Abstract for IAEA 2014

Use of Assessment as Learning to Develop Self-Directed Learners of Science

Compassvale Secondary School

Ng JunJie, Cheong Tien Beng, Choy Mun Kheong Nicholas, Fazleen Mahmud,

Preeti Vikas Palkar, Tay Zhi Xiong, Widayah Othman

One of the key student outcomes in the 21st Century Competencies Framework (C2015) is developing students to become self-directed learners capable of questioning, reflecting, persevering and taking ownership of their learning.

This paper shares our experiences and findings on the use of Assessment as Learning (AaL) to enable students to assess their learning, thereby encouraging them to take greater ownership and accountability.

We extended the use of Assessment for Learning strategies already employed by the school through the use of AaL which consists of three components, namely self-monitoring, self-evaluation and self-correction. Focusing on self-monitoring and self-evaluation, assessment is designed and various self-monitoring strategies such as success criteria and checklist were used across the three science disciplines of Chemistry, Biology and Physics to enable students to collect evidence of their learning (self-monitoring) and provide structure for review if they had met their learning objectives (self-evaluation).

The extent of students' independence and self-directness in learning was assessed through data from lesson observations, focused group discussions and reflections. The findings of this cross-subject collaboration involving eight teachers and a sample population of eighty Secondary Three students, the challenges faced in implementation and future plans to improve and extend these strategies would be shared. (200 words)

Email addresses of co-authors:

Ng JunJie: ng_junjie@moe.edu.sg

Cheong Tien Beng: cheong_tien_beng@moe.edu.sg

Choy Mun Kheong Nicholas: choy_mun_kheong_nicholas@moe.edu.sg

Fazleen Mahmud: fazleen_mahmud@moe.edu.sg

Preeti Vikas Palkar: preeti_vikas_palkar@moe.edu.sg

Tay Zhi Xiong: tay_zhi_xiong@moe.edu.sg

Widayah Othman: widayah_othman@moe.edu.sg

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REPORT

BACKGROUND

In 2010, the Ministry of Education (MOE) implemented a new framework, the 21st Century Competencies Framework (C2015), to enhance the development of 21st century competencies in our students as shown in Fig 1. One of the four key outcomes in the framework is to develop our students to be independent and self-directed learners. The attributes of a self-directed learner is one who will question, reflect, persevere and take responsibility for his or her own learning[1].

Fig 1. 21st Century Competencies Framework

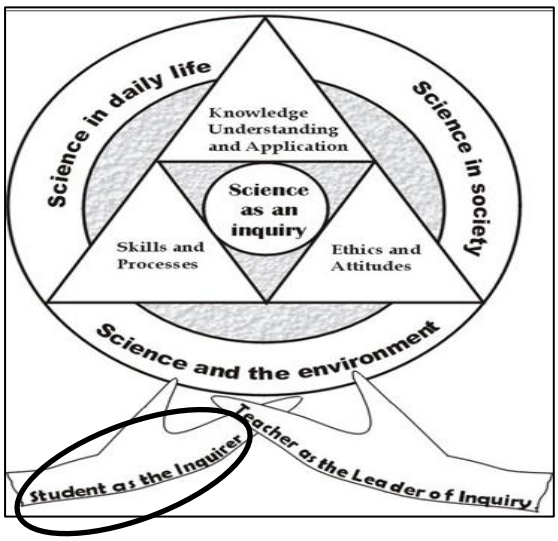

Fig 2. Science Curriculum Framework

The Science Curriculum Framework as shown in Fig 2 encapsulates the thrust of science education in Singapore to prepare our students to be sufficiently adept as effective citizens, able to function in and contribute to an increasingly technologically-driven world. Central to the curriculum framework is the inculcation of the spirit of scientific inquiry[2]. To enable students to be an effective inquirer in learning of science, they need to be self-directed and be able to monitor how they are learning so as to enable them to understand and apply their knowledge to solve problems.

Assessment for Learning (AfL) was the key pedagogical focus for the school in 2010 and 2011. In classrooms where assessment for learning is practiced, students know at the outset of a unit of study what they are expected to learn. Assessment as Learning (AaL) takes AfL a step further by transferring ownership and accountability of learning to the student. Students are actively engaged in the learning and assessment process. When they make the connection between learning strategies and assessment results, they will be aware which method works for them to get the results that they desire. This will motivate them to work towards developing more effective study habits of learning. The teacher's role is in helping students set clear targets and explaining assessment criteria and standards, giving effective feedback and affirming the students. Students equipped with these learning attitudes and strategies, will take charge of their learning thus developing the skills necessary for life-long learning.

[1] http://www.moe.gov.sg/media/press/2010/03/moe-to-enhance-learning-of-21s.php. Retrieved on 19 Mar 2014
[2] Science Curriculum Framework, as retrieved from Science Syllabus from http://www.moe.gov.sg/education/syllabuses/sciences. Retrieved on 19 Mar 2014

APPROACH

Compassvale Secondary School (CVSS) is one of the Professional Learning Communities (PLC). In a PLC, all teachers work collaboratively in Learning Teams to attain high levels of student learning and positive student outcomes in alignment with school goals[3].

The Science Department is one of the Professional Learning Teams (PLT) in CVSS. The team brainstormed on the following four critical questions which formed the core of our weekly discussions:

1. What do we want our students to learn?
2. How will we know they are learning?
3. How will we respond when they don't learn?
4. How will we respond when they do learn?

The team looked into the 21st Century Competencies Framework (C2015), the Science Curriculum Framework and tried to align the team's project with the school's focus. Developing our students to become self-directed learners is one of the four key desired outcomes of education in the 21st Century Competencies Framework (C2015) but students are not as independent and self-directed in their own learning as the team of teachers would like them to be. Besides relying on their teachers for direction in learning, the students are also unaware of how they are learning and if they are learning.

Assessment as Learning (AaL) takes AfL a step further by transferring ownership and accountability of learning to the student. Assessment as Learning is the use of on-going self-assessment by students to monitor their own learning, "characterized by students reflecting on their own learning and making adjustments so that they achieve deeper understanding." [4]

Assessment as Learning (AaL) was chosen for the following reasons:

- Enables extension of the use of existing AfL strategies that the students are familiar since these strategies have already been employed in the school.
- Encourages greater ownership and accountability of students' learning through application of three components: self-monitoring, self-evaluation and self-correction.
- Enables students to collect evidences from assessments to evaluate their own learning and decide on the next course of action to achieve their learning objectives through use of self-monitoring tools and strategies such as checklists and success criteria
- Enables students to think and learn about how they are learning through evidences collected from formative and summative assessments
- Gives students the opportunity to develop skills necessary for life-long learning and become self-directed learners by equipping them with tools and strategies to help monitor their own learning, evaluate how well they are learning, correct their concepts and fine-tune how they are learning.

Self-monitoring strategies requires student to collect 'evidence' of their learning and to keep track of their progress. The evidence can be collected from tasks in the form of short quizzes or practical work and/or assessment tasks designed and assigned by teachers to probe student learning. The team explored the various self-monitoring strategies such as success criteria and checklist, and they were used across the three science disciplines of Chemistry, Biology and Physics. From the collected evidence, students self-evaluate their learning by reviewing their evidence collected and records to determine if they have met the learning objectives.

[3] An Introduction to PLCs. http://www.academyofsingaporeteachers.moe.gov.sg/ Retrieved on 19 Mar 2014
[4] Western and Northern Canadian Protocol for Collaboration in Education [WNCP], 2006, p.41

IMPLEMENTATION – RESEARCH METHOD

Lesson Study was used as a research method by the team as shown in Fig 3 so as to enable teachers across different disciplines to observe students' responses and reactions to strategies introduced.

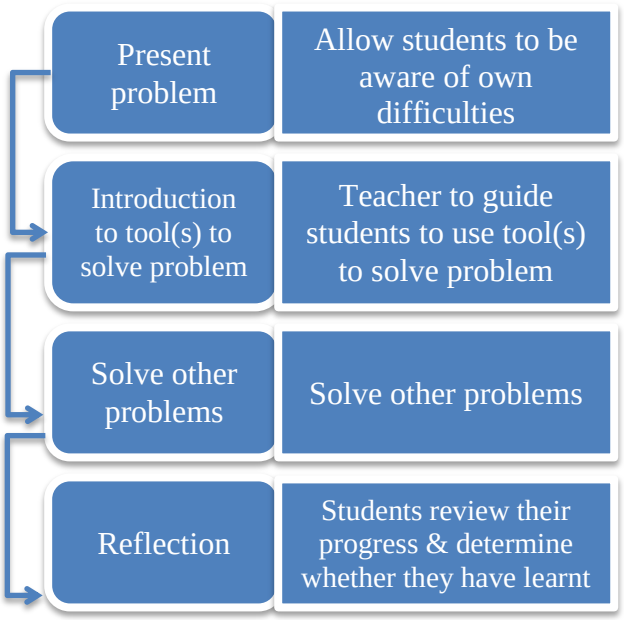

Fig 3. Lesson Study as Research Method

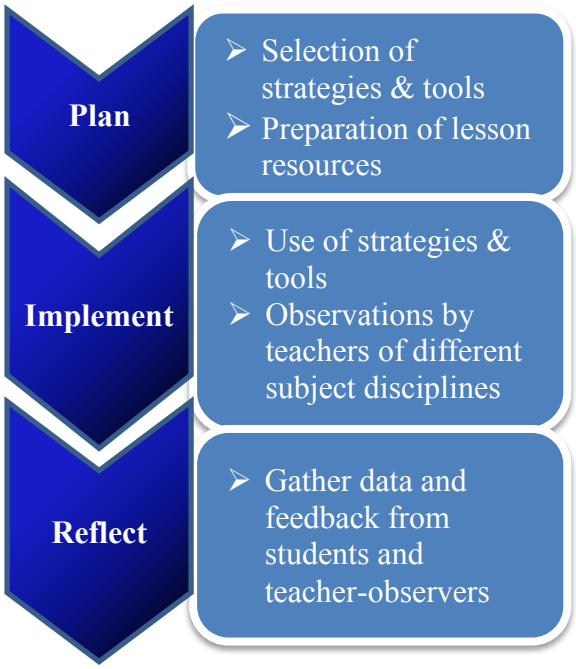

Fig 4. Research Process

To test out and refine the use of AaL across the three sciences, the team used the above approach in our research process as shown in Fig 4 in the application of self-monitoring and self-evaluation tools and strategies in the teaching and learning of Science.

IMPLEMENTATION – RESULTS AND FINDINGS

The following section summarises the key results and findings of this cross-subject collaboration. The data collected thus far from lesson observations, focused group discussions and reflections, relating to the self-monitoring and self-evaluation tools and strategies, would also be shared as the team continues the development and refinement of the use of AaL in the teaching and learning of Science to develop self-directed learners.

SELF-MONITORING TOOLS AND STRATEGIES

Teachers from the three different Sciences crafted meaningful tools suitable for the teaching and learning of each Science to scaffold and enable the application of self-monitoring strategies. These tools are incorporated in the learning materials of the students and students are given opportunities to learn and practise how to use these tools with the facilitation of their teachers.

Checklists are being used in Physics for various topics which students are having difficulty with, for acquisition and mastery of skills and competencies to conduct experiments and write reports, and in all three Sciences to help students monitor their progress in terms of achieving

learning objectives and in their learning and readiness for the national examinations. Success criteria is used in by Biology to help students plan and write general approaches to design experiments and in all three Sciences for helping students craft accurate answers to free-response and/or data-response questions. A summary list of the tools that were used for each of the three Sciences, the purpose of the tool and examples of how these tools are being used can be found in Annex A.

Through the use of these self-monitoring tools and strategies to collect data from their own tasks and assessment, students were observed to be able to monitor their own learning and achieve one or more of the following to varying extents:

1. get started on solving problems confidently and independently
2. gain confidence in crafting answers to free-response and/or data-based questions that are more accurate
3. monitor own progress in the acquisition of skills and competencies necessary for carrying out experiments, obtaining accurate and reliable results and report-writing
4. plan and write a concise general approach for design experiments
5. gain awareness of learning objectives for each Science topic and be able to monitor own progress in the achievement of these objectives
6. monitor and review their learning and readiness for the national examinations through identification of strengths and areas for improvements

SELF-EVALUATION TOOLS AND STRATEGIES

Teachers from the three different Sciences also crafted meaningful tools to scaffold and enable students to employ self-evaluation strategies and modeled the use of metacognitive questions in problem solving. Besides building on and incorporating these tools into the learning materials of the students that enable them to monitor their learning, teachers across the three Sciences also adapted and introduced a set of metacognitive questions that students can ask themselves to evaluate their learning and provided opportunities for students to practise.

Through the use of these self-evaluation tools and strategies based on data collected from their tasks and assessment during the self-monitoring process, students were observed to be able to evaluate if they are learning, how they are learning to different extents and at the same time, achieve one or more of the following:

1. Make thinking and learning more visible through the use of metacognitive questions
2. Identify strengths and areas for improvement in specific topics for each Science
3. Identify misconceptions in learning
4. Identify next steps to take in order to achieve learning objective(s)
5. Evaluate and improve effectiveness of learning and study habits

SURVEY

A survey consisting of questions adapted from “Self-Directed Learning With ICT: Theory, Practice and Assessment (ETD, 2011)” was also crafted and administered to Secondary Three Express students in 2013 and to Secondary Four Express students in 2014. The team plans to re-administer the survey at a later time this year to include the current Secondary Three Express students. Students were asked to respond by choosing the frequency ranging from “Never” to “Very Frequently” that applies for each of the survey question, These questions

can be broadly categorised as those relating to "Management and Monitoring", and those relating to "Taking Ownership of Learning". A copy of the survey administered and the results can be found in Annex B.

The survey was administered to help assess the effectiveness of use of AaL and the tools and strategies employed to help develop the students to become more self-directed learners over a longer period of time and help the team facilitate the planning and development of the AaL tools and strategies used by:

1. getting students to identify the various AaL strategies which they may have been using in their learning and daily work
2. getting a better sense on students' perception on how they monitor their own learning, how they know that they are learning and what do they do if they do not understand their learning based on survey results
3. helping teachers to better understand students' self-monitoring strategies in their learning of Science

SURVEY RESULTS AND ANALYSIS

It was observed that there is an increase in the percentage of students who had picked the options "Frequently" and "Very Frequently" for all survey questions from 2013 to 2014. It was also observed that there is a decrease in the percentage of students who had picked the options "Rarely" and "Never" for all survey questions from 2013 to 2014 and that the percentage of students choosing "Never" was consistently the lowest of the five options which had been provided for all questions over the two years. Furthermore, a majority of students had picked the options "Frequently" and "Very Frequently" for all questions over the two years. These results strongly suggested that:

1. students were utilising the self-monitoring strategies introduced in their daily work
2. a majority of them were utilising these strategies regularly
3. some of the students have went on to utilise these strategies more regularly and perhaps to some extent, more pervasively

With regard to individual strategies, it was observed that many students did not have a habit of making a list of the learning tasks which they had to carry out for Science as only 50% of respondents indicated that they did this frequently or very frequently in 2014 even though it was an improvement from 43%. It was also seen that 62.5% of students surveyed regularly did up a timetable to monitor their revision for the tests and examinations in 2014 as opposed to only 30% of students surveyed in 2013. In addition, 65% of respondents regularly set deadlines to complete their learning tasks in 2014 as compared to 45% in 2013. These three strategies were in contrast to the other strategies posted in the survey, in which a majority of respondents indicated that they regularly practised them.

The survey results from 2013 proved useful for the team in identifying which tools and strategies need to be further developed and how to introduce these strategies to the students so that they would be able to apply these more regularly and pervasively when compared against the results obtained in 2014. For example, one of the general strategies which was being developed was the use of checklists to help students keep track of their own learning, and knowledge of students' current habits helped the team to identify and modify the tools which students are not using as regularly and how best to introduce and pitch some of these tools and strategies to the students more effectively as seen from the survey results from 2014.

In analysing the survey results from 2013, several areas of concern were highlighted by members of the PLT then. As the survey was administered by a particular subject teacher for each class, students may have had the impression that the survey was to be done under the context of that subject alone. For example, a student who received the survey from his Physics teacher may have thought that he was being asked about the frequency with which he used each self-monitoring strategy for Physics alone. However, the intention of the survey was for students to gauge the frequency with which they used each self-monitoring strategy across all the science subjects which they took. As such, the results obtained may not be accurate unless students uniformly apply each self-monitoring strategy across all the sciences.

In order to mitigate this, students were reminded at the start of the survey in 2013 that they should respond based on their study habits for all their science subjects but students may not have registered this and continued to provide responses under the assumption that the survey was being done only for that particular subject. In 2014, the administering of the survey was further improved by getting students to complete the survey online in addition to the mitigating actions taken in 2013. This helped to remove the presence and effect of the teacher on the students while they are doing the survey since students seemed less likely to associate the survey with a particular subject.

Taking into consideration the concerns which have been raised in 2013 and comparing the results obtained from the two surveys, the team was able to leverage on the results obtained in 2013 to plan how to teach and encourage the use of the various self-monitoring strategies more effectively. The team also noted that there may be other areas of concern raised in 2014 and would continue to work on improving the implementation of future versions of the survey in order to include self-evaluation strategies and to improve on the accuracy of the results obtained.

EVIDENCE OF IMPACT ON STUDENT LEARNING

Students were given time after the lesson study observations and lessons to reflect on their learning and how useful they found these AaL strategies that were introduced to them and small focused group discussions were carried out with selected students to elicit feedback as well. Feedback gathered by the students through qualitative questions regarding the usefulness of the self-monitoring tools and strategies introduced and their level of confidence in problem solving and answering questions includes the following:

1. an increase in students' level of confidence in their ability to start and solve similar problems improving students' ability to internalise steps in checklist(s) to guide themselves to solve similar problems
2. enhancing students' ability to identify relevant key points and their own misconceptions of the topic(s)
3. enhancing students' ability to simplify / clarify questions and problems and helping students to remind themselves to elaborate on their answers
4. raising awareness of quality of students' answers and how to improve own answers
5. developing ability of students to be more self-directed in carrying out self-analysis and reflection of own answers.

The feedback given by students was congruent to the observations made by teachers about the quality of students' answers to commonly asked questions and students' learning and study habits in general. Generally, the teachers agreed that with the use of checklist and success criteria, students' answers were more complete and organised, with the necessary key points and key words. Some students were also able to articulate the success criteria when prompted by their teacher and some commented that they observed that some students are now able to better focus on the relevant points required to help them solve problems. It was also observed that some students also used the checklist during consultation session with their teachers to clarify their doubts for the objectives that they identified to be at the 'Red' and 'Amber' level which is an example of students using of a self-monitoring tool to monitor their learning and after evaluating how well they have learnt or whether they have achieved the learning objective, go on to take the necessary next steps to advance their learning.

Given that both success criteria and checklist(s) proved to be useful for the students, the teachers have since used these self-monitoring tools and strategies more extensively and explicitly in the teaching and learning of Science, extending their use to most, if not all of the learning materials and notes, and to different extents, graded assignments. The team is looking to continue our work in further developing the tools and strategies used by students for self-evaluation and planning for its extensive use in the teaching and learning of the three different Sciences.

CONCLUSION

Through this project, the team concluded that self-monitoring tools such as flow charts, success criteria and checklists helped to increase students' level of confidence in solving problems and answering questions and at the same time develop students' independence and self-directedness in learning. The team also noted that the above mentioned are possible only after students have sufficient practice to help them internalise these self-monitoring tools and strategies. Only when students become sufficiently proficient in the use of these are they able to apply and extend the use of such tools and strategies to other areas of learning.

Moving forward, with the resources developed in 2013, the team has already embarked on the next phase of the project in 2014 by further developing the existing self-monitoring tools and strategies while focusing on the development and refinement of self-evaluation tools and strategies that are being employed and explored.

ANNEX A - SUMMARY LIST OF SELF-MONITORING TOOLS & STRATEGIES

	Self-Monitoring Tools & Strategies			**Self-evaluation Tools & Strategies**		
Subject	**Flow chart**	**Success criteria**	**Checklist**	**Checklist**	**Metacognitive questions**	**Learning Log**
Biology Description of usage of tool	X -	√ – Answering of free response questions and understanding of specific topics – General approach for design experiment	√ – Holiday homework – Assessment objectives for each topic	√ – Notes – Checklist for monitoring of overall progress and evaluation of learning	√ – Notes – Solving of problems – Evaluation of learning	X -
Chemistry Description of usage of tool	√ – Process questions and problems	√ – Answering of free response questions – Answering of data-based questions	√ – Daily and holiday homework – Assessment objectives of each topic	√ – Notes – Checklist for monitoring of overall progress and evaluation of learning	√ – Notes – Solving of problems Evaluation of learning	X -
Physics Description of usage of tool	X -	√ – Answering of free response questions and data-based questions – Requirements of Science Practical	√ – Solving contextual application questions – Assessment objectives for each topic	√ – Notes – Checklist for monitoring of overall progress and evaluation of learning	√ – Notes – Solving of problems Evaluation of learning	√ – Students' own learning log consisting of notes and reflection of learning*

*Student initiative

ANNEX B – SURVEY RESULTS

	2013					2014				
Behavioural Indicators	**V.Fre**	**Fre**	**Oca**	**Rare**	**Never**	**V.Fre**	**Fre**	**Oca**	**Rare**	**Never**
I make a list of learning tasks for Science.	5%	38%	40%	12%	5%	10%	40%	40%	7.5%	2.5%
I set deadlines to complete these learning tasks.	9%	36%	35%	15%	5%	12.5%	52.5%	27.5%	6.5%	1%
I know which parts of my lessons I do not understand.	20%	62%	14%	5%	0%	22.5%	65%	10%	2.5%	0%
I can identify what I need to know or do in order to understand these parts.	18%	56%	21%	5%	0%	18.5%	57.5%	21.5%	2.5%	0%
I try to understand where I went wrong in my homework/assignments/ tests.	21%	55%	18%	6%	0%	36.0%	51%	10%	2.5%	0%
I take action to fill up the gaps in my understanding.	14%	50%	31%	5%	0%	27.5%	60%	10%	2.5%	0%
I am able to identify keywords that are required in my answers	16%	54%	25%	5%	0%	20%	51.5%	23.5%	5%	0%
I have my own timetable to monitor my revision for my tests and exams.	7%	23%	39%	16%	16%	21%	31.5%	26.5%	15%	6%

Legend: **V.Fre: Very Frequently** **Fre: Frequently** **Oca: Ocassionally** **Rare: Rarely**