**School-based Science Practical Assessment – The Singapore Experience**

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**Abstract**

Science examinations at the Singapore-Cambridge General Certificate Advanced Level (GCE A-Level) have always had a practical component. In 2004, Singapore embarked on a radical shift to a School-based Practical Assessment (SPA), breaking a long tradition of the once-off summative practical examination. The rationale and driving force for the switch is that school-based assessment offers the potential for formative assessment, besides a more comprehensive assessment of experimental and investigative skills. The shift created waves of challenges for various stakeholders. Close monitoring of the implementation enabled swift review and adjustment of the school-based assessment model to minimise its well-discussed limitations and re-focus on the positive spin-offs in learning outcomes and teachers' professional development. The GCE A-level SPA model has since evolved to the current hybrid model of school-based assessments with the assessment of Planning skill in the written examination. This paper shares Singapore's experience and learning points in the journey of school-based science practical assessment.

**Key words**:
school-based, science, practical, assessment, examination

## Introduction

Science practical assessment has always been an essential component in the Singapore-Cambridge General Certificate of Education (GCE) A-Level Examination with several changes over recent years to meet the increasing emphasis on process skills. This paper highlights the key changes over the last twenty years, focusing both on the benefits derived as well as some lessons learnt.

A common criticism of practical examinations is its tendency to concentrate on a written product, without due emphasis given to the processes of investigation and thinking (Tan & Towndrow, 2006; Watson & McRobbie, 2004). There was also little incentive for students to do investigative tasks. These shortcomings were recognised by Singapore in earlier days and in 1992, one of the two practical tasks in the practical examination was replaced with a planning task for A-Level Physics which also required candidates to implement their individual plans. Subsequently planning tasks were also incorporated into A-Level Chemistry and Biology assessments. For A-level Physics, these evolved later into two practical tasks where candidates followed procedural instructions and two planning tasks on different topics in which candidates focused on the procedural approach without implementing their plans.

Another shortcoming was that the use of sophisticated equipment was limited in the practical examination due to various logistic reasons. For example, cathode ray oscilloscopes and data-loggers which are useful as a teaching resource for achieving higher order process skills were not set in the practical examination due to logistic reasons. There were concerns that not all available scientific equipment were fully utilised for teaching purposes. Such views have been echoed by many educators who believed that assessment is a key motivator for teaching (Millar, 2004; Keiler & Woulnough, 2002; Gott & Duggan, 2002),

An External Review Committee Report (1998) commissioned by the Ministry of Education had recommended that learning activities should go beyond achieving high scores in examinations, and should broaden to equip students with the skills and competencies for the 21st Century, emphasising on creative problem-solving and critical thinking in curriculum design and assessment.

In particular, self-directed project work in the form of mini-projects was recommended for A-Level Physics. These should require the complete process of problem identification, research of related information, designing an investigation, implementing and testing the experiment, and making innovations along the way to pursue meaningful conclusions. The stage was set for a more concerted effort to bring about a re-focus on more meaningful learning.

**First Experience with School-based Science Practical Assessment (SPA) at the GCE A-Level**

In 1999, MOE took a decision to replace the one-off science practical assessment with a continuous school-based mode that emphasises on the process of scientific thinking and inquiry. A key shift was the explicit articulation of teaching and learning of the basic practical skills and scientific inquiry skills in the syllabus and the allocation of curriculum time and recourses to these activities. Teacher training was provided in early 2000 to prepare teachers for implementing school-based Science Practical Assessment (SPA). Such trainings equipped teachers with a better understanding of the skills and appropriate use of scientific laboratory equipment so that they could teach and evaluate more effectively the learning outcomes in inquiry skills. To further ensure school readiness, a dry run was conducted in all junior colleges (JCs) from 2002 – 2003 to familiarise teachers with the processes and to surface implementation issues that needed support beyond the schools' means. SPA eventually replaced the practical examination from the 2004 JC 1 cohort.

In SPA, the practical skills were divided into 4 categories: Planning, Manipulation, Analysis and Evaluation. Each skill had to be assessed twice on different topics[1] in the 2-year A-Level course. Centres could select from a pool of assessment tasks provided by the examination board. As with any coursework, there were internal moderation at the school level and external moderation at the national level to ensure comparability within and across centres respectively.

In the Planning skill, students would need to develop an investigative approach based on scientific principles, implement the plan and then suggest modifications to the initial plan. This process would benefit students with a more holistic learning experience. However, the assessment of Planning skill was eventually modified into a written examination as the objective could be achieved without any logistics concern.

A central idea in SPA is to provide scope for developing scientific inquiry skills in a greater variety of contexts and promote a broader understanding of scientific process skills associated with scientific inquiry and problem-solving. To allow timely feedback to the teaching and learning process, refinements were made along the way without compromising the intent and rigour of the assessments. One example was the flexibility for schools to use tasks assessing a single skill although use of tasks with combined skills was encouraged. This served to align with the intent of SPA being a formative assessment.

A key implementation issue which had been widely anticipated and well known (Millar, 2004; Keiler & Woulnough, 2002; Gott & Duggan, 2002; Yung, 2001) was managing the dual role of teacher-cum-assessor. While many teachers were able to balance between these roles, some due to misguided intentions, tended to opt for discrete teaching and assessment of single skills thus resulting in missed opportunities to teach and impart practical skills in different contexts. Another concern raised was the increase in teachers' workload due to lengthy discussions at the internal moderation. This might provide incentive for some schools to use the same choices of assessment tasks over the years and result in narrowing of learning experience for the students.

[1] This is an attempt to broaden context for assessment. For illustration, if Assessment 1 on Manipulative skills for Physics is on Mechanics, Assessment 2 on the same skill will have to be on another topic such as Electricity and Magnetism.

**Addressing Concerns Promptly**

Severable measures were quickly put in place in the initial years to address the various concerns as they were surfaced. For example, to ensure that the workload of the teachers was manageable, regular trainings were conducted so that all assessors could conduct their internal moderation more efficiently. Assessment criteria for the 4 skills combined was reduced from 18 to 15. A cap on the number of assessment for each skill was imposed: one for the Planning skill and two for each of the other three skills. Centres were also provided with more funds to employ laboratory assistants to assist the teachers both in the preparation and during the assessment of SPA. Centres were also given the autonomy to make minor modifications to existing assessment tasks, including extending the duration for assessment in view of differing apparatus across Centres without compromising the rigour and objectives of the assessment. Centres needed however to submit justifications for any modifications.

**GCE O-Level SPA**

The lessons from A-Level SPA were quickly applied to O-Level SPA for the pure science subjects which was implemented in 2006. A portfolio with a range of competencies and at least 75% of topics in each subject was introduced as a requirement to ensure comprehensive coverage of the scope of practical skills. For example, the use of data-loggers was included as one of the required competencies. Experimental techniques and recording of raw data were also combined into a single skill set to balance the compartmentalised teaching and learning of practical skills.

To ease implementation, assessment of Planning Skill was combined into a single written examination task from the hitherto three sessions of planning, implementing the plan, and making modifications. Implementation of the plan and evaluating the plan/suggest modifications were incorporated as part of requirements of the portfolio. On hindsight, this was a right development in view of negative backwash effects experienced in assessing investigative work elsewhere (Millar, 2004; Gott & Duggan, 2002). In addition, rubric marking was simplified with the adoption of a 3-level Mastery model instead of a 6-level rubric assessment modelled after the A-Levels. Additional manpower was provided by MOE to ensure that there were two teachers for all science practical lessons in view of the larger class size in secondary schools.

**2009 A-Level SPA Model**

As part of the routine syllabus development process, the A-Level SPA was reviewed in 2006. Possible negative impact on teaching such as drilling to the task, narrowing of scope in teaching and learning fuelled by the dual role of teacher-assessor, all of which were not unique (Millar, 2004; Black et al, 2004; Keiler & Woulnough, 2002; Gott & Duggan, 2002), were examined and potential challenges to the successful implementation of SPA were identified. In the interim period, further adjustments were introduced. Assessment of single skills was no longer permitted from 2008 to avoid compartmentalised teaching and learning of practical skills. The autonomy for Centres to extend the assessment duration by up to 25% of that stated was withdrawn to ensure a greater standardisation of the assessment duration.

The assessment of Planning skill would be incorporated into the end-of-year examination from 2010. It is envisaged that the objective could be better served as an unseen examination paper with its lessened predictability to help encourage a wider exposure of investigative skills in the teaching and learning process.

The assessment of the other three skills[2] was incorporated into 2 combined skill tasks (of 1 h 15 min duration) to be assessed within a specified window period once in each academic year of the 2-year A-Level course. The tasks would be released by the examining authority immediately before the window period[3] of assessment. This arrangement required teachers to teach all the required practical skills and prepare their students well for the practical tasks. In addition, marking was further refined to increase marking reliability. Together with the externally marked planning skill, this would make the marking load of teachers more manageable.

**Benefits**

Although SPA surfaced a number of implementation issues in the initial years, especially the increased workload of teachers and cost, it had benefited the system. A key positive outcome was the improvement in development of teachers' competency in the teaching and learning of practical skills in scientific inquiry. This was further helped through the development of assessment literacy among teachers where the expected levels of proficiency in various aspects of practical skills were communicated to all teachers via the mark schemes. This new marking scheme, being more accessible helped to make the marking workload more manageable. They also helped teachers to better understand the skills required and ultimately helped them to teach and guide their students better. The internal moderation sessions, though time-consuming, served as a platform for professional development and helped to engender professional discussion on assessment and teaching of practical skills. This was especially helpful for professional development of teachers who were newly posted to teach at GCE A-Level.

In a small survey conducted in 2006, a number of students interviewed preferred continuous assessment compared to the one-off practical examination. They felt that SPA had assessed their practical skills more accurately as the assessment was continuous and gave them more opportunities to demonstrate their capabilities as compared to a one-off practical examination.

**Concluding Remarks**

The journey in school-based assessment of Science practical skills may be summed up by Fig.1, starting with a major shift from centralised assessment to a minimally controlled assessment in the initial years, followed by a gradual transition to a more controlled assessment.

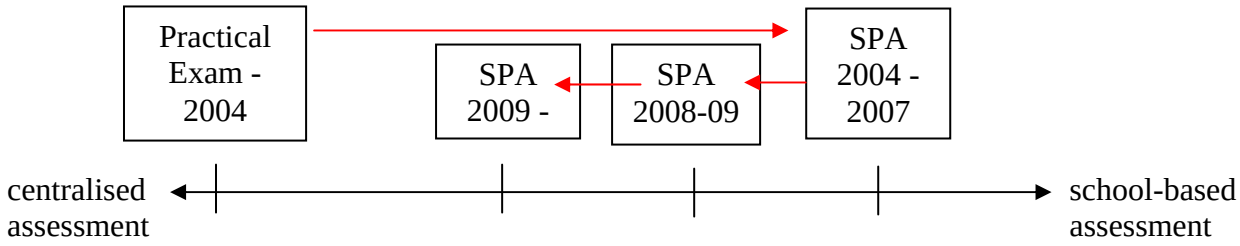


**Fig.1 Journey of SPA**

The full impact of the 2009 A-level SPA model has yet to emerge. Further refinements would be expected. Some key considerations would be to minimise the teacher-assessor dual role conflict to encourage practices that promote learning of students and to promote the explicit teaching and learning of practical skills.

[2] MMO: Manipulation, Measurement and Observation, PDO: Presentation of Data and Observation and ACE: Analysis, Conclusions and Evaluation

[3] 3 weeks for trials and preparation by school assessors and 8 weeks for conduct of assessment.

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