


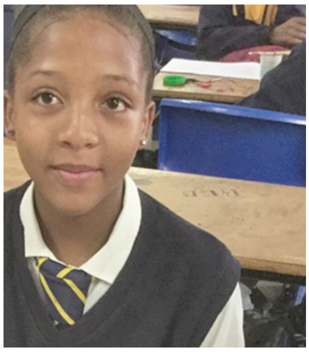
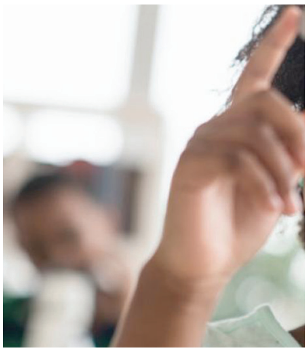

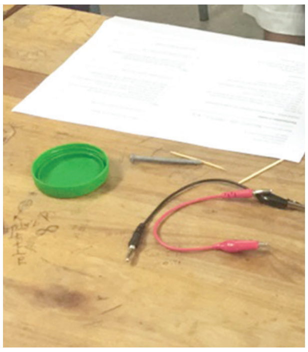
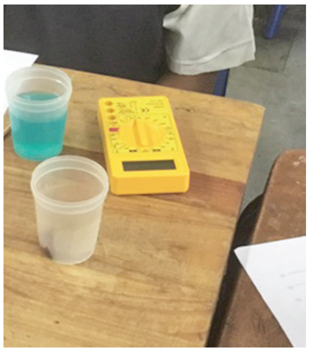

AN EVALUATION OF THE IMPACT OF THE SIEMENS STIFTUNG 2016 EXPERIMENTO PROGRAMME IN THE WESTERN CAPE


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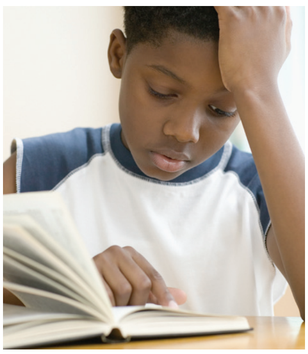


An Evaluation of the Impact of the Siemens Stiftung 2016 Experimento Programme in the Western Cape

SUBMITTED BY

The Schools Development Unit
School of Education
University of Cape Town
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SIEMENS | Stiftung

Contents

1. EXECUTIVE SUMMARY

The Schools Development Unit (SDU) was tasked with evaluating the Experimento teacher development programme run in the Western Cape, South Africa in 2016. This was done by exploring how the Experimento 8+ and 10+ kits, the short courses, access to the Siemens media portal and school-based support have impacted on teachers' thinking and practice, focusing particularly on curriculum implementation with respect to science practical work.

Ten primary school teachers and 10 high school teachers completed the programme. The extent to which these teachers were using the kits and implementing the teaching approaches and methodologies promoted by the programme, was explored. The data sources used in this study included lesson observations, teacher interviews, teacher reflections, and scrutiny of the teaching and learning materials used in the lessons.

It was found that the kits and experiments have the potential to support the implementation of the Science curriculum from Grade 4 to 12. Teachers found the kits and some of the experiments useful and they report that it has impacted on their practice. However, the Experimento task sheets were seldom used and the more learner-centred approaches to scientific inquiry were seldom implemented. A number of recommendations have been made which could further improve the value and effectiveness of the Experimento programme.

2. CONTEXT AND PURPOSE OF THE EVALUATION

The Siemens Stiftung, working in close collaboration with local educational institutions, has implemented an international Experimento programme in Chile, Peru, South Africa, Nigeria and Germany. This programme aims to promote and model inquiry-based instruction by providing teachers with a set of inquiry-based activities, all the necessary resources to implement these activities, as well as exposure to strategies which promote a more learner-centred pedagogy. The programme is currently offered in four South African provinces and is presented as three progressive modules targeting teachers of learners in three different age groups namely:
Experimento 4+ (ages 4 -7),
Experimento 8+ (ages 8 -12) and
Experimento 10+ (ages 10 -18).

The Experimento 8+ and 10 + programmes were offered in the Western Cape in 2016 and targeted primary school teachers and high school teachers respectively. Each of these programmes consisted of a 15-hour long short course. At the end of the course each school represented received a box containing all the resources needed to do the activities in the accompaying manual. Teacher-conducted hands-on experiments and strategies that promote learner-centred, cooperative learning were discussed and modelled. Teachers were also given access to the Siemens media portal where additional resources are available. In addition, all teachers were offered school-based support to implement one or more of the activities or to use the resources for curriculum-related activities.

The purpose of this study was to evaluate the effectiveness and value of the Experimento programme by exploring how the Experimento 8+ and 10+ kits, the short courses, access to the Siemens media portal and school-based support has impacted on teachers' thinking and practice.

3. SCOPE AND LIMITATIONS OF THE STUDY

The Experimento programme offered in 2016 was different to the programme offered in previous years. This study is confined to an evaluation of the impact of the 2016 programme across four schools and 10 teachers. It undertakes to explore the usefulness of the Experimento kits, as well as the teaching approaches and strategies covered in the short course in as far as it impacted on teachers' thinking and implementation of inquiry science instruction using a learner-centred, cooperative learning approach. The impact on learner performance was not considered in this study.

The focus of the Experimento programme is science practical work. However, given the fact that in the majority of South African schools very little hands-on practical work is undertaken, the assessment of the implementation of Experimento activities and ideas in the classroom was limited in this study to the one lesson taught as part of the assessment of the course, planning sessions with some teachers, and observation of at least one additional lesson. The opportunites to implement the activities were also limited by the non-alignment of the timing of the experiments done in the course with timing of the teaching of the related topic as prescribed by the National Curriculum.

Linked to the above point, a limitation of this study relates to teachers' limited experience in conducting hands-on practical work and most teachers were still using traditional, didactic methods in the classroom. To move beyond this point (and extending Vygotsky's concept of the "zone of proximal development" to teachers as learners), scaffolded interventions are required to assist teachers to develop the knowledge and skills required to facilitate open or minimally-guided scientific inquiry using a cooperative learning approach – considered the ideal by some researchers (Hattingh, Aldous & Rogan, 2007).

Given the limited engagement with teachers, school visits in most cases were confined to planning and preparing cookbook-type hands-on practical activities rather than on the full investigation cycle. It should also be noted that the Experimento programme was not designed to promote open-ended inquiries.

This qualitative study is presented as a case study. Case studies are context specific; the intention was not to make general claims about the impact of the programme. This, however, does not exclude the possibility of claiming some transferability of the findings of this study to teachers in similar contexts.

[1] This is clearly defined in each subject at each grade in the "Curriculum & Assessment Policy Statements" (or CAPs as they are commonly referred to).

4. ETHICS AND TRUSTWORTHINESS OF THE STUDY

All teachers were invited to participate in this study and were free to withdraw at any time (see consent form in Appendix A). The confidentiality of the teachers and the school was respected by using codes and by restricting access to the audio and video recordings to those involved in the research process.

Qualitative research often relies on evidence collected during the study to increase its credibility (Maxwell, 2008). Suggestions of how to reduce validity threats often include prolonged engagement, triangulation, rich data, respondent validation, comparisons (Bassey, 1999; Maxwell, 2008).

The researchers from the SDU were able to develop positive working relationships with some of the participants during the course of this study. Our presence and co-facilitation in some of the contact sessions, observation of one or more lessons and interviews with participants allowed us to build trust and reduced the risk of us making unfounded claims. Interviews were transcribed verbatim and some lessons were video recorded to provide a number of different sources of rich data to reduce the effect of bias (Becker, 1970) and these and other data sources, allowed for triangulation, thus reducing the risk of systematic biases (Maxwell, 2008).

5. THEORETICAL AND CONTEXTUAL BACKGROUND

Scientific Inquiry Learning and Teaching

Constructivism is a philosophy of learning that emphasises that knowledge is individually constructed by learners who are actively engaged (both behaviourally and mentally) and create shared meaning through social interaction. As constructivism gained popularity in science education in the 1970s, so did the focus on scientific inquiry (Minner, Levy, Century, 2009).

According to the American National Science Education Standards (2000, p. 23):

Scientific inquiry refers to the diverse ways in which scientists study the natural world and proposes explanations based on the evidence derived from their work. Inquiry also 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.

In recent years some consensus has been reached on the types of activities science learners should be engaging in the inquiry classroom. According the the National Research Council (NRC, 2000, p. 25), learners are engaged in scientific enquiry if they:

- engage in scientifically oriented questions
- rather evidence
- formulate explanations from evidence
- evaluate their explanations
- communicate and justify explanations.

Taitelbaum, Mamlok-Naaman, Carmeli & Hofstein (2008) developed a more extensive list which encompassed all of the characteristics above but also included "designing and conducting experiments".

What remains a fairly contested area is the interpretation of science inquiry instruction (Minner et al. 2009: Dudu, 2016) – what is it that the teacher should be doing in the inquiry classroom? One possible answer is provided by Minner et al., (2009), who characterized inquiry science instruction as having the following elements:

- the presence of science content
- student engagement with science content
- student responsibility for learning, student active thinking or student motivation within at least one component of instruction – question, design, data, conclusion, or communication. (p 5).

Cooperative Learning
Cooperative learning involves more than learners working in groups to complete a task. Cooperative learning is a teaching approach in which every learner, as part of a small group, is actively engaged, while working towards a common learning goal. At the same time learners develop personal skills such as listening, communication and collaboration. Johnson, Johnson & Holubec (1991), identified five key elements of co-operative learning. These are:

- positive interdependence
- individual accountability
- face-to-face interaction
- group processing
- social skillls development

A number of teaching strategies underpinned by one or more of these elements have been devised over the years. A few of these strategies, such as, the "think-pair-share" and the "jig-saw method", are modelled and discussed in the Experimento courses.

Teacher Professional Development

South African learners have performed dismally in international Mathematics and Science benchmark tests and in local tests such as the Annual National Assessments (Spaull, N, 2013). This can partly be ascribed to the fact that although the expected learning outcomes have changed significantly with educational reforms, classroom practices have remained largely unchanged. It is thus not surprising that in an effort to improve learner performance, greater emphasis has been placed on teacher development.

Numerous studies have shown that teacher professional development has limited positive impact on teacher knowledge and changing teaching practices (Supovitz & Turner, 2000; Dudu, 2016). Supovitz & Turner (2000) point out that Guskey (1986) attributed this to a poor understanding of what motivates teachers and a lack of insight into the factors that impact on the process of change.

According to the model developed by Belle and Gilbert (1996) the essential requirements for effective science professional development are that the programme should:

- involve teachers who acknowledged the need for acquiring new ideas and skills,
- provide teachers with an opportunity to discuss ideas amongst themselves and
- support teachers in implementing the new ideas and skills.

"According to the Experimento manuals the programme is based on the'principle of discovery-based learning'. Discovery-based learning is an instructional method associated with constructivist learning. "

The two shortcomings of previous teacher development programmes highlighted by Guskey (1986) seem to have been addressed by Belle and Gilbert 's model.

Many South African teachers have not experienced science inquiry instruction as learners in their own schooling. Yet it seems self-evident that as Windschitl (2003) has pointed out, teachers have to experience an inquiry-based approach to science teaching in order to implement such an approach themselves. Furthermore, Dudu (2015) concurs with Holland (2005) who argues that teachers are more likely to change their instructional strategies when there are clear links between their teacher professional development (TPD) and their daily teaching experiences, curriculum standards and assessments. In the South African context this means that all activities have to be closely aligned to the prescriptive current curriculum.

The South African Schooling System and Science Curriculum

The public schooling system in South Africa is typically divided into primary schools and high schools. Primary schools offer Grade R to Grade 7, aimed at learners from age 5 to age 12. High schools offer Grade 8 to Grade 12, aimed at learners from age 13 to 17.

The South African curriculum, is however, divided into four phases:

- Foundation Phase (FP) – Grades R - 3
- Intermediate Phase (IP) – Grades 4 - 6
- Senior Phase (SP) – Grades 7- 9
- Grades 10 -12 – Further Education and Training Phase (FET).

The Senior Phase therefore spans primary and high schools.

In the Foundation Phase science is not a separately defined subject but is embedded in the subject, Life Skills. In Grades 4 - 6 Natural Science and Technology (NST) is considered one subject, whereas in Grade 7- 9 there are separate Natural Sciences (NS) and Technology curricula. In Grades 10 -12 the Physical Sciences (PS) curriculum covers both Physics and Chemistry and the Life Sciences (LS) curriculum covers Biology.

The Curriculum and Assessment Policy Statement (CAPS) for each subject at each of the phases outlines the content to be covered, the teaching schedule and assessment protocols. The Sciences CAPS is quite prescriptive. It allocates times for the teaching of each topic and either suggests, recommends or prescribes practical activities.

The 2016 Experimento Teacher Development Programme

According to the Experimento manuals the programme is based on the "principle of discovery-based learning". Discovery-based learning is an instructional method associated with constructivist learning. Kirschner et al. (2006) view inquiry learning and discovery learning as equivalent approaches and understand it to be a completely unguided or minimally guided approach. They found these approaches to be ineffective and, based on their interpretation, make the claim that inquiry learning per se is ineffective.

However, based on their interrogation of the literature on inquiry science instruction, Minner et al. (2009) found that most researchers understand inquiry-based instructions to have some instructional guidance throughout the learning process. This could range from minimal guidance to strongly teacher-guided activities.

The Experimento manual states that Experimento "allows independent experimentation" which could suggest that it is completely unguided. However, most of the activities require learners to follow the given method and then to answer higher order questions. The manual also suggests that teachers "guide playful experimentation toward research-based learning" and that "hands-on" is not enough and that "scientific thinking and practice" embed the inquiry. There are a few instances where learners are asked to design an experiment to answer a scientific question. If teachers were to allow their learners to conduct these experiments as intended, it would meet the criteria for guided, inquiry-science instruction as outlined above.

As stated previously, the programme promotes cooperative learning. It does this by modelling laboratory organisational strategies such as the fun ways of forming mixed ability groups, the use of learning stations, and assigning roles in the group. It also focuses on different ways in which learners could collaborate within their groups for example, "think-pair-share". The quality of learner engagement is also addressed using "methodology tools" that support language (e.g. word strings) and facilitates the effective organisation of information for more effective learning (e.g. mind maps).

In 2016, two teacher development programmes were run by the Schools Development Unit (SDU) in collaboration with Siemens Stiftung facilitators. The format for both programmes was identical and each had the following inputs:

- An instruction manual containing teacher and learner materials to conduct a number of experiments.
- A teacher handbook which focuses on organisational and learner-centred teaching strategies.
- A box containing all the equipment and materials required to conduct the experiments with up to eight groups of learners simultaneously.
- A university approved and SACE (South African Council of Educators) accredited short course offered over five 3-hour-long sessions presented by Siemens Stiftung and university facilitators. In these sessions teachers performed some of the experiments included in the kit in order to familiarise themselves with the equipment and the activities. Some of the organisational and teaching strategies which promote cooperative learning were modelled in these sessions. Finally, teachers were given the opportunity to reflect on and discuss the broader purposes of science practical work in the science curriculum, the activities they performed, and the teaching and learning strategies employed.
- School-based support to assist teachers with the implemetation of some of the activities and ideas into their teaching.
- Exposure to the Siemens Media Portal where teachers are able to access additional resources.

The Experimento programme meets the requirements of an effective teacher development programme in that :

- Only teachers willing to learn attend the course since attendance is voluntary.
- The teachers have the opportunity to discuss science content and pedagogy amongst themselves.
- The teachers have the opportunity to engage in certain aspects of scientific inquiry themselves.
- Many of the activities are linked to their everyday teaching experiences.
- Teachers are supported with the implementation of new ideas through the school-based support offered by the SDU staff.

Each of the Experimento experiments consist of between two and six sub-experiments. Not all these were done during the short course due to time constraints. The experiments included in the 8+ and 10+ contact sessions are given in Table 1 because it is anticipated that teachers would be more likely to implement activities they did themselves.

The quality of learner engagement is also addressed using "methodology tools" that support language (e.g. word strings) and facilitates the effective organisation of information for more effective learning (e.g. mind maps).

FIGURE 1. Teachers engaged during the short course.

Experimento 8+ experiments	Method/Strategy used
Simple electrical circuits	Catalyst questions
Complex elecrical circuits	Catalyst questions, group work
Generating energy	Group work – group roles
Water purification	Group work & poster presentations
Recycling	Group work & poster presentations
Renewable energies	Group work & poster presentations
Nutrients	Working at stations
Hygiene	Working at stations
Repiration	Working at stations
Muscles and bones	Working at stations
Experimento 10+ experiments	**Method/Strategy used**
We store heat – from heat store to molten salt	Group formation, co-operative learning
Lemon batteries and other batteries	Jigsaw method
Renewable energies – sun, water, wind, hydrogen fuel cell	Poster presentations
We burn sugar – cellular respiration and breathing chain	Working at stations
Carbohydrates as providers of energy for metabolism – starch and sugar	Working at stations
pH value of beverages	Working at stations

TABLE 1 . Experiments teachers did during the short course

6. METHODOLOGY

The purpose of this study was to evaluate the effectiveness and value of the Experimento teacher development programme. It was guided by the following research questions:

a) To what extent are teachers using the Experimento kits?
b) To what extent are teachers using the kits to promote inquiry science instruction?
c) To what extent are teachers are using the co-operative learning strategies and methodologies promoted in the progamme?

A qualitative research design, guided by an interpretive paradigm, was deemed the most appropriate and the study is presented as a case study.

THE DATA SOURCES

The data sources used in this study included:

1. Interviews with selected teachers (Appendix B – interview questions)
2. Video recordings and/or photographs of selected lessons
3. Teacher reflections on the contact sessions (Appendix C – example of teacher reflection)
4. Learning material used during the lesson
5. Researcher field notes
6. Experimento manuals and handbooks
7. CAPS documents

THE PARTICIPANTS

All teachers who attended the course did so voluntarily. They all teach in schools that serve working class communities in the Cape Town Metropole in the Western Cape. None of the primary schools have a science laboratory but each of the high schools do. These schools are generally poorly resourced with limited science equipment. The home language of the learners in eight of the 10 schools represented is IsiXhosa and the language of instruction is English. One primary school is a dual medium school in that the home language and language of instruction of some learners is Afrikaans and the rest of the learners are Isixhosa speaking and are taught in English. In one secondary school the home language and language of instruction is English.

The participants, the schools in which they teach, the subjects and grades they teach and the data captured for each participant are shown in Table 2. Teachers in primary schools are coded as PT and those in high schools, as ST.

A purposive sample of teachers from those who attended the courses were interviewed for this study. This sample consisted of five teachers in the Experimento 8+ programme working in two primary schools and five teachers in the 10+ progamme working in two high schools.

TABLE 2. Participants in the course

PRIMARY SCHOOL PARTICIPANTS IN THE PROGRAMME					
Teacher	**School**	**Science subjects they teach**	**Interviews**	**Classroom observation**	**Reflections**
PT1	P1	6 NST	✓	✓	✓
PT2		7 NS	✓	✓	✓
PT3		5 NST			✓
PT4	P2	7 NS	✓	✓	✓
PT5		6 NST	✓	✓	✓
PT6		5 NST	✓	✓	✓
PT7	P3	5 NST			✓
PT8		4 NST			✓
PT9	P4	5 & 6 NST		✓	✓
PT10	P5	6 & & NST		✓	✓
SECONDARY SCHOOL PARTICIPANTS IN THE PROGRAMME					
Teacher	**School**	**Science subjects they teach**	**Interviews**	**Classroom observation**	**Reflections**
ST1	S1	8 NS, 10 PS, 11 PS, 12 PS	✓	✓	✓
ST2		10 LS, 11 LS, 12 LS	✓	✓	✓
ST3		9 NS, 10 PS	✓	✓	✓
ST4		8 NS, 10 LS	✓	✓	✓
ST5	S2	9 NS, 10 LS, 11 LS	✓	✓	✓
ST6		8 NS		✓	✓
ST7	S3	10 PS, 11 PS, 12 PS		✓	✓
ST8	S4	9 NS		✓	✓
ST9	S5	9 NS, 10 PS			

FIGURE 2. Plant clip, digital thermometer and multimeter

DATA ANALYSIS

The different data sources were analysed using an analytical framework consisting of three broad categories guided by each of the research questions. These categories are:

1. Use of the Experimento equipment and activities:
   - i) Equipment: – teachers' perceptions of usefulness of equipment
     – ways in which equipment was used and managed
   - ii) Experiments – alignment with CAPS
     – experiments done in classrooms
   - iii) Task sheets – use of task sheets
2. Extent of inquiry-science instruction - inquiry science instruction conceptual framework developed by Minner et al. (2009)
3. Extent of implementation of cooperative learning and other strategies - five elements of cooperative learning, use of other strategies

7. RESULTS AND DISCUSSION

Use of the Experimento equipment and activities

EQUIPMENT

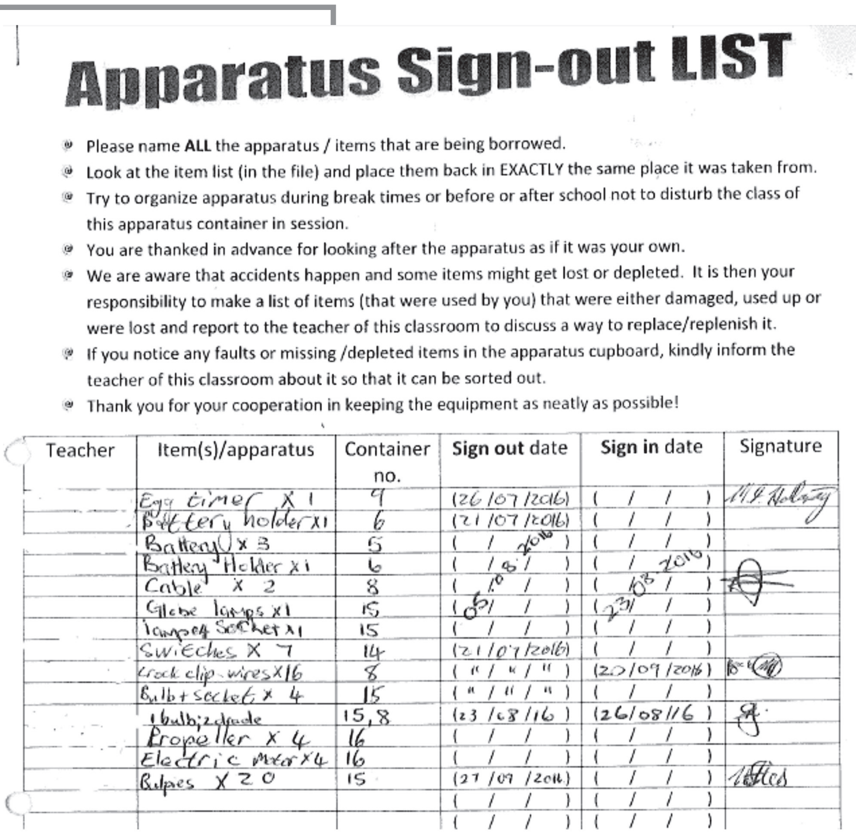
Each of the schools had limited equipment before they received the Experimento kit but appreciated the additional equipment. Nine of the ten teachers interviewed thought the equipment was very useful, describing the equipment as "excellent", "helpful", "relevant", "made life easier" (e.g. Appendix B). The one teacher who teaches only Life Sciences in Grade 10 to 12 did not find the equipment or activities relevant to her teaching. Many of the items in the boxes are basic items which could be purchased from supermarkets or hardware stores. One teacher commented on this, saying, "I have learned that simple equipment can be used to do practicals".

Teacher PT2 reported that he found the egg timer particularly useful, not only for practical work, but also as a timing device for other classroom activities. Teacher ST5 found the plant clips, multimeters, digital thermometers and magnets most useful (Figure 3).

Teacher PT2, the Science Subject Head at his school, put a system in place to manage the equipment. The register (Figure 3) he keeps indicates that the electrical equipment was used not only by the teachers that attended the programme but by two other colleagues as well.

Two teachers indicated that the way equipment is packaged, facilitated preparation for the lesson. One teacher explained: "The fact that you have a file so that you know what is in the box and how many, makes work effectively" (Appendix D). Most science classes across the four schools have between 30 and 45 learners per class. Although in the interview only one teacher stated that there was not enough equipment to cope with the large classes, saying it "causes noise making from fighting over limited resources" (Appendix E), during the school visits a number of teachers expressed this reservation. The number of sets of equipment available resulted in groups

FIGURE 3. Equipment register



Apparatus Sign-out LIST

- Please name **ALL** the apparatus / items that are being borrowed.
- Look at the item list (in the file) and place them back in EXACTLY the same place it was taken from.
- Try to organize apparatus during break times or before or after school not to disturb the class of this apparatus container in session.
- You are thanked in advance for looking after the apparatus as if it was your own.
- We are aware that accidents happen and some items might get lost or depleted. It is then your responsibility to make a list of items (that were used by you) that were either damaged, used up or were lost and report to the teacher of this classroom to discuss a way to replace/replenish it.
- If you notice any faults or missing /depleted items in the apparatus cupboard, kindly inform the teacher of this classroom about it so that it can be sorted out.
- Thank you for your cooperation in keeping the equipment as neatly as possible!

Teacher	Item(s)/apparatus	Container no.	Sign out date	Sign in date	Signature
	Egg timer X 1	9	(26/07/2016)	(/ /)	[illegible]
	Battery holder X1	6	(21/07/2016)	(/ /)	
	Battery() x 3	5	(/ 2016)	(/ /)	
	Battery Holder x1	6	(/ 08 /)	(/ 2016)	[illegible]
	Cable X 2	8	(10 / /)	(08 /)	
	Globe lamps x1	15	(05 / /)	(23 / /)	
	lamp of Socket x1	15	(/ /)	(/ /)	
	Switches X 7	14	(21/07/2016)	(/ /)	
	Crock clip wires X16	8	(" / " / ")	(20/09/2016)	[illegible]
	Bulb + socket X 4	15	(" / " / ")	(/ /)	
	1 bulb; 2 diode	15,8	(23/08/16)	(26/08/16)	[illegible]
	Propeller X 4	16	(/ /)	(/ /)	
	Electric Motor X4	16	(/ /)	(/ /)	
	Bulbes X 20	15	(27/07/2016)	(/ /)	[illegible]
			(/ /)	(/ /)	
			(/ /)	(/ /)	

consisting of up to eight learners. A number of teachers also raised the question about where additional equipment or replenishments of equipment and chemicals could be purchased.

In many cases teachers used the Experimento equipment to do experiments which were not included in the Experimento programme. These included lessons on acids and bases, electric circuits and the test for starch. Figure 4 shows high school learners using the multimeters from the 10 + kit and the incandescant lamps and lamp holders from the 8+ kit in an activity they designed with the support of the Experimento facilitator as part of the school-based support.

EXPERIMENTS AND TASK SHEETS

As noted earlier, a number of studies have found that South African teachers conduct very few practical lessons with their learners (Hattingh et al., 2007; Rogan & Aldous, 2005). Anecdotal evidence suggests that these practicals are generally confined to those prescribed in CAPS or by the Subject Advisors in a particular Education District . Teachers often attribute their failure to engage in practical work to the impact of the CAPS curriculum which is highly prescriptive and content-heavy.

Given these circumstances, it is thus unlikely that resources such as the Experimento activities and equipment will be utilised extensively unless the activities are closely aligned to CAPS. Because of this, the links between each of the Experimento experiments and the Grades 4 –12 Sciences curricula were carefully considered by the researchers. To this end, Tables 3 and 4 list the 17 experiments contained in the 8+ manual and the 18 experiments in the 10 + manual respectively, and show the links to the CAPS content and its prescribed and/or recommended experiments. Since there are no prescribed experiments in the primary school curriculum only recommended activities are indicated.

The 8+ activities correspond closely with 14 topics across the Grade 4-6 curriculum, and 9 of these link directly to the recommended experiments. Only one experiment was aligned with a recommended Grade 4 practical and none aligned with the recommended Grade 7 practicals. The 8+ programme seems to be best suited to Grade 6 teachers.

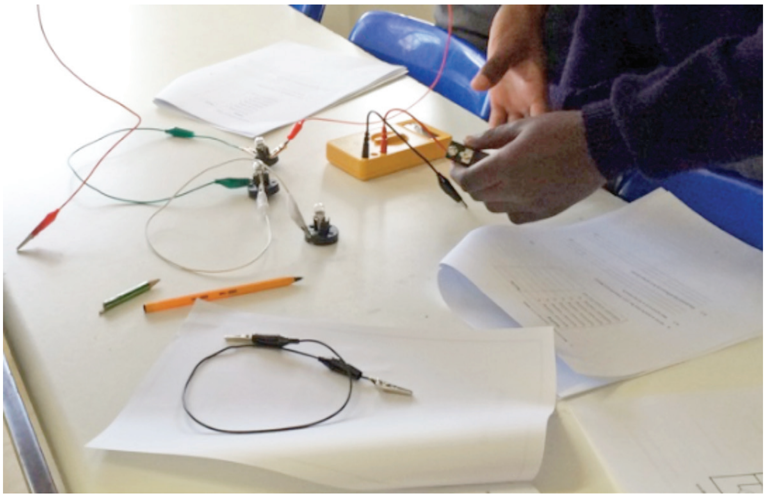


FIGURE 4. High school learners using multimeters

The 8+ experiments also link with eight topics covered in High School. One of the 8+ experiments is recommended for Grade 11 Life Sciences. Extracts from the Experimento manual and the Grade 10 – 12 Life Sciences CAPS show this alignment (Figure 5).

Extract from Experimento Manual	Extract from CAPS
Build your own model of the lungs!	Construct a model of the human breathing system. Explain the limitations of the model

FIGURE 5. Extracts from Experimento 8+ experiments and the Grade 10 – 12 Life Sciences CAPS.

There are three expriments aligned with Grade 8 recommended practicals and two with Grade 9. The only experiment that has no links with the current South African CAPS Sciences curricula is the one on the sense of hearing.

The 10+ programme was attended by high school teachers. The Physical Sciences and Life Sciences CAPS provides a list of prescribed and recommended practical activities.

The activities in the 10+ programme align closely with three of the recommended practicals in Grade 6 and six in Grade 7, making these appropriate for primary school teachers as well. Five experiments align with practicals in Grade 8, five in Grade 9 and five in Grade 10 Physical Sciences. There is one linked to Grade 11 Life Sciences , two to Grade 11 Physical Sciences and two to the topic of Electrochemistry in Grade 12 Physical Sciences.

In total then, 28 of the activities can be used

"Teachers often attribute their failure to engage in practical work to the impact of the CAPS curriculum which is highly prescriptive and content-heavy".

Experiment	Grades	Topics in CAPS	Recommended CAPS experiment
Energy			
Simple electrical circuits	5 6	Energy and electricity Electric circuits	✓ ✓
Conductors and insulators	6	Electrical conductors and insulators	✓
Complex electrical circuits	8	Series and parallel circuits	✓
Adjusting electrical circuits	5 6	Safety with electricity Illegal connections	✓
Generating energy	6	Renewable ways to generate electricity	✓
Environment			
Water cycle	4 4 10	Water cycle What plants need to grow Transpiration	
Water purification	6	Processes to purify water	✓
Air pollution	5	Burning fuels	✓
Wind	8	Pressure	
Recycling	4	Solid materials	
Renewable energies	7	Renewable and non-renewable sources of energy	
Health			
Nutrients	6 9	Nutrients in food Healthy diet	✓ ✓
Hygiene	8	Chemical reactions	✓
Sense of hearing			
Sense of vision	8	Visible light	✓
Respiration	9 11	Respiratory system Human gas exchange	✓ ✓
Muscle and bones	4	Strengthening materials	✓

TABLE 3. Alignment of Experimento 8 + experiments to CAPS

as recommended practical activites and two as prescribed activities. A project on the purification and quality of water is prescribed for Grade 10 Physical Sciences. The three activities related to Experimento's "We produce drinking water – methods of purifying water" and the additional questions provided could form the basis for such a project. The activity "carbohydrates as providers of energy for metabolism – starch and sugar" could be used for the tests for starch and proteins listed as essential activities for Grade 11 Life Sciences.

- Investigating the chemical reaction that takes place when a whole egg is placed in white vinegar

FIGURE 6. Extract from CAPS, Natural Sciences, Senior Phase Grade 7 – 9, p.45

In the workshop, the "acid on the teeth" sub-experiment under Hygiene, was modified. Instead of using pieces of eggshell as instructed in the Experimento task sheet, whole eggs were used and this is one of the investigations recommended for Grade 8 under the topic of "Chemical Reactions".

Given that there are so many links with the curriculum, the Experimento activities certainly have the potential to support the implementation of the Science curriculum from Grade 4 to 12.

Although all teachers thought that the activities were aligned with CAPS for Natural and Physical Sciences, four high school teachers, who are familiar with the Life Sciences curriculum, indicated that the activities were not aligned to Life Sciences curriculum (Appendix E).

Experiment	Grades	Topics in CAPS	Prescribed CAPS experiment	Recommended CAPS experiment
Energy				
Electric current from solar cells	7 9 12	Sources of energy Electricity generation Electrochemical reactions (PS)		✓ ✓ ✓
We store heat – from heat store to molten salt	7 7 8 10 11	Physical properties of materials Insulation and energy saving Change of state Thermal conductors and insulators(PS) Chemistry of water (PS)		✓ ✓ ✓ ✓ ✓
Lemon batteries and other batteries	8 9 10 10 11 12	Electric circuit Series and parallel circuits Electric circuits (PS) Reactions in aqueous solutions (PS) Redox reactions (PS) Electrochemical reactions (PS)		✓ ✓ ✓ ✓ ✓ ✓
Evaporation heat – how to cool with heat	8	Change of state		✓
Properties of solar cells – voltage, current, power	7 10	Sources of energy Electric circuits (PS)		✓ ✓
Environment				
Water cycle – evaporation from plant leaves	10	Hydrosphere (PS)		
Greenhouse effect in a drinking cup	7 9 11	Sources of energy The greenhouse effect The atmosphere and climate change (LS)		
How does waste separation work? – separation by density and magnetism	7 8	Separation of mixtures Density		✓ ✓
We produce drinking water – methods of purifying water	6 7 8 10	Processes to purify water Separation of mixtures Conservation of the ecosystem Hydrosphere (PS)	✓	✓
We build a thermal solar power plant	7 11 11	Sources of energy Geometric optics (PS) Energy resources (PS)		
Renewable energies – sun, water, wind, hydrogen, fuel cell	6 7 11 12	Renewable ways to generate electricity Sources of energy Energy resources (PS) Electrochemical reactions (PS)		✓
Capacitor, hydrogen, redox flow- we store renewable energy	9	Electricity generation		✓
Health				
We burn sugar – cellular respiration and breathing chain	8 11	Respiration Energy and chemical change (PS)		
Carbohydrates as providers of energy for metabolism – Starch and sugar	6 8 9 10	Photosynthesis Photosynthesis Digestive system Organic compounds (LS)	✓	✓ ✓ ✓
How does human digestion break down fats?	9 11	Digestive system Types of reactions (PS)		
pH value of beverages	7 9	Acids, bases and neutrals Acids and bases, and pH values		✓ ✓
What functions does the skin have?				
Skin and hygiene	9 11	Acids and bases, and pH values Molecular structure and intermolecular forces(PS)		

FIGURE 7. Making paper experiment in progress.

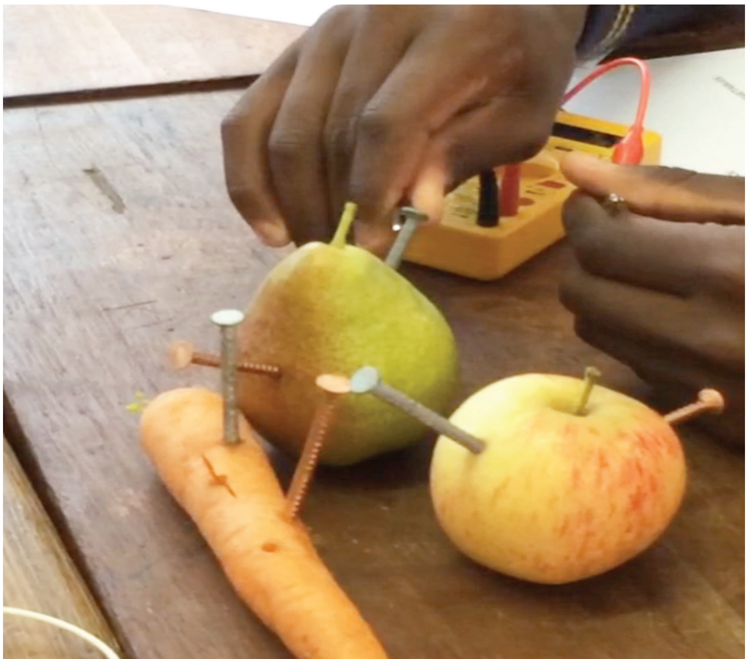


FIGURE 8. Lemon battery experiment

Refering to the experiment in which the egg is placed in vinegar, one teacher pointed out that the activity was " the same as in the prescribed CAPS textbook" and another pointing out that one of the air pollution experiments in Experimento 8+ is included the Grade 5 curriculum. Two teachers suggested that more of the CAPS prescribed experiments should be included (Appendix E).

Ony one teacher, Teacher PT2, conducted one of the Experimento activities, "Making new from old: making paper" using the learner task sheets provided.

In some cases the Experimento experiments were undertaken but teachers either used task sheets from a different source or developed their own (See Appendix F for an example of a worksheet used by HT5). Teacher ST5, for instance, did the lemon-battery experiment (Figure 8) using a learner sheet she developed herself.

The teacher did this experiment as a formal practical assessment task. These tasks often have to conform to a particular format determined by the Departmental Subject Advisors. For this activity the teacher indicated the total mark allocation for the task had to be 20 marks and that the task had to contain questions at a range of cognitive levels. The Experimento activities were not designed as formal assessment tasks and thus no marks are allocated for performing any actions or answering any questions. She also thought that her learners would not be able to answer the questions in the Experimento task, represented in Figure 9, without scaffolding questions.

1.5 Analysis

Summarize your results in the following form:

- The motor with propeller runs when…
- The LED lights up when…
- The multimeter indicates…

1.6 Questions

What do you think: Does the electricity really come from the lemon, or what is the real source?

FIGURE 9. Extract from student sheet for experiment A3, Experimento 10+, page 3 of 14.

Teacher PT4 and teacher ST3 replicated the experiments on series circuits (Figure 10) and the cooling curve of water respectively. Both teachers developed their own worksheets for formal assessment purposes.

Most teachers thought the activities were suitable for their learners. Besides teacher ST5 who thought the Experimento 10 + activity sheets were too diificult for her learners, one Primary School teacher also felt some task sheets "may be too diificult to understand". The teachers teaching at the school where they teach both English and Afrikaans classes felt the Afrikaans classes were disadvantaged since worksheets were not available in Afrikaans[2] (Appendix D).

Only two teachers accessed the media portal after the course. These high school teachers found a number of good resources on the portal but have not used any of these ideas in their teaching. Given that teachers general do the minimum number of practicals prescribed, and that the other experiments were not prescribed experimetns, it was not surprising that none of the teachers conducted any experiments that were included in the manual but not done in the workshops.

The Experimento contact sessions were held across Terms 1–3 of the South African academic year. The school-based support extended across this period. It must be noted that CAPS prescribes the content to be taught in particular weeks, thus teacher could only be expected to implement those activities which corrresponded to topics that they were mandated to teach at the time. Thus if the pH value of beverages was only covered in a contact session in the third term but the topic was caught in the second term, teachers would not have had the opportunity to implement this activity.

In summary, the equipment, although not always enough, was found to be useful. Whilst most of the experiments aligned to practical activities recommended in CAPS, the Experimento task sheets were seldom used, mainly because they were not suitable for formal practical asssessment purposes. All the teachers either used the activities sheet from other sources or designed their own worksheets. The number of Experimento experiments conducted in schools may have been influenced by the timing of the experiments in the course, in relation to the timing of the teaching of the topic.

EXTENT OF INQUIRY-SCIENCE INSTRUCTION

Since practical assessments are compulsory in CAPS it is not surprising that all teachers reported that they had been doing some practical work before attending the Experimento course. However, most reported that since participating in the programme they are doing fewer teacher demonstrations and that learners are now doing more experiments themselves. Most of the experiments done by learners before were for formal assessment purposes in which learners generally worked in groups, followed instructions, recorded their observations and then formulated a conclusion. The question is – were teachers engaged in inquiry science instruction?

The inquiry science instruction conceptual framework developed by Minner et al. (2009) (Figure 11) was used to determine the extent to which teachers were engaged in inquiry science instruction based on evidence provided by teachers or on lessons observed.

According to this framework, inquiry science instruction must pertain to the natural sciences such as Life Science, Physical Science or Earth and Space Science; or to Science as Inquiry. The learners must also be engaged in particular types of activities related to the science content and the instruction should emphasise i) learners taking responsibility for their own learning ii) active learner thinking and iii) learner motivation, as they engage in the investigative cycle.

PRESENCE OF SCIENCE CONTENT

All the practical activities observed or reported on by teachers were related to life or physical science content. Some of the topics included electric circuits , food tests, properties of matter. None of the lessons focussed on how scientists study natural phenomena.

TYPES OF STUDENT ENGAGEMENT

As stated previously, a number of teachers reported that since participating in the programme they do fewer teacher demonstrations and that learners are doing more hands-on practicals. When asked to reflect on how the Experimento programme

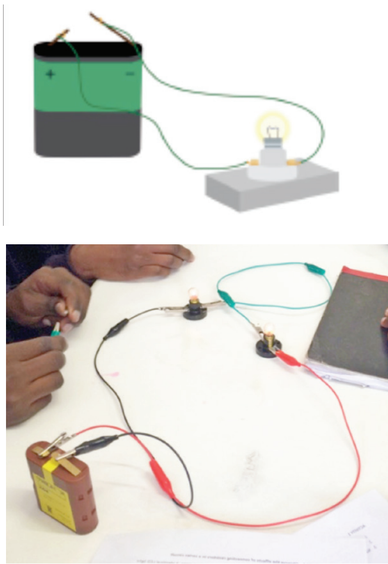


FIGURE 10. Experimento experiment replicated in the classroom.

"Whilst most of the experiments aligned to practical activities recommended in CAPS, the Experimento task sheets were seldom used, mainly because they were not suitable for formal practical asssessment purposes".

[2] Afrikaans is the Language of Learning & teaching (LoLT) in a significant number of schools in the Western Cape.

<table>
<tr><td>Presence of Science Content</td><td></td><td colspan="3">• Science as Inquiry
• Life Science
• Physical Science
• Earth and Space Science</td></tr>
<tr><td>Type of Student Engagement</td><td></td><td colspan="3">• Students manipulate materials
• Students watch scientific phenomena
• Students watch a demonstration of scientific phenomena
• Students watch a demonstration that is NOT of scientific phenomena
• Students use secondary sources (e.g., reading material, the Internet, discussion, lecture, other's data)</td></tr>
<tr><td colspan="2"></td><td colspan="3">Elements of the Inquiry Domain</td></tr>
<tr><td rowspan="5">COMPONENTS OF INSTRUCTION</td><td></td><td>Instruction emphasises Student Responsibility for Learning when it demonstrates the expectation that students will:</td><td>Instruction emphasizes Student Active Thinking when it demonstrates the expectation that students will:</td><td>Instruction emphasises Student Motivation when:</td></tr>
<tr><td>Question</td><td>Decide which question to investigate; seek clarification of the investigation question(s).</td><td>Generate investigation question(s); use prior knowledge to inform the question(s); consider or predict posible outcomes of the question; explore the reasons question(s) are being asked to determine if they are appropriate for scientific investigation; refine questions so that they can be investigated; discuss questions based on previous study or data collected.</td><td rowspan="5">It demonstrates the expectation that students will: display/ express interest, involvement, curiosity, enthusiasm, perserverance, eagerness, focus, concentration, pride (all affective)</td></tr>
<tr><td>Design</td><td>Identify when and where they need help understanding the design; ensure that they (or the class/group/partner) graps the design and how to implement it; decide what to investigation design to use; ensure that the design addresses the research question.</td><td>Use prior knowledge to inform the design; determine if the design is an appropriate match for the question including variables and procedures; debate the merits of different investigation designs and whether it is "doable" and will result in needed data; consider where and how issues of bias may need to be addressed; generate investigation designs.</td></tr>
<tr><td>Data</td><td>Decide the data organisation strategy; decide what data collection strategy to use and/or how to adapt it; identify if they or others need help collecting or organising data; seek out clarification and advice when it is needed.</td><td>Alter and refine their approach to gathering, recording, or structuring the data based on information they acquire as they proceed.</td></tr>
<tr><td>Conclusion</td><td>Decide what strategies to use to summarise, interpret or explain the data; identify when they or others need help in summarising, interpreting or explaining; and seek out other relevant information to assist in drawing conclusions.</td><td>Ensure that their conclusions are supported by their data; apply prior knowledge to summarise, interpret, or explain the data; construct conclusions; consider conclusions' reasonableness and credibility; identify applications of their findings to other situations and/or contexts; offer explanations for variations in the findings among the class and/or within their working groups; generate new questions that arise out of their explanations.</td></tr>
<tr><td></td><td>Communication</td><td>Decide how to structure their communication; seek advice and suggestion from others about how/what to communicate; provide feedback to others about their communication.</td><td>Engage in sound discussion and debate; demonstrate the logic they used to draw conclusions and interpretations; articulate the reasonableness and credibilty of other's work; discuss appropriate communication mechanisms including language, visual aids, technology, etc.; articulate the merits and limitations of their work.</td></tr>
</table>

Inquiry science instruction conceptual framework (adapted from Minner et al., 2009) has changed their practice, one teacher said that she learned about the importance of "learners being more hands-on" and that instead of doing teacher demonstrations she now takes on the role of a facilitator. Another teacher attributed this shift from demonstrations to hands-on practicals to the confidence she gained as a result of the programme and the availbility of the equipment (Appendix G).

All but one lesson observed or reported on were designed for the purposes of formal practical assessment. In these lessons learners worked in groups and typically had to manipulate materials according to instructions provided in a worksheet, record results, formulate a conclusion and answer a few questions. An example of such a worksheet is seen in Figure 12.

THE ELEMENTS OF THE INVESTIGATIVE CYCLE

The Experimento experiments are not open-ended discovery-based activities but learners who engage is these activities as intended would be engaging in scientific inquiry according to the criteria identified by the NRC (2000), as discussed previously. Thus, in most of the activities, learners are only given the opportunity to make the decisions regarding the way in which they formulate conclusions and the way in which they communicate their results.

However, all of the worksheets used in the observed classrooms comprised of activities that were carefully structured by the teacher. Consequently, they did not encourage learners to take responsibility for their own learning in any of the five components of the investigative cycle. Teacher ST1, for example, in an experiment investigating the effect of increasing the number of cells on the strength of the electric current, included the following question in the worksheet:

"1.2 Draw a line graph showing the relationship between an ammeter reading and number of cells. (6)" (Appendix H). The decision about how to communicate the results was thus predetemined by the teacher. The comment by one teacher that "learners learn a lot by discovering things on their own" here refers to learners manipulating materials themselves rather than a teacher demonstration and does not constitute a situation wherein learners' are encouraged to actually take much responsibility for their own learning.

Looking at the extent to which instruction emphasises active student thinking, the Experimento materials do this but in practice this approach is not carried through in teachers' worksheets which tend to emphasise the manipulation of materials and observations rather than critical thinking skills. In classrooms formulating explanations or conclusions based on evidence, discussions about their findings and interogations of explanations or conclusions, were the exception rather than the rule.

The Experimento materials are designed to tap into learners' natural curiosity and stimulate interest, by linking the activities to learners' daily lives and interests.

1. PRACTICAL ACTIVITY

AIM: how to use citrus fruit to make your own battery

1. Squeeze the fruit on all sides to make the juices inside flow.
   Do not break the skin of the fruit.
2. Push the nails or metal plates into the fruit so that the
   two ends are close to the centre, but not touching
3. Attach one end of the crocodile clip to one
   electrode and the other end of the voltmeter.
4. Observe what happens, take the reading from the voltmeter or multi-meter.
5. **Write a conclusion and answer the following questions**:
   - 5.1 What happens to the voltmeter or multi-meter? (1)
   - 5.2 Why would it be preferable to use a meter rather than an LED or a bulb? (1)
   - 5.3 Where does the electricity of this cell come from? (1)
   - 5.4 Give a more scientific name for the two metal objects/ plates. (1)
   - 5.5 What is an electrolyte? (1)
   - 5.7. What is fluid found that is found in a car battery? (1)
   - 5.8 If there are no chemicals, what else could be used to make a cell? (1)

FIGURE 12. Example of a typical worksheet

For example, some of the topics relate to shortages of drinking water and renewable energy. In practice, teachers' activities were often decontextualised, stand-alone activities sometimes done after the topic had already been taught. Based on the classroom observations many learners were keen to manipulate the materials and to complete the task, but very few displayed a real curiousity about the science involved. The novelty of doing hands-on experiments was one of the reasons for the excitement amongst some learners.

"The expressions on the faces of many learners and the squeals of delight when the light bulb glowed after connecting a circuit, also indicates a great sense of pride for completing the task".

The expressions on the faces of many learners and the squeals of delight when the light bulb glowed after connecting a circuit, also indicates a great sense of pride for completing the task. Teacher ST5 reported that :

> *I can see that learners are excited and interested as well. I realised that they can sense my passion and knowledge! The experiments we did are very simple and I will be able to do this with my learners.*
> (ST5 reflections)

The effective domain is to some extent emphasised by these cookbook-type experiments.

In practice then, although certain elements of inquiry science instruction were evident, learners were engaged mainly in the hands-on activity of gathering evidence but the important "minds-on" activities, such as formulating explanations based on their evidence, evaluating their explanations and justifying their explanations, were lacking.

EXTENT OF IMPLEMENTATION OF COOPERATIVE LEARNING AND OTHER METHODS

As outlined above, the Experimento programme promotes cooperative learning and a number of strategies to facilitate cooperative learning are demonstrated during the course. The programme also includes a focus on methodological tools, including those that support the development of langauge (including scientific language) and the use of mind maps, concept maps, etc.

The description of the extent to which cooperative learning was implemented in the classroom is guided by the five elements of cooperative learning on which we elaborate here:

Positive interdependence –
learners share a common goal and perceive that working together is beneficial both individually and collectively in a non-competitive environment. This may be structured by establishing mutual goals, joint rewards and assigned roles.

Individual accountability –
every learner is accountable for their own learning and individual learners are assessed and feedback is given to individuals and groups. This could be structured by giving individual tests or asking one group member to answer a question on behalf of the group.

Face to face interaction –
learners help, share ideas, encourage each other in order to promote learning. This is structured by seating learners in such a way to facilitate such intearactions.

Group processing –
learners reflect on how well they are working together to achieve their goals. This could be done by allocating time for structured reflection sessions.

Social skills development –
learners are explicitly taught social skills such as leadership, decision making, communication, conflict resolution.
(Johnson et al. 1991)

Learners were divided into groups of between five and eight in all observed lessons, depending on the resources available. For cooperative learning it is strongly suggested that groups are heterogenous and have a maximum number four. All but two teachers allowed learners to select their own groups in the lessons observed. The exceptions were teacher at ST5 who had grouped learners with mixed ability and teacher ST7 who grouped learners according to their height.

Some high school teachers allowed learners to work together while conducting the experiment but insisted that learners work individually when completing those sections of the task which required them to analyse the results. In one lesson a number of learners merely observed proceedings and then copied the results onto their answer sheets. The teacher however, reported that learners were working in groups and they were all participating. Learners in none of the high schools were assigned particular roles in the group, informal discussions related to the activity were confined to only a handful of learners in any particular class and there were no whole class discussions based on the activities. At the end of the lesson, worksheets were collected for the teacher to mark and the only feedback learners received was the mark they scored.

A warning often sounded is that group work is not cooperative learning (Johnson & Johnson, 2009). The lessons described above clearly illustrate this. Although learners were seated in groups around tables, a seating arrangement that would facilitate face-to-face interaction, and one teacher ensured that the group were heterogenous, none of the elements of cooperative learning were present. Teacher ST5 thought that cooperative learning would not work in my school because of "the type of learners I have and the size of my classes". The teachers also did not use any of the other strategies modelled in the course.

In the primary schools the situation was not significantly different. Teacher PT2 taught in a classroom in which the only flat surface was the teacher's table, at the front of a very crowded classroom. He set up four "work stations", a strategy demonstrated in the contact sessions of the programme, on his table about 1,5 m long and 900 mm wide (Figure 13). About 20 learners gathered around the table, allowing only a few learners to manipulate the materials while the rest watched from behind. In the reflection on the lesson during the school-based support, ways of facilitating the use of work stations were discussed and resulted in the teacher requesting the use of a classroom with flat desks for his science lessons.

Teacher PT1 at the same school also used work stations and reported that she found identifying a number of appropriate activities linked to the broader topic, challenging.

In another lesson teacher PT2 also assigned group roles to promote positive interdependence (Figure 14). Reflecting on the assignment of roles, he acknowledged that it was not as effective as expected and that he and the learners needed more practice in using this method.

Interviews revealed that the programme also broadens teachers' knowledge with regard to the preparation and management of practical lessons. PT1 reported that the main thing she learned was that "you need to plan well in advance and thoroughly" (Appendix D). Teacher ST5 commented on why it was important for teachers to do experiments beforehand. She thought it is important not only so that they know how to do it but also to learn what could go wrong and therefore be able to plan accordingly. Although not implemented by many teachers, they found the inclusion of the use of work stations, presentations, ways of constituting learner groups and assigning groups roles particularly useful. Two teachers said they now appreciated how simple equipment can be used for practicals. Referring to a planning session as part of the school-based support in primary schools, the teacher said he found the "… breakdown of the CAPS document topics into manageable and effective lessons …," extremely valuable (Appendix E).

Three primary school teachers reported that learner behaviour during practical lessons has improved and two claimed that learner performance has improved. This study did not attempt to verify these claims.

FIGURE 13. Four work staions on one table

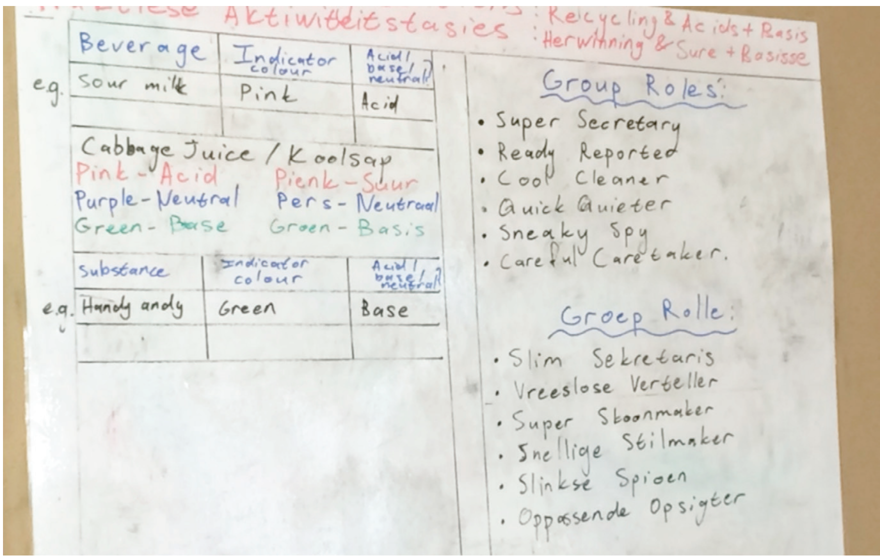


FIGURE 14. Group roles on the board

8. CONCLUSIONS

The equipment, although not always enough, was found to be useful for Natural Sciences and Physical Sciences. Whilst most of the experiments aligned to topics taught across Grades 4 to 12 Sciences, the experiments aligned particularly well with the Grades 6, 8 and 9 and Physical Sciences 10 activities recommended or prescribed in CAPS. The equipment and activities are not well suited to Grade 10 to 12 Life Sciences. A minor adjustment to the instructions on one of the worksheets would align it to one of the popular recommended practicals. The Experimento task sheets were seldom used, mainly because they were not suitable for formal practical assessment purposes. All the teachers either used activity sheets from other sources or designed their own worksheets.

"The opportunity for learners to manipulate the materials themselves created a sense of excitement and the successful completion of a task instilled a sense of pride. The value of this cannot be underestimated in a learning environment which is, as suggested earlier, often dominated by teacher-centred didactic teaching".

The Experimento materials promote mainly guided scientific inquiry in that in most experiments, student responsibility in the investigative cycle is limited to the conclusion and communication components. And since they do encourage active student thinking and emphasise the effective domain, they thus promote inquiry science instruction. The cooperative learning approach advocated is well suited to do just that.

Participation in the programme has shifted teachers' practice in that they are engaging their learners in more hands-on practicals as a result of increased confidence to do these in class and access to the materials required. Teachers, however, are adapting these activities for formal assessment purposes resulting in reduced learner responsibility, a virtual absence of active learner thinking and decontextualised activities. Despite this, the opportunity for learners to manipulate the materials themselves created a sense of excitement and the successful completion of a task instilled a sense of pride. The value of this cannot be underestimated in a learning environment which is, as suggested earlier, often dominated by teacher-centred didactic teaching.

Although learners were divided into groups, learners were not engaged in cooperative learning since sharing, discussion etc. were not encouraged. Although some of the strategies which facilitate cooperative learning were implemented by some primary school teachers, the absence of some of the other elements of cooperative learning resulted in lessons being less effective than anticipated.

It thus appears that despite access to equipment, resources and support, further interventions that scaffold the development of teachers' skills and knowledge to engage in the science inquiry instruction, using a cooperative learning approach, promoted by the Experimento programme is necessary.

9. RECOMMENDATIONS

1. A local supplier of the equipment has to be arranged. This supplier must be able to supply individual items, as well as the full kit. Teachers should be able to purchase equipment directly from the supplier.
2. More activities aligned to Grade 10 to 12 Life Sciences should be developed or the programme must only be offered to Natural Sciences and Physical Sciences teachers.
3. A number of experiments included in the 10+ box should be included in the programme offered to primary school teachers.
4. Some assessment tasks sheets that are very closely aligned with the curriculum that meet the requirements for formal and informal assessment purposes have to be developed. This should be done in consultation with teachers and the Subject Advisors.
5. Since teachers often use the CAPS-aligned textbook as a guide to their teaching, opportunities to use the Experimento equipment and methodolgies in the activities included in the textbooks should be explored with teachers.
6. Greater emphasis should be placed on the cooperative learning strategies in the contact sessions. This could be done by asking teachers to reflect not only on the practical activities they completed during these sessions but also on their teaching strategies that were modelled and discussed.
7. As teachers become more comfortable with engaging their learners in hands-on practical work, greater emphasis should be placed on supporting teachers with the implementation of the cooperative learning strategies. This has to be done at the school level. Facilitators and teachers should collaborately plan lessons, focusing not only on the activity but also on the pedagogy.

"A practical lesson is one of a series of lessons on a particular topic. Teachers should be supported with the development of a series of lessons on a particular topic incorporating an Experimento activity and the methodologies promoted in the programme".

8. A practical lesson is one of a series of lessons on a particular topic. Teachers should be supported with the development of a series of lessons on a particular topic incorporating an Experimento activity and the methodologies promoted in the programme.
9. Teachers' perception that practical work and cooperative learning cannot be done with large classes and with learners thought to be weak or poorly behaved have to be changed. This could be done by specifically addressing these issues in the planning of lessons and by facilitating or modelling such activities within these contexts.

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APPENDIX A

University of Cape Town Faculty of Humanities

Consent Form

Title of research project:	Siemens Experimento Project
Names of principal researcher:	Gillian Kay
Department/research group address:	Schools Development Unit, School of Education, Faculty of Humanities, UCT
Telephone:	Gillian Kay: 021 650 5326
Email:	gillian.kay@uct.ac.za

Name of partcipant: ……………………………………………………………………….

Name of school: ……………………………………………………………………….

Nature of the research:

Purpose of the research

The overall aim of the research is to investigate the impact of the Siemens Experimento project on the learning of participating teachers in South African schools. Furthermore: it aims to identify the strengths and challenges of the project, important for improving aspects of the project.

In light of the goal, we are video-recording all the workshop sessions, may conduct teacher interviews, focus group meetings with teachers and learners, classroom observations, record meetings, and a review selected documentation. We also hope to video-record classroom activities.

At all stages of the research process, we will not use your name, and will only use biographical information relevant to our research. If you should feel at any stage of the research process (before or during or after your interview) that you no longer want to participate in the research, you can withdraw your consent, and all data you have provided will be destoryed.

Although there are no foreseeable risks to taking part in this research, should you feel at risk in any way, you have the right to inform the researchers, and we will work with you to address any risk factors to the best of our abilities.

Should you need any further information, or should you wish to contact the researchers, please contact Gillian Kay at the above number**.**

What is involved: (Please tick what is appropriate)

□ Each workshop session will be video-recorded.

□ You agree to be interviewed regarding your views on the impact of the Experimento project on teaching and learning at your school. The interview will be audio-taped and transcribed. You may ask to view a copy of the transcripts at any time and they will be made available to you at a suitable time.

□ You agree to take part in a focus group meeting on issues pertaining to the project. This will be audio-taped and transcribed. You may ask to view a copy of the transcripts at any time.

□ Your classroom practice involving Experimento resources will be video-taped and used as a means for identifying the strengths and challenges of the project. The parents/guardians of all learners will be asked to give consent for them to participate. The learners will be free to ask any questions related to the research.

Risks: No risks have been identified that might befall you. In particular, this research will not be available for use by the WCED which might affect your teaching career in any way.
Benefits: Participants may benefit from the resources, knowledge and skills gained with the critical engagement with Siemens Foundation and Schools Development Unit staff. Furthermore, it is hoped that classroom pedagogy would be enhanced by involvement in the Experimento project.

Costs: No costs or payment are involved.

Participant's involvement: Consent to take part in the research

- I agree to participate in this research project. I have read this consent form and the information it contains and had the opportunity to ask questions about them. I understand that I will be given a copy of this completed form, to keep.
- I agree to my responses/classroom practices being used for education and research on condition my privacy is respected, subject to the following:
- I understand that any personal details included in the research will not be able to betraced back to me.
- Pseudonyms will be used when referring to the school and individuals.
- Videotapes of my classroom practice will be viewed by researchers on the project only**.** Videos will be shown at public arenas such as conferences and presentations **only with my explicit consent**.
- I understand that I am under no obligation to take part in this project.
- I understand I have the right to withdraw from this project at any stage.

Signature of Participant /

Guardian (if under 18): ——————————————————
Name of Participant / Guardian: ——————————————————
Name of Researcher: ——————————————————
Signature of Researcher: ——————————————————
Signatures of Principal Researchers: ——————————————————

Experimento evaluation teacher interview questions:

1. What grade or grades do you teach?
2. Did you do any practical work before you started Experimento?
3. If so, describe a few of these practicals:
   a) was it a teacher demonstration, did learners work in pairs or groups, etc.?
   b) what was the objective of the activity?
   c) describe what learners had to do?
   d) what was your role as the teacher?
   e) what resources did you use?
   f) was it used for assessment purposes (if so, what type of assessment)?
4. Tell me what the main things were that you learned at the Experimento workshops.
5. Have you used what you have learned at the workshop in your classroom? Explain.
6. Has the Experimento project changed what you do in the classroom? Explain in relation to
   – the types of practical activities
   - the number of activities
   - the learners' role in the lesson
   - your role in the lesson
   - the way you manage your class
   - your preparation for the lesson.
7. What do you think about the Experimento equipment provided?
8. Have you experienced any problems with the equipment?
9. Are there any suggestions for improvements to the kits?
10. What do you think about the Experimento activities?
11. Are the activities suitable to use in your class?
12. Are there any suggestions for improvements to the activities?
13. Do you find that the activities are linked to the current curriculum? Explain.
14. Have you designed any other activities in which you used the Experimento equipment?
15. What resources do you have for practical work besides the Experimento resources?
16. Have you used the Experimento resources for assessment purposes? Explain.
17. Have you gone to the Siemens/ Experimento media portal? Any comments?
18. Overall – what are the strengths of the Experimento resources and methodologies?
19. What are the challenges you may have experienced using these resources and methodologies in the classroom?

Apart from a few batteries and conductors that were not working and that the resources were fewer for our combined class size. This may cause noise making from fighting over the limited resources.

20. What improvements would you suggest to the methodologies covered in the workshops?
21. Give any three words that come to mind when you think about Experimento.

Example of teacher reflection
Reflections on session 1

Name:

ST7

1. How has this session impacted on your science knowledge and skills?

I gained more knowledge and skills on heating and cooling curve, heat packs, etc

2. How has this session impacted on your knowledge of teaching and learning?

It impacted positively, my confidence has improved a lot.

3. How do you feel about using the resources and activities used in this session in your own teaching?

I am happy because we did not have some of the resources that we are getting now.

4. Any other comments:

I am looking forward to more sessions.

Teacher PT1's written responses to interview questions

1. Grade 5

2. Yes, I did do a few experiments.

   Describe:

   a) The learners worked in pairs on some activities, other activities I demonstrated.

   b) Building electric circuits, testing for starch, vinegar and brick practical.

   c) Learners had to build electric circuits.

   d) I lend help where learners were struggling.

   e) Internet, Platinum Textbooks

   f) The vinegar and brick practical has been used for a formal assessment. It was a practical research. Learners had to observe how the vinegar affected a brick over a time period. They made their drawings on certain times and had a conclusion.

3. How to divide my class up in groups and make it work effectively. I also learned with practical groups you need to plan well in advance and thoroughly.

4. To some extent I have used what I have learned. My practical lesson I have attempted to work in groups but I still need to work on my planning to make it work effective and make each station interesting.

5. What I do in the classroom:

   g) The number of activities is still the same, but I do try to do stations. As I said in question 5, I need to plan better to make the lesson more interesting as well have different project on the same topic.

   h) Learners are more hands on. More practical work and discovering things for themselves. I have other resources, for example, reading material so that learners do not just hear the answer or solution from me but discover it for themselves.

   i) My classroom is more structured; I also take the practical part of Natural Science more seriously and am excited to do a practical.

   j) My planning needs more attention because it needs more detail, especially for the practical part. It has improved, but it still needs more attention.

6. The equipment is exciting and interesting. There is enough of everything for one class. The fact that you have a file so that you know what it is in the box and how many makes work effective.

7. The worksheets. Although it is perfect for an English class, it does not work nicely for an Afrikaans class. The equipment is also just enough for one class so it is a problem if you work with a colleague and you get the same class on the same period, teaching the same practical lesson.

8. The kits are complete; however, I do think that you should put a price tag on the equipment so that the schools with bigger classes or multiple grades have the opportunity to buy a second box. I also think that the worksheets should be in English and in Afrikaans to assist the teachers teaching the Afrikaans classes.

"The equipment is exciting and interesting. There is enough of everything for one class. The fact that you have a file so that you know what it is in the box and how many, makes work effective".

9. As already said in question 9. The worksheets should be in English and in Afrikaans to assist the teachers teaching the Afrikaans classes.

10. Yes, I think it is suitable to use in class. Some activities may be difficult to understand as I have experienced doing some of the activities during the course but when understood it is very easy to follow and complete.

11. In some activities it is difficult to understand what is being asked or what the instruction is trying to say, especially if the person has not done the experiment for a while or even have done it at all. I would suggest that the instructions of the experiment be clearer to the learners and teachers.

12. Yes, because the box was constructed for the higher grades there are a few experiments that cannot be used by the lower grades, but most of the experiments can be used for all grades. For example, for grade 5 I could use the candles to test how long it can burn underneath a sealed holder. I could also use the electric circuits.

13. No

14. We have a Natural Science cupboard that contains mostly everything we need for the experiments that we use. Our subject head has broad knowledge of the subject and can assist you with anything that you may need or want to know.

15. No

16. Yes, I have used the candle and oxygen experiment for a formal assessment.

17. It can be used for any grade. There is enough of everything that you may need for either a demonstration or practical work that the learner self may do. It is well organised into certain boxes so you know precisely where certain things are. The file with all the equipment and activities is also a helpful tool to see what is in the boxes and what you can use it for.

18. I teach an Afrikaans class so I had to set up my own activities. I cannot just take a worksheet and put on the different station.

19. Nothing, I think that it was an excellent presentation, and I enjoyed every one of the sessions. It broadened my knowledge and made me look at Science with excitement again.

20. HELPFUL, EXCITING, FUN

Extracts from interviews

PT3 interview

I: What are the challenges you may have experienced using these resources and methodologies in the classroom?

PT 3: *Apart from a few batteries and conductors that were not working and that the resources were fewer for our combined class size. This may cause noise making from fighting over the limited resources.*

PT6 interview

I: Tell me what the main things were that you learned at the Experimento workshops.

PT6: *Lesson planning and preparation,*
Teaching styles, approaches or models,
Work stations,
Presentations and use of charts and other resources,
Demonstrations, Active learner involvement in all lessons,
That learners also learner a lot by discovering things on their own,
The Big Idea and breakdown of the Caps document topics into manageable and effective lessons, and conducting practical tasks effectively.

ST2 interview

I: What do you think about the Experimento equipment provided?

ST2: *It is good for Physical Science and Natural Science, very little was done for Life Science.*

ST1 interview

I: Are there any suggestions for improvements to the activities?

ST1: *More activities on prescribed practical activities especially grade 10,11 & 12.*

Grade 9

Natural Sciences

Energy and Change

20 April 2016

Total marks 20

Name and Surname………………………………………………………………………………………

Instructions

1. Answer all the questions.
2. Use only blue or black inked pen .
3. All diagrams to be drawn with a pencil and labelled with a pen.

Questions

1. What is the electrical voltage between the two nails? (Use the micro meter to measure the voltage.) (1)

2. What is the electrical current between the nails? (1)

3. UNDERLINE THE CORRECT WORD IN THEFOLLOWING QUESTIONS:
   3.1 The positive pole is called the cathode/anode (1)
   3.2 The copper nail is the positive/negative pole (1)
   3.3 The zinc nail is the negative pole and called the anode/cathode (1)

4. Draw a neatly labelled diagram of your circuit showing ine cell a switch and a light bulb. (5)

5. Differentiate between a cell and a battery. (2)

6. The instrument used to measure current is called a ...... (1)

7. The instrument used to measure voltage is called a ...... (1)

8. Does adding more cells increase the current in a circuit? (1)

9. Give a reason for your answer in number 8. (2)

10. Does the electricity come from the vegetable? (1)

11. What is the real source of the electricity? (2)

TOTAL 20 MARKS

Reflections - Teacher ST5

1. My knowledge of the subject has increased tremendously! Thank you. I qualified a long time ago to teach physical sciences, but always taught Life Sciences for the senior grades. For the past four years I have been teaching in the GET phase and I really enjoy the Physical and Chemistry components of the Sciences curriculum. This course has awaken the love for this field of work again.

2. I enjoy teaching the subject as I feel a lot more confident about my knowledge and I can see that learners are excited and interested as well. I realised that they can sense my passion and knowledge! The experiments we did are very simple and I will be able to do this with my learners.

3. The resources are amazing and I am very grateful as the school where I teach is completely under resourced. The equipment is most welcome and treasured. I have already used some of the equipment with a small grade 11 group.

4. I am thrilled to be part of this course. Thank you!

"I enjoy teaching the subject as I feel a lot more confident about my knowledge-and I can see that learners are excited and interested as well. I realised that they can sense my passion and knowledge! The experiments we did are very simple and I will be able to do this with my learners."

Practical Investigation 3 | 20 Marks
Examiner: | Moderator: Ms
Grade 8

Aim of the Investigation:
To investigate the effect of increasing the number of cells connected on the electric current.

Apparatus:
Three 1,5 V cells
Insulated copper conducting wires
Ammeter
2 torch light bulbs

Method
Connect a circuit with **ONE** cell, the ammeter and **TWO** light bulbs, observe the brightness of the bulbs and ammeter reading, and write your results in the table provided below.
Add the **SECOND** cell, observe the brightness of the bulbs and record the ammeter reading.
Write your results in your table.
Add the **THIRD** cell, observe the brightness of the bulbs and record the ammeter reading in the table below

QUESTION 1
RESULTS

Complete the table below

Number of cell(s) in series	Brightness of bulbs	Reading on the Ammeter (A)
1		
2		
3		

(6)

FOR FURTHER INFORMATION, PLEASE CONTACT:

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