion and Perspectives

All in all, the module was able to engage the students and provided students with the real world scenarios brought into the laboratory with hands-on activities, sharing of life

experiences by personnel from the HSA and SPF, and use of ICT tools such as videos and simulations. Additionally, it was further inferred that the module had a positive influence on students' attitude towards forensic science and its applications in crime scene investigation. Teachers can readily bring the world of Forensic Science to students with guest lectures, video explanations and a simulated crime scene to allow students to put themselves in the shoes of an investigator. They will be provided with a chance to think, feel and work like a Forensic Scientist or Investigator. Overall, they have benefitted both academically and personally through learning opportunities afforded by the ***WALES*** framework.

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