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Introduction of radmaste microchemistry in disadvantaged schools in Gauteng: a case study

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		KTS	WORKSHEET	CONTENT	COMING
34	P: Ahh...I don't have any problems. Maybe I have forgot it but I...				
35	I: Would you like to look at the worksheet, so that if you remember parts				
36	that you had problems on you can use this highlighting pen to highlight				
37	those parts.		✓		
38	P: O.K. (quiet for 35 seconds). Aaa I don't have a problem.				
39	I: You understood everything?				
40	P: Yes.				
41	I: O.K. I'd like us to talk about the experiment now. What did you do in that				
42	experiment? Can you tell me briefly what you did?				
43	P: Ahh...in that experiment?				
44	I: Mmm?				
45	P: (Unclear) we had used water and methyl orange...and acid B and (unclear)			✓	
46	and.. sodium hydroxide. So, in well 1, well 1, we mixed water with one			✓	
47	drop...we mixed water with one drop methyl orange.			✓	
48	I: Mhh?				
49	P: And in well...2, we mixed mm... a five drops of wat.. of a..one drop of			✓	
50	methyl orange. The colour was not the same. But if we...			✓	✓
51	I: The colour of.what was not the same? You compared it to which one?				
52	P: To water and methyl orange and acid A and methyl orange.			✓	
53	I: O.K.				
54	P: The colour was not the same, but if we mix it in each well, well A and				
55	well B..				
56	I: Mhh?				
57	P: If we mix a... mmm sodium hydroxide six drops in each well, we changed			✓	
58	that colour, the colour was the same.			✓	
59	I: What colour are you referring to, that of?				
60	P: Yes the colour was the same for them both.			✓	
61	I: O.K. so you put six drops of sodium hydroxide into?				
62	P: Into...well A and six drops of sodium hydroxide ...(unclear) in that.. in				
63	that a...(unclear)				
64	I: (unclear) six drops into well..				
65	P: Into well A and ten drops into well B, the colour is (unclear).			✓	
66	I: Is (unclear). So are you talking about acid A or acid B where you put five				

drops?
P: Both.
I: Acid A and ten drops acid B?
P: Ye..No. In well A,..
I: Mhh?
P:...we used water.
I: Water?
P: Yes. And in well B, we used acid B..acid A.
I: Acid A?
P: Yes.
I: O.K. then what else did you do?
P: After that we we pour a...hyd...sodium hydroxide
I: Mhh?
P:...on well A. We put water and methyl orange and then on well..in well B, a.. we used acid acid A and methyl orange.. one drop of it and then when we introduce a.. sodium hydroxide, the colour is the same as that...
I: Of water?
P:..of water.
I: O.K. so what did you do with acid B?
P: In acid B, is stronger than acid A because it takes mmm much drops. When we used it in in when we used (unclear) instead of using acid A we used acid B and then we take a much drops of sodium hydroxide to.. to mmm to change the colour to be the same as that of of water.
I: As that of water. O.K. so what is the name of that procedure?
P: Of that ahh.. of that procedure? Of the this process?
I: Mhh?
P: It is titration.
I: Titration. O.K thank you very much.
P: Thank you.

KITS	WORKSHEET	CONTENT	CONNE
		✓	
		✓	
		✓	
		✓	
		✓	
		✓	
		✓	
		✓	
		✓	
		✓	
		✓	

PUPILS' EVALUATION

Please fill in this evaluation form after you have completed some or all of the practical experiments using your own RADMASTE Basic microchemistry kit.

1. General information:

a) School name:

b) Did you work alone or with a partner?

c) How many experiments did you do?

d) List the experiments you did:

Please circle the number of the option you most strongly agree with in the following statements.

Scale: 1 - Strongly agree 3 - Disagree
2 - Agree 4 - Strongly disagree

2. Previous practical experience:

	YES			NO
a) I have performed many experiments by myself while at school.	1	2	3	4
b) The teacher has demonstrated many experiments for me while at school.	1	2	3	4
c) It's not necessary to have had practical experience at school to understand chemistry	1	2	3	4

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

3. I found that microchemistry equipment:

	YES			NO
a) Was easier to use than beakers, burettes etc.	1	2	3	4
b) Was safer to use than beakers, burettes etc.	1	2	3	4
c) Is not real chemistry equipment.	1	2	3	4
d) Developed my confidence in practical work.	1	2	3	4
e) Required a great deal of my attention to use.	1	2	3	4
f) Was fun and exciting to use.	1	2	3	4
g) Was too small and clumsy to use.	1	2	3	4
h) Developed my practical skills.	1	2	3	4

i) Any further comments?

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4. Microchemistry worksheets:

	YES			NO
a) Have clear and easy to understand instructions	1	2	3	4
b) Have clear drawings.	1	2	3	4
c) Are too long.	1	2	3	4
d) Have too many questions.	1	2	3	4

e) Any further comments?

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

5. Microchemicals kits:

	YES			NO
a) Have chemicals which are adequately stored in their container.	1	2	3	4
b) Are safer to use than using chemicals directly out of the store-room.	1	2	3	4
c) Have chemicals which are clearly labelled.	1	2	3	4
d) Have too many chemicals in each kit.	1	2	3	4
e) Are confusing to use.	1	2	3	4

f) Any further comments?

RADMASTE INTERVIEW (SETTING THE SCENE)

Hello?

How are you?

Thank you very much for making time for this interview. I really appreciate that. As we both know, I am doing my research on the implementation of RADMASTE microchemistry in secondary schools. I am interested in the introduction in Duduza and Soshanguve. I would like to interview you in order to get your opinions and perceptions in the way you introduce RADMASTE microchemistry in the schools.

In a few sentences, I would like to tell you where I am coming from in this research.

My research questions are the following:

a) how are the RADMASTE microchemistry and allied materials introduced to teachers?

b) how do the teachers introduce RADMASTE microchemistry and allied materials in their schools? and

c) what are the skills, attitudes and content aims of practical work achieved by the RADMASTE microchemistry approach?

To answer these questions, I have used a variety of methods. I have asked the teachers how they planned to introduce RADMASTE microchemistry and observed them introduce it. Now I want to hear from you through an interview, what you believe is happening in the schools.

RADMASTE (MANAGEMENT/FACILITATOR) INTERVIEW PROTOCOL

1. a) What are your (RADMASTE's) main reason(s) for introducing a microchemistry kit and teaching materials to teachers in secondary schools? [Expect general 'redress' cost effective rationale.]

   b) What specific knowledge, skills and attitudes do you think the kit can develop?

2) Are there any reason(s) that this particular format (i.e orientation plus two follow-ups) was chosen?

3) Do you have any idea about what teachers actually Do when they introduce 'The kit'?

IF YES: What do you think happens?
Why do you think it happens this way?

IF NO: What would you hope for?
Why would you hope for that?

4) What support systems (i.e. hands-on classroom help, teaching aids or phone-in help) are available for the teachers?

5) Is there anything else you can tell me that you think I should know?

RESEARCH QUESTIONS

a) how are the RADMASTE microchemistry and allied materials introduced to teachers?

b) how do the teachers introduce RADMASTE microchemistry and allied materials in their schools? and

c) what are the skills, attitudes and content aims of practical work achieved by the RADMASTE microchemistry approach?

	R. M/CHEM.	AIMS	APPROACH	HELP	S. INTRO	COM
1	RADMASTE FACILITATOR INTERVIEW					
2	I: (Read out to the facilitator the paragraph prepared to set the scene). And then:					
3	Firstly, what are your main reasons for introducing the RADMASTE microchemistry					
4	kit and teaching materials to teachers in secondary schools?					
5	F: I think there are a couple off amm odd objectives (not clear) introduce					
6	microchemistry into the schools. I think I think the first one is amm because of the	✓				
7	lack of practical work in the schools, it's a novelty to have students amm do their	✓				
8	own experiments. Not only for us but also for them and so we'd like to find out how					
9	they get about it. That's the one one reason. I think the second reason is that amm	✓				
10	I think most people believe that and I'm certainly of that opinion that you learn by					
11	doing. Amm and a large as I said initially a large number of people got the					
12	opportunity to do. So the learning process is just thrown out the window. So I I	✓				
13	believe that introducing the the aaa practical work not only increase the chance to					
14	actually do things but but also to learn by doing things. So that it's no use (unclear)					
15	without understanding why you're doing it. I think amm (not clear) to this amm					
16	we've designed the materials almost (not clear) sense amm in a vacuum and we have					
17	to try once with amm college lecturers and other people. But we never actually gone				✓	
18	into the schools and try it out ourselves. It certainly is a very it's a very nice				✓	
19	opportunity to have teachers put that to use in their classrooms and give us feedback.				✓	
20	Amm we have designed something which we felt is felt it was appropriate and they					
21	find it's totally inappropriate. So we need to find out. So I say those are the three					
22	main ones I I'd be interested in.					
23	I: O.K. And then what specific knowledge, skills and attitudes do you think the kits					
24	can develop?					
25	F: Amm, well let's start with the skills. A just, I think it is initially the skills amm					
26	as amm a manipulatory sort of skill that is associated with the microchemistry kits		✓			
27	particularly with the propettes and the little lids and tubes and things like that. I think		✓			
28	that's what we want amm we want the kids to learn amm including just manipulatory					
29	skills. I think that's not all. You want skills you want you want aaa students to learn					
30	other types of skills which are more (not clear) intended so I'm thinking more along					
31	the lines of the scientific process. Amm you have a problem amm how do you go		✓			
32	about solving that problem scientifically? If you (not clear) that was all meaningful					
33	amm and then trying to reach conclusions about what you've actually observed. The		✓			

		R.M/CHEM	AIMS	APPROACH	HELP	S.INTRO	COM
34	conclusions may or may not be correct amm but at least you've gone through the						
35	process of trying to understand what you've observed. Amm so so as far as skills are						
36	concerned I think that amm (not clear) amm the rest of the question... may you just						
37	repeat it?						
38	I: Amm we talked about the skills...						
39	F: Yes?						
40	I: Attitudes?						
41	F: Well the test for attitudes amm what would I like them to to get out of that? Or...						
42	I: Do you think that the kit can develop?						
43	F: Yes I think so, I think amm from the kinds of responses we've had not only from						
44	those students, but also from in around the country in different education institutions.						
45	We've seen that the attitudes do tend to change. Initially they do seem to be a little		✓				
46	bit scared aaa little bit aaa afraid of aaa trying out this new material. But after they		✓				
47	almost invariably say they enjoyed it and they'd like to try it again. Amm the		✓				
48	attitudes I think I'd like to see aaa come out of that, attitudes change towards science		✓				
49	in general. 'Cause I think amm I think that people who don't know about science see		✓				
50	science as something that's very scary and unapproachable amm I think by the by the		✓				
51	mere size of the kit, you can see it's small and it's approachable and even if		✓				
52	something very dreadful goes wrong, amm it's not gonna course a major problem.		✓				
53	And amm not only that but also to see amm where does the section fit. So it's O.K.		✓				
54	to do an electrochemical cell but what does that actually mean? Amm what is the		✓				
55	implications. So the attitude change towards science that science is something		✓				
56	understandable, it's not something mysterious. And it's something that you can do		✓				
57	amm without having to injure yourself or be involved in an accident.						
58	I: O.K. And the third one is content.						
59	F: Content? Amm I think the content is related to amm to the school syllabus. Aaa		✓				
60	there but there again I think the addition is amm I think theee syllabuses they		✓				
61	restricted itself to saying amm you have to this this and that. There's no there's no		✓				
62	(not clear) to where that lies or how does that fit? So the content would be syllabus		✓				
63	based but in the same time would be to extend the students just a little bit more amm		✓				
64	to where does this actually fit, why have you done this?		✓				
65	I: Amm are there any reasons that this particular format, that is the way you						
66	introduce it through the orientation workshop and the the two follow-up workshops						

		R.M/CHEM	AIMS	APPROACH	HELP	S.INTRO	CO
67	is followed?						
68	F: Yes?						
69	I: Are there any particular reasons for choosing that particular format?			✓			
70	F: That format? Aaa I think as I said initially, aaa I think you learn by doing, I think						
71	that we we discussed initially all the all the different kinds of ways that could be used			✓			
72	to to introduce teachers to microchemistry. Amm I felt that if aaa if you just send the			✓			
73	equipment without having some form of introduction, amm the teachers will put it on			✓			
74	the shelf and they won't use it. Amm if you send equipment and you have some form			✓			
75	of introductory tape or something like that that goes along with it, amm there is a			✓			
76	there is the issue of understanding. Aman you may be speaking to somebody who is			✓			
77	a who who has english as a second language amm and then doesn't use it very			✓			
78	preferably either. Aaa and you've got your high polluted high polluted aaa aaa english			✓			
79	where they don't understand what you are saying. I think amm the reason that we've			✓			
80	chosen amm by using this partic lar method is a face-to-face one. Amm it allows						
81	people to see that amm by interaction not only with the person who is introducing it			✓			
82	but with other people, then everybody is in the same level. We all don't know what						
83	we are doing, to start off with, so it doesn't make it doesn't make it it doesn't make			✓			
84	it a problem to learn how to do it to start off with. So I think that is one of the most						
85	important reasons why we've chosen this method. But amm just to add to that that			✓			
86	amm I understand that it may not be the most appropriate way. And amm at this point			✓			
87	in time I I I'm considering what what other way? If if you don't do it this way what			✓			
88	what is the other way that you can do it? And I I don't come up with any serious			✓			
89	alternatives.						
90	I: Is there any reason why you don't find it the most appropriate approach...						
91	F: You want the reason why I don't personally find it the most appropriate?						
92	I: Yes?			✓	✓	.	✓
93	F: Amm this may may be a concern that aaa you you're coming you are seen as the			✓			✓
94	expert and aaa teachers are seen as people lower down (laughs). And aaa they don't			✓			
95	know what they are doing. And I do think this perception is the wrong one and I try			✓			
96	as far as possible to when I'm introducing to show teachers that I'm approachable.			✓			
97	Aaa and if they don't understand something or if they don't know anything it's not			✓			
98	because they are they are dumb. It's just because they don't have that conceptual						
99	knowledge. And that I'm there to help them to try and gain that knowledge. Amm but			✓			

		R.M/CHEM	AIMS	APPROACH	HELP	S. INTRO.	COMM
100	I still feel that even though you said that, that there are some teachers who feel amm				✓		
101	that they can't approach because they will be seen as stupid or you know, I've been				✓		
102	teaching this for for such a long time, maybe he'll tell my subject advisor that I don't				✓		
103	know what I'm doing or something along those lines. So that is the one possible						
104	concern that I could have. Amm and also the other one that I do h ve is that although						
105	I've been assessing that more more on an informal bases, amm there's no formal			✓			
106	assessment of those workshops, besides your study. And I have no idea whether that's			✓			
107	the most appropriate way of doing it, I just instinctively think that's the right way			✓			
108	because I don't know about the other way to go about it that may not be true.			✓			
109	I: O.K. Do you have any idea about what teachers actually do when they introduce						
110	the kit in their classrooms?					✓	
111	F: Amm a fair idea, amm because I've never actually been there to go and see. But					✓	
112	what I have done in subsequent workshops is I've I've had a a report back session					✓	
113	where I ask teachers to explain to me what they've done in the classroom, what					✓	
114	problems they've had in introducing microchemistry, what advantages they've got.					✓	
115	Aaa just the general things that they've experienced. And from that I I've generally						
116	got (not clear) classroom when we completed this and this experiment we've done that					✓	
117	or I found this was the problem or so I have the general idea that I've done (unclear)					✓	
118	been in the classroom. Even if I did it in one (not clear) of the other classrooms.						
119	I: Mmmm. Amm what support systems are available for the teachers? I mean hands-						
120	on classroom help, teaching aids or any form of help?				✓		
121	F: Well amm, we have we have said to them in introductory workshops that our				✓		
122	telephone number is on the front cover of the worksheet. That they can phone if they				✓		
123	do need a they do need assistance. Amm so that's the one possible amm they do also				✓		
124	have the telephone number of our commercial associates so they have been told about				✓		
125	that (not clear). Amm they do have the telephone number of the co-ordinator of the				✓		
126	Thousand Schools Project in their particular regions so (not clear). And now having				✓		
127	said all of that, (not clear) to have a phone call. Now I don't know whether that				✓		
128	means that they find that they are satisfied and it's not a problem, or whether they				✓		
129	are too scared to phone to say there is a problem. So silence doesn't necessarily mean				✓		
130	that there is no problem.						
131	I: Yes. So there has never been a time where one of your staff members from						
132	RADMASTE has visited the teachers (not clear) schools.						

R. M/CHEM.	AIMS	APPROXH	HELP	S. INTRO.	COM
			✓		
			✓		

133 F: We've offered to do that in the past amm but because of the limited aa budget, the
134 constraints that are on the budget, basically that hasn't been possible.
135 I: O.K. Is there anything that you would like to tell me that you think I should know?
136 F: Nothing that I can think of. Amm (quiet for five seconds) no...
137 I: No?
138 F: No there's nothing I can think of.
139 I: O.K. Thank you very much.
140 F: Thank you.

R. M/CHEM.	AIMS	APPROACH	HELP	S. INTRO	CON

RADMASTE MANAGEMENT INTERVIEW

I: What are your main reasons for introducing a microchemistry kit and teaching materials?

M: The main reason is aaa to make aaa hands-on practical work in chemistry possible. Aaa my own opinion is that aaa there is a minority of schools that have equipment for practical chemistry. Ammm amongst the schools that have the equipment, not all of them use the equipment, for various reasons. Ammm that's the fact that is is most significant is that, the majority of schools don't have equipment aaa sufficient anyway to provide practical experiences for individual students. And aaa in addition it's true in many cases, they don't have a laboratory which they could do practical work even if they had equipment. Ammm and again the microchemistry doesn't face that problem because ammm it doesn't actually require a traditional laboratory amm set-up. So the answer is aa we are keen to introduce the microchemistry because I see it as a means by which chemistry can be made accessible to the great majority of students.

I: O.K. What specific knowledge, skills and and attitudes do you think the kit can develop?

M: That is a much less easy question to to answer. Aam and I think really one has to appreciate that aam the kit itself doesn't produce any of those things. The kit is simply aam a set of concrete objects, and what your objectives are in using that equipment can be variable. And some teachers will have certain objectives and other teachers will have different objectives. Then what skills and and knowledge and and attitudes might be developed aam I think the answer is that there is a whole lot of things that can be developed. It depends critically on aam teachers' decision firstly as to what objectives are important for him or her and then secondly those on the ability of the teacher to to actually chose those aims based on their knowledge that's the knowledge of teachers of how to do things, and on resources maybe printed materials or courses, maybe workshop courses aam which are made available to them aaa in order to achieve their chosen objectives. But aaa as I say the point is that aa there is a big range of possible objectives that aa the kits can aaa be useful to help the

		R. M/CHEM.	AIMS	APPROACH	HELP	S. INTRO.	COMM
31	teacher.						
32	I: So in the case of RADMASTE they did not have any specific aim or...						
33	M: I think...						
34	I: ...or in that category?						
35	M: Yes that's right. I think that we we have read our literature and we are aware						
36	that there are many reasons for doing practical work and aam we actually would be						
37	reluctant to actually sort of pin it to to one particular thing because we feel that's		✓				
38	very much aaa something where decision-making basically rest with the teacher. Now		✓				
39	obviously if we believe that the teachers that we are working with aam know nothing						
40	about the possible aims of practical work, we would want to then take steps to tell		✓				
41	them about the different kinds of aims that could be involved. And aam on the whole		✓				
42	obviously again aam the aa less experienced teacher we would recommend less						
43	ambitious aims and for the more experienced then the more aa ambitious objectives.		✓				
44	So I think aaa no particular aim has been advanced as aa as an emphasis. Aaa we		✓				
45	would often have drawn attention to a variety of aims and basically left as a decision						
46	for the teacher.						
47	I: O.K. Are there any reasons for the particular format that the RADMASTE is using						
48	which is the orientation workshop and two follow-up workshops? Are there....						
49	M: I don't think there are any strong reasons. I think it is seen as a aam a fairly			✓			
50	practical and realistic ammm aaa what aa shall we say? The point I'm trying to make						
51	is that we are very clear that simply to sent out kits without ourselves having any aaa			✓			
52	interaction with the teacher aaa is is probably very problematic for most teachers.			✓			
53	And it would only be the most competent and motivated of teachers who could go						✓
54	well on that basis. Aam equally aa we we and everybody else simply doesn't have the			✓			✓
55	time and resources aaa to to really spend unlimited amounts of time with the teacher.			✓			✓
56	So one knows that neither of those are sensible and and you have to go somewhere			✓			✓
57	in the middle now I I think basically we are interested in aaa (laughs) what is the			✓			
58	minimum we can get away with. That sounds a very bad thing but I mean the point						
59	is again resources aa we would like to a find out in fact what is the minimum we can						
60	get away with. If it is one workshop of one afternoon. That is enough for the majority						
61	of teachers I would be delighted. I don't think it will be enough I suspect it will need						
62	to be more. Ammm but the particular thing that you mentioned of aaa the one initial						
63	workshop and two follow-ups is is a typical sort of aam compromise kind of (unclear)						

		R. M/CHEM	AIMS	APPROACH	HELP	S. INTRO.	COM
64	and we don't have good evidence aa as to whether it is adequate for the majority of						✓
65	teachers or not and it is important for us to find out that.						✓
65	I: Do you have any idea about what teachers actually do when they introduce the kit?						
66	M: No no I'm very ignorant of that.						
67	I: What would you hope for?						
68	M: (Sighs) What I would hope is that the teacher would be a well organised person					✓	
69	and aaa would therefore make the kits available to the students and arrange for an					✓	
70	initial session in which not very much is done but in which the students have an					✓	
71	opportunity to open the kits and to look at the pieces and for the teacher to aaa tell					✓	
72	them what the pieces are called and then in fact encourage them tooo use the pieces					✓	
73	in the most simple way of aam working simply with some water possibly using the						
74	propette and using the syringe and using the microwell plate to get used to to					✓	
75	handling the pieces aaa without having a very demanding chemistry objective. Aaa						
76	that will be the emphasis of of the initial period and where the teacher would also					✓	
77	explain how how the whole thing is going to operate what we would hope is that					✓	
78	basically the approach would be that the kit would be the responsibility of the					✓	
79	individual student. And and either he keeps it in his own little box or else he had					✓	
80	a defined cupboard in school where he can put it. It's got his name on it anyway. It's					✓	
81	his responsibility his responsibility. And that is the sort of approach that I would						
82	favour. That the teacher aam arranges for an initial period where there is a chance					✓	
83	to familiarise with the kit and where the student gets the message very very clearly					✓	
84	that the kit basically is his or her responsibility. The the details of how that would					✓	
85	work obviously depends on on the school situation, there will be a lot of variability						
86	there and but if those things are done then I think one has started on the right track						
87	And then sure amm again it will vary according to the teacher. But obviously one						
88	would hope the teacher would use the practical work first amm with a very simple						
89	activity one that was not going to use more than what is out of the kit and which was						
90	basically rather simple. And and then to evolve towards amm more complicated						
91	experiments aaa on a sort of weekly bases. Amm so those are some of my thoughts						
92	about how it should be introduced in the classroom.						
93	I: Why would you hope for that?						
94	M: For that particular pattern?						
95	I: Yes?						

		R.MICHEM	AIMS	APPROACH	HELP	S. INTRO	COMM
96	M: Yes, well I I I believe that aaa faced with new items of equipment, aaa most						✓
97	people at any level aaa need a bit of time to to to find out what they are and r.d the						
98	basics of how to use them and and so that's that's all that lies behind that notion. I						
99	think that by contrast to put a worksheet for one of our experiments amm sort of					✓	
100	Acids and Bases or Redox, see that matters not and then have on top of that the the					✓	
101	completely new equipment, I think that will be difficult for the students and amm it's					✓	
102	rather unlikely that they will get much out of it because it's just too much to to learn					✓	
103	at the same time. Let alone the overload kind of situation. So I believe one must						
104	guard against that because it could set up a generally negative feeling about practical						
105	work because they simply couldn't cope with the very first session. Amm and						
106	similarly this business of the the personal responsibility for a kit I I do favour that						
107	amm a approach aaa because I think one is then one is dealing with an an aspect of						
108	of slight personal behaviour. It's it's taking responsibility for for aaa your own						
109	learning. And admittedly in this case it's actually to the piece of equipment. It's a kit.						
110	But O.K. but you're being responsible for that. And I think that's an important life		✓				
111	skill and attitude that amm would be fostered by this. Amm on on the purely practical		✓				
112	side also would amm (relief) the teacher of some of the burden of running practical						
113	sessions. Aaa the last thing that we wanna do is to create a negative attitude on the						
114	part of the teacher, amm because practical work involves so much of extra labour for						
115	the teacher. Well there will be extra labour but you if the teacher doesn't have to						
116	be...you know, directly have to look after each individual student's kit. One has to						
117	take a little bit of the burden away from the teacher and aaa therefore is is reducing		✓				
118	the stress and and therefore the potential of negative feelings of doing it.						
119	I: O.K. What support systems are available for the teachers? That is (on) hands-on						
120	classroom situation?						
121	M: I believe one can say that it is in place. I don't think that it's being effectively				✓		
122	used. And it may be that teachers amm are not used to the idea of having such help				✓		
123	available. Amm we are in no position and and neither is the manufacturer in any						
124	position to to make regular classroom visits on every teacher. I mean it's absolutely						
125	out of the question. And aaa basically therefore a lot of amm the support that we are				✓		
126	in the position to give and also the manufacturer and it has to be by telephone and				✓		
127	amm I know that the manufacturer has indicated in his literature that there is a help-				✓		
128	line and aa as far as I'm aware that's completely genuine, there is a help-line there						

		R.M/CHEM	AIMS	APPROACH	HELP	S. INTRO	COMM
129	and I just had a suspicion that it's a minority of teachers who who've actually taken				✓		
130	that up. RADMASTE itself has also indicated willingness to receive amm enquiries				✓		
131	amm I think we have done it less forcefully than the manufacturer has. Amm but we				✓		✓
132	have actually indicated in in the usually in a workshop context that resource is				✓		
133	available. So as it stands aaa there is something like that available- a help-line. I don't				✓		
134	think it'sss aaa operating very intensively. Amm and I don't think it's it's enough.				✓		
135	Aaa I think from our perspective sort of thing that we would be keen aaa on on						
136	strengthening is the support capacity aaa of the Provincial Education Departments aaa				✓		
137	through the subject advisors and of course a number of them are probably doing that.				✓		
138	I I again don't know on the ground aaa to what extend that's happening. We are in						
139	a very fluid situation at the moment where many subject advisors actually haven't						
140	been appointed or changing their responsibilities and so forth, is a very messy						
141	situation. But I believe that they amm are doing something and that needs to be						
142	strengthened because obviously visiting schools aa must be part of their their brief so				✓		
143	if they can aaa themselves be knowledgeable aaa about the microchemistry practical				✓		
144	work ammm, then of course provide on the spot help, that will be much the best.				✓		
145	I: O.K. Is there anything else that you can tell me that you think I should know?						
146	M: I I think that amm the the experience we've had to date with the the kits and the						
147	responses from teachers and and students and from lecturers from other institutions						
148	and so forth I mean I think it has been a remarkable surprise to us ammm how						
149	positive people have been. There are so few aaa negatives. And I've not seen this						
150	with any new development before amm I've seen new developments and and I know						
151	it's always been some people are in favour and some people are against and so forth.						
152	I'm really very impressed and I think aaa the chances are excellent that it will achieve						✓
153	aaa widespread aaa adoption. And I think that what we are all hoping is that all those		✓				✓
154	aims of the practical work that you referred to amm will suddenly actually become		✓				
155	onto the agenda as a as very real possibilities and amm that would be tremendous		✓		✓		
156	because I'm quite sure there's a lot of positive aims there that at the moment cannot		✓				
157	be realised aaa that this development could could help achieve so amm perhaps that's		✓				
158	all that I have.						
159	I: That's all I wanted to ask, thank you very much for the information you have given						
160	me.						
161	M: Thank you!						

4.3 ORIENTATION WORKSHOPS OUTCOMES

[The leader of the microchemistry project at RADMASTE took the role of a facilitator during the workshops. He is thus referred to as the facilitator.]

4.3.1 Orientation workshop in Duduza

This workshop was held on the 23rd of May, 1995 at the Duduza Resource Centre. Four teachers were present at the workshop. Three of these teachers were males and one teacher a female. Two of the males and the one female were from the same school (School 1) and the other male teacher was from another school (School 2). Other participants in the workshop were the RADMASTE Centre facilitator who ran the workshop, and the researcher who acted as an observer, and took field notes. The workshop can be divided into four major events. These were:

a) introduction to RADMASTE microchemistry;

b) experimental exercise for the teachers;

c) discussion and guidance for school use; and

d) distribution of microchemistry equipment.

The description of the outcomes of these four events follow the same sequence as the above list of events.

a) Introduction to microchemistry

The facilitator introduced RADMASTE microchemistry with the aid of overhead transparencies (OHT). First the facilitator told the teachers the advantages of using small-scale chemistry. The facilitator said RADMASTE microchemistry was a low cost, small- scale practical chemistry for all science learners and teachers. Below is a summary of reasons given for using small-scale chemistry. The overhead transparencies used for putting forward these points are in Appendix 7.3 (pages 2 - 3).

(i) Microchemistry practical chemistry costs less than the conventional method of doing practical work because the equipment is made of plastic (which does not break easily and which was cheap to obtain). Less chemicals and time are required to perform these experiments.

ii) Microchemistry is a safer approach to practical chemistry because less waste is produced and plastic equipment is safer to work with than glass.

iii) Because the apparatus cost less than the conventional practical work, it makes it possible for practical work to be done for many pupils on individual bases.

Microchemistry was presented to the teachers as a joint initiative of the RADMASTE Centre and a laboratory equipment manufacturing company called 'Somerset Educational'. The worksheets that were developed at that time covered five topics. Namely: equilibrium, acids and bases, pH indicators, reduction and hydrogen sulphide generation (Appendix 7.3, page 4).

Using overhead transparencies, the names of the different pieces apparatus found in the RADMASTE microchemistry kit with their respective functions, were shown to the teachers. The pictures of these pieces of apparatus and their names are shown in Appendix 7.3 (pages 5 - 9) as copies of the overhead transparencies. The teachers were then told about the teachers' manual which furnished teachers with information about the experiment and how to use the available equipment.

It was stated that the workshop was generally designed to introduce microchemistry techniques to teachers so that when these teachers become confident about them, they could then introduce these to their pupils, and promote individual practical work with exciting and enjoyable chemistry in schools. Page 10 of Appendix 7.3 lists these aims as a copy of the overhead transparency.

The facilitator displayed the final overhead transparency which, using cartoon-style illustrations, showed the type of transition the teachers would undergo when changing from conventional style of practical work to small-scale chemistry. The facilitator said that the role of the teacher becomes that of a facilitator (Appendix 7.3 page 12).

b) **Experimental exercise for the teachers** (Duduza)

Two tables, each with two chairs were set out. On each table there was one paper cup filled with water, two microchemistry kits, one pupil worksheet, one box of chemicals and two pieces of white paper. Each table was prepared for two persons to work on. The experiment which was selected by the facilitator and that the teachers performed is attached as Appendix 7.4.

Before the teachers could start with the experiment, they were first asked to familiarise themselves with the apparatus and also to familiarise themselves with the chemicals from the chemicals kit, using the chart placed on the lid of the chemicals kit. The facilitator helped the teachers in this respect. The facilitator also went through the microchemistry kit and told each pair of teachers at their tables the names and uses of some of the apparatus found in the microchemistry kit although this had already been done using overhead transparencies. The teachers were also advised to concentrate on the focus question before performing the experiment. On an average, the facilitator gave similar guidance and advice to the people at the two tables.

On the first table, the two teachers had their individual kits although they shared the worksheet. They discussed the procedure to be followed although each person worked with his own kit. One of the two teachers had to leave in the middle of the experiment. The other teacher who was referred to as (T1) was left alone and completed the experiment on his own.

At the second table, there was one teacher (T2) from School 2 and another teacher from School 1. T2 read from the worksheet and told the other teacher what to do. This teacher did as she was told. When T2 looked at their results and found that they had obtained different numbers of drops for the three titrations (i.e. using the same acid and base in all three trials), he told the facilitator 'I think I've got something wrong somewhere'. The facilitator assured T2 that nothing was wrong with the procedure but he should look at the question carefully. The facilitator told T2 that what was important was the average number of drops in the two sets of titrations. T2 insisted that something had gone wrong. The facilitator took some time discussing the relationship between the dissociation of an acid and its neutralisation by a base. He used several examples to drive his point home until T2 claimed to have understood what

was going on. T2 said he was going to keep the paper that the facilitator used to explain the problem as reference material to be used at a later date. T2 also struggled to understand the difference between precision and accuracy (this was one of the questions which the teachers had to answer, having completed the experiment). The facilitator discussed this with the teacher using several examples. T2 claimed again that he could see the difference. Although T2 was working with another teacher (female), he read the worksheet and gave instructions to this teacher who followed the instructions given to her [this may be an instance of gender domination]. The discussion with the facilitator never included the female teacher.

The teacher who worked with T2 only reported at the end of the experiment that she taught mathematics and not physical science. [Perhaps this was the reason she never took an active part in the discussion with the facilitator.] She claimed to have attended the workshop because they were told that it was a workshop for mathematics and science teachers. [There could have been communication problems here.] Although this teacher had attended the orientation workshop, she was not given any microchemistry equipment, [since she would not use this equipment with her pupils as she did not teach science].

c) Discussion and guidance for school implementation

Regarding the experiment, the facilitator cautioned the teachers that the pupils in the classroom might think that the drop count of the titrations in a diprotic acid is twice that of a monoprotic acid because the diprotic acid was twice as concentrated as the monoprotic acid.

The teachers were asked whether they would be confident in performing the experiments at their schools after having tried them in the workshop. The teachers replied that they would be able to perform the experiments. One teacher added that all along they ignored some of the experiments since they did not have enough time to prepare for them. The teachers were given implementation questionnaire (Appendix 7.5) to complete. The questions on this questionnaire were later discussed amongst the teachers. [Because the chemicals were to be given to the schools in small (65 ml) bottles (from the chemicals kit)], the facilitator advised the teachers to dispense chemicals that were to be distributed to the class into the big wells of the comboplate. Some of the pupils could be given authority to watch the wells as the other pupils used their propettes to collect the chemicals. [This was in response to one of the questions of

the implementation questionnaire which asked how they were going to distribute chemicals to the pupils in their schools.]

The researcher asked the two science teachers remaining (Teachers 1 and 2) for their contact telephone numbers. [This was to allow the researcher to arrange school visits to the teachers in their schools at a later date to observe microchemistry introduced in these schools.] The teachers gave their (home) telephone numbers [since the schools did not have telephones] and assured the researcher that they did not mind being observed as they introduced the RADMASTE microchemistry equipment to their pupils. Thus the two teachers, T1 and T2, and their schools, S1 and S2 respectively, took part in this research.

d) **Distribution of equipment**

Each of the two teachers was given a box containing 40 RADMASTE microchemistry kits, 20 worksheets and one box of chemicals. The teachers signed documents indicating receipt of the equipment and the workshop participants dispersed.

4.3.2 Orientation workshop in Soshanguve

The workshop was held on the 14th of June, 1995. The venue was the only school represented at the workshop in that cluster (School 3 or S3) in that area. About five teachers from this particular school were present before the workshop started, [possibly intending to participate in the workshop]. As the RADMASTE Centre facilitator tried to establish what subjects the teachers were currently teaching, it was established that some teachers taught mathematics and some taught biology. The facilitator made it clear to the teachers that the workshop was for physical science teachers. One physical science teacher, who was also the Head of Department, decided to attend a soccer match which was due at the same time as the workshop. Teachers from a second school who were also expected at the workshop were not present. It was believed by the teachers at School 3 that the teachers from the other school were not informed about the exact time and place for the workshop. In the end, one science teacher (T3) and one biology teacher (Tb) remained for the workshop. This biology teacher decided to stay and no one asked him to leave although he did not teach physical science.

The workshop in Soshanguve also followed the same procedure under the four major components as the one in Duduza: introduction to RADMASTE microchemistry; teachers' experimental exercise for the teachers; discussion for school implementation; and issuing of equipment.

a) Introduction to RADMASTE microchemistry

In the orientation workshop in Soshanguve, the facilitator introduced RADMASTE microchemistry. In his introduction, he included how and where it began. The facilitator also attempted to give the teachers a fair picture of the position of the RADMASTE microchemistry at that time. Using overhead transparencies, the facilitator showed the teachers the pictures of apparatus found in the RADMASTE microchemistry kit. He also told the teachers the names and functions of these pieces of apparatus.

b) Experimental exercise for the teachers

In this case there were two tables prepared. The teachers had their individual boxes of chemicals, microchemistry kits, worksheets, paper cups of water and the white pieces of paper to work on. They were asked to perform the acid-base titration experiment (experiment B2,

Appendix 7.4). [The same experiment was performed at the orientation workshop in Duduza.] The facilitator read the focus question and requirements of the experiment to the teachers. The teachers were asked to work through the experiment step by step and record their answers whenever they were told to do so. The teachers were asked to copy both the tables in the experiment on to their workbooks and record their answers there. They were also asked to do the same thing with their pupils (i.e. ask them to copy tables into their workbooks).

The values obtained by both teachers were compared. The biology teacher (Tb) was asked to repeat the titrations after he had explained what he had done. [Perhaps from Tb's response, the facilitator found something wrong with the way Tb had performed the experiment.] Later T3 was also asked whether he was coping and when he stated that he had put in too many drops, he was also asked to repeat the titration. The facilitator later demonstrated to the teachers how to get uniform drops from the propette. He also asked the teachers to practise how to get drops from the propettes. The facilitator also showed the teachers another way of getting drops from the propette and this was by stretching the propette's stem out so that it became even thinner and this was also demonstrated to the teachers. [He possibly went through this procedure because he observed that the teachers were not able to use the propettes correctly.]

When the first set of titrations was completed, it was found that T3 obtained accurate results (i.e 5 drops for each titration) and Tb was supposed to have repeated all the three titrations. [Tb possibly obtained values that were not close enough to the experimentally determined value in the facilitator's view]. The facilitator, however, asked the teachers to move on to the titration of the second acid (acid B) as they were running out of time. Tb wanted to carry out a titration when he found that all his propettes were full but he seemed not to be able to identify the contents of each propette. The facilitator then asked Tb to use an indicator to identify the contents of the propettes. Tb managed to identify the contents of his propettes and then he repeated the titration. Even after this second trial, both Tb and the facilitator could not accept the results obtained from the titration. The facilitator decided that there was something wrong with what the teacher had done. [Tb had trouble coping with the experiment. The facilitator later commented to the researcher that he found Tb incompetent.]

c) Discussion of the teachers' evaluation form

The facilitator then completed the rest of the experiment with the teachers. He then discussed the content of the experiment with the teachers. The discussion included the dissociation of the two acids and the base, and the definitions of precision and accuracy.

After the teachers completed the implementation questionnaire (Appendix, 7.5), T3 mentioned that the microchemistry apparatus was easy to handle. Both teachers also agreed that the worksheets were easy to follow and that they would possibly be easy for the pupils to follow as well. Tb mentioned that although he might not use the microchemistry kits, he might be able to help 'if anything went wrong'.

Regarding the chemicals, the issue was raised that the biggest class had about fifty pupils (standard 9) and standard 10 had thirty pupils. It was agreed by both T3 and the facilitator that if these classes were divided into groups and these groups were controlled, then each group could get enough chemicals to complete an experiment. [Although it was said that *microchemistry was meant for individual practical work, at this point the facilitator agreed* with the fact that it could be used in groups. Perhaps the size of the group was important as well, since microchemistry is planned for individual practical work. The volumes of chemicals available was also of concern to the teacher and the facilitator.]

d) Distribution of equipment

Only the science teacher (T3) received the RADMASTE Centre microchemistry kits and allied materials. The materials were the same as those issued in Duduza.

Events and outcomes of this section are tabulated on the next page.

4.4 TEACHERS' REFLECTIONS AND IMPLEMENTATION PLANS

The researcher arranged the dates of visit with the teachers over the telephone. The purpose of this first visit to the schools was for the researcher to interview the teachers on their opinions regarding the orientation workshop and plans to introduce the RADMASTE microchemistry to their pupils. The researcher used an interview protocol (Appendix 7.6) to interview the three teachers, and subsequently transcribed the interviews (e.g. Appendices 7.7.1, 7.7.2 and 7.7.3).

T1's reflections and implementation plans

T1 was interviewed on the 13th of June, 1995. This was a school day. T1 was able to recall that at the orientation workshop they were first told what RADMASTE Centre and RADMASTE microchemistry were. They then `substantiated' what the RADMASTE microchemistry was by performing an experiment (Appendix 7.7.1, page 1, lines 7- 9).

Regarding what they did for the experiment, he said they were checking the concentrations of two acids, `...one with two protons and the other acid with one proton'. [This referred to the titration of the monoprotic and diprotic acids, namely hydrochloric and sulphuric acids respectively. The explanation T1 gave implies that the two acids had one and two protons only. He does not show that the molecules of one acid would each liberate one and the other acid's molecules liberate two protons.] When asked whether he had learnt any chemistry content, he said he had never done an experiment determining the effect of concentration before but all the same, he was not expecting the results from the two sets of titrations to be the same (Appendix 7.7.1, page 47-50). [The two acids and the base had the same concentrations (of 0.1 mol dm^3) although T1 said he was determining their concentration. One acid was monoprotic and the other acid diprotic. The experiment was about checking the effect of a monoprotic and a diprotic acid on the volume of base needed to neutralise each acid, not the effect of concentration].

T1 claimed that he struggled to get drops from the propettes into the comboplate. Although this was the case, he still believed that with time and practice, one could ma er using the propettes (Appendix 7.7.1, page 1, lines 22-28). His opinion was that the wc tsheets were easy to follow. He especially liked the fact that the wells of the comboplate were labelled (Appendix 7.7.1, page 2, lines 32-34).

Regarding the style of practical exercises he followed with his pupils prior to being introduced to RADMASTE microchemistry in S1, he said that experiments were performed in some cases with the standard 10 class. T e were 32 pupils in standard 10 (Appendix 7.7.1, page 3, line 83). When the standard tens performed experiments on the conventional scale, they shared one set of apparatus in the form of two groups. As one group took the measurements, the other group recorded the results. This normally happened in the laboratory. In other cases, the teacher performed demonstrations either in the laboratory or in the classroom (Appendix 7.7.1, page 3, lines 67-73, 89-90).

Regarding how T1 was going to introduce the RADMASTE microchemistry equipment to his pupils, he wanted to do it `...the way it was done...' at the orientation workshop (Appendix 7.7.1, page 3, line 93). However, he first wanted to introduce the following topics to the pupils: acids; protons; and indicators. He was then going to demonstrate a titration process using conventional apparatus available in the school. When asked to further explain what he meant by his statement, he said that he was going to tell the pupils what the experiment they were about to perform was about,`...especially the labelling of the comboplate'. The pupils were each going to get a microchemistry kit and worksheet. The pupils were going to follow the instructions from the worksheets as he found the worksheets easy to follow and he also wanted to see whether the worksheets were comprehensible to the pupils or not (Appendix 7.7.1, page 4, lines 99-102, 122-130). [T1 seemed to overlook the help and guidance he received from the facilitator in the orientation workshop. First the facilitator introduced the concept behind RADMASTE microchemistry. He then showed the items found in the kit using an overhead projector (which T1 neither had nor intended to use). The facilitator also showed the apparatus to the teachers individually at their tables. He guided the teachers through the experiment itself which T1 was not planning to do for his pupils.]

T2's reflections and implementation plans

This interview was held on the 13th of June at School 2 [same day as the one in S1]. When asked to reflect on what happened at the orientation workshop, T2 only mentioned that the workshop `...was all right'. He did not elaborate on what happened.

When asked about his feelings about microchemistry, T2 said that microchemistry was interesting and he especially liked the comboplates. He claimed to have experienced no

difficulties at all when performing the experiment using the RADMASTE microchemistry kit and allied materials (Appendix 7.7.2, page 3, line 80). [T2 did not mention that they had a long discussion with the facilitator regarding the numbers of drops that T2 and his partner obtained from their titrations. The two (i.e. facilitator and T2) also had another long discussion regarding the difference between accuracy and precision and this T2 did not mention during the interview.]

T2 claimed to have learnt some chemistry content in the workshop. When elaborating on this issue, he claimed to have been amused by finding the numbers of moles for the two acids (Appendix 7.7.2, page 3, lines 85-88). [This experiment required them to find the numbers of drops (which would be equivalent to volumes) used to titrate monoprotic and diprotic acids of the same concentrations using a base of that same concentration. This led to the ratio of acid to base being 1:1 and 1:2, respectively. The experiment did not require them to find the number of moles]. T2 said nothing about the introduction made by the RADMASTE Centre facilitator, the exposure to microchemistry (except that it was interesting) or the discussion about the experiment and the implementation questionnaire (Appendix 7.5) that they completed at the workshop.

The normal practical work at this school was related by T2 as being group work. He claimed said there were thirty nine pupils in the class who were divided into groups of six. He believed that this was the appropriate group size since bigger groups would not work, they would instead rely on a 'group leader' and take everything the group leaders said. T2 reported that the instructions for these practical exercises were given by him and the groups obtained apparatus and recorded their results in their daily exercise books. He continued by saying that this method posed problems since they had limited apparatus and chemicals. He claimed that his major problem in practical work was time constraint on which he did not elaborate in detail.

Regarding introduction of microchemistry, T2 first said that he had already introduced microchemistry to his pupils. He claimed to have done this by explaining to the pupils why '...the kit was implemented instead of test tubes..' (Appendix 7.7.2, page 1, lines 25 - 27) and then he let the pupils perform the experiment and he supervised the exercise for those who had

difficulties. The experiment that the pupils performed was, however, on the rates of chemical reactions. What he could report from this experience was that the pupils loved the kits so much that they wanted to take them home. [He did not report any cognitive part the RADMASTE microchemistry played.]

T2 was asked to explain how he intended to introduce the pupils to the experiment on acid-base titrations which he had performed at the orientation workshop. He first said that he believed that his class had encountered burettes, conical flasks, indicators, acids and bases and titrations (which he believed the pupils knew as neutralisation from standard 8). This information he believed was enough for the pupils to understand the experiment on their own. He then went on to say that they would perform the experiment together as a class where the pupils each had their kits and worksheets. He then changed to say that he would choose eight pupils from his class (at random), teach them about acids and bases and then let them perform the experiment on their own. T2 claimed that he expected the pupils to give him a feed back before he could discuss the experiment with them. He believed this was a good approach to show the pupils how the experiment the pupils performed linked to the theory the pupils were taught. [T2 failed to see this as part of normal teaching and wanted to select some pupils and probably perform the experiment for the researcher.]

T2 also commented that microchemistry was better than what they normally received from the subject advisors. [He was not asked to elaborate on this comment.] He also claimed that microchemistry had saved him preparation time as he would not have to collect the apparatus for experiments. He added that as preparation time had been greatly reduced, the pupils would then move faster so much that he would finish the chemistry component (of physical science) within a month. He had mentioned earlier that due to regular disturbances that they experienced, the progress in the syllabus was rather slow.

T3's reflections and implementation plans

T3 was first asked to report on the orientation workshop that he had attended. In response to this question, he said that they were first introduced to monoprotic and diprotic acids, and then they performed an experiment to determine these types of acids. [T3 gave a vague answer

probably to avoid exposing himself.]

Regarding difficulties with the experiment, he claimed to have experienced problems only when getting drops from the propettes. He however thought that the RADMASTE microchemistry was a helpful prospect for the pupils as the pupils would get their hands on practical activities. He also appreciated having learned something in the orientation workshop when determining monoprotic and diprotic acids.

T3 was then asked about the type of practical work they performed at the school. He claimed that no practical work was done since they had no laboratories available at the school. [T3 was, however, not asked to elaborate on whether they had any chemicals or apparatus available at the school, or whether they just did not have the place to perform practical exercises.]

When introducing RADMASTE microchemistry to his pupils, T3 claimed that he would first familiarise the pupils with the apparatus in terms of their names and uses. He would also demonstrate how the apparatus worked. Having thirty eight pupils in the class, he would arrange the pupils into groups of ten. Technical difficulties were experienced with the tape and another day was arranged for the interview to be completed. [When the discussion was continued, the teacher had changed his plans.] He was then going to pair the pupils and each pair was going to share a kit and a worksheet.

He was first going to introduce the relevant topic to the pupils and then let the pupils perform the experiment. When the pupils had completed the experiment and obtained the results, he would use questions to help the pupils link between theory they were taught and the experiment (i.e. practical) they would have performed.

4.5 SECOND WORKSHOP OUTCOMES

4.5.1 Duduza second workshop

The second workshop was held at the Duduza Resource Centre. Present at the workshop were T1 and T2 who attended the orientation workshop and two other persons whom the researcher had not met before.

One of these two other persons was a teacher from School 1 and apparently T1 had asked her to represent him at the workshop as he had thought he would be late for the workshop. So, when T1 arrived, this teacher left. The other person called himself a Community Worker. He said his task was to see to it that the Duduza Resource Centre was being utilized by the Duduza community and he also gave possible support in this respect. He said he could be of use for communication between teachers and people involved in education.

The RADMASTE facilitator had brought someone else (who had just been employed by RADMASTE Centre for the same microchemistry project) with him to assist him in running the workshop. This person was introduced to the teachers.

The workshop was planned to progress through three major steps. These were:

a) report-back by the teachers on their experiences in the schools plus any issues that the teachers wanted to raise regarding microchemistry with possible solutions and hints from the facilitator;

b) teacher exposure to more microchemistry experiments; and

c) discussion of the experiment just performed.

Details of the three events follow the same sequence as the list of events above.

a) Teacher report-back from schools

The facilitator asked the teachers to tell him how far they had used the RADMASTE microchemistry equipment. The facilitator also wanted to know the extent to which these materials (especially the worksheets) were relevant in the classrooms.

T1 reported that he had not had the chance to introduce RADMASTE microchemistry to his pupils. He said this was because the timing of the orientation workshop did not allow him to

do so. He claimed that immediately after the workshop he was tied with setting midyear exams and doing some administrative work at his school. T1 said that in earlier years, they had no pressure to complete the syllabus since they used to experience regular riots. [This he mentioned in an informal conversation with the other teacher.] In his opinion the acid-base titration experiment required a lot of preparation in the form of teaching to prepare the pupils for the experiment. The concepts he listed, that he thought needed to be included in the teaching for preparation, included protons, concentration and titration.

T2 reported to have introduced RADMASTE microchemistry to his pupils. For the purpose of introduction he had used the experiment on rates of chemical reactions which he had found in the worksheet. [This experiment looked at the effect of concentration on equilibrium.] Although T2 had looked at this experiment, he claimed that introducing microchemistry was not an easy task as he was pressed for time. The problems he claimed to have experienced were of lessons dragging for two to three hours when experiments were included and this meant hard work on the side of the teacher. [In the interview, T2 expressed his belief that with microchemistry available to him, he would be able to complete the syllabus in a month (see Appendix 7.9.2). He had already introduced RADMASTE microchemistry to his pupils when he said this, but did not mention that the lessons dragged for too long. Perhaps he was not aware that the first lessons using a RADMASTE microchemistry approach, would be long as the learners needed to familiarise themselves with handling apparatus.]

The community worker was mainly interested in the logistics of TSP and how the Resource Centre could be of help to TSP. He took this opportunity to show the facilitator the resources available at the Resource Centre. When the facilitator saw these resources, they both made suggestions as to how these could be of help to the teachers and the learning community of Duduza. The community worker stayed through out the whole workshop and participated in the workshop (i.e. performed the experiment and took part in the discussion when the experiment was completed). [From his input, he could have done chemistry up to standard 10 (grade 12) level.]

In response to what the teachers had said, the facilitator told the teachers that the main issue with the workshops was that the teachers and pupils were learning to use the RADMASTE

microchemistry equipment. He expressed his joy at the fact that T2 tried introducing RADMASTE microchemistry to his pupils and used a different experiment to the one they had performed in the orientation workshop. He also mentioned to the teachers that they did not have to complete an experiment, but were welcome to do any part they wanted to do and also they were allowed to adapt the experiments to suit their needs.

b) Teacher exposure to more experiments

The facilitator showed the teachers the apparatus found in the microchemistry kits. Some of the apparatus was new to the teachers (i.e. was not in the kits that they received) and some items the teachers had seen in the orientation workshop. The facilitator then asked the teachers to select an experiment that they wanted to perform from the list. The teachers selected an experiment which was on determining the rates of chemical reactions at different concentrations. [This is the same experiment T2 said he performed with his pupils.]

The facilitator then asked the teachers to take out from the chemicals kit, the chemicals that they would need for this experiment. The facilitator then read out the introduction to the experiment. He then explained this introduction using some examples. The teachers were then asked to predict the expected results of the experiment. The prediction of each teacher was discussed by all participants. This was done until they reached a consensus on the expected results of the experiment. Thus two of the three participants had individual help.

As the teachers attempted the experiment, each person was working individually. The community worker was seen to struggle with handling the microchemistry apparatus. The person assisting the facilitator (Assistant facilitator (AF)) approached him and worked with him through the experiment. The facilitator then worked with T2 by helping him keep the time as T2 added the chemicals and observed the changes in the experiment. T1 worked on his own through out the experiment.

c) Discussion

The results obtained in the experiment were discussed. The facilitator kept asking the teachers questions to try and get the answer to the focus question of the experiment and also to cover the subject matter involved in the experiment. The facilitator made up some hypothetical cases

to which he asked the teachers to predict the results. After some considerably lengthy discussions, the workshop participants then dispersed.

4.5.2 Soshanguve second workshop

Two teachers were present for the workshop. These were T3 and another teacher from a second school (T4) who had not attended the orientation workshop. This workshop was held at School 3 where the orientation workshop was held.

When all participants were seated, the facilitator put out some microchemistry equipment. This equipment composed of chemicals kits, microchemistry kits and worksheets.

This workshop covered four major areas, these being:

a) overview of RADMASTE microchemistry;

b) report-back by the teachers on their experiences in the schools plus any issues that the teachers wanted to raise regarding microchemistry with possible solutions and hints from the facilitator;

c) teacher exposure to more microchemistry experiments; and

d) discussion of the experiment just performed.

Below is a report of these four events following the same sequence as the one in the list.

a) Overview of RADMASTE microchemistry

The facilitator introduced himself and the researcher for the second time as he had done in the orientation workshop. He also added the researcher's interests in the workshop. The facilitator continued by introducing the RADMASTE Centre and its aims. He also added the history of microchemistry and the role played by the RADMASTE Centre in starting a microchemistry section. [This introduction was done in the orientation workshop. Perhaps the facilitator repeated himself for the sake of T4.]

The facilitator then asked the teachers some questions about the schools they taught in. First the facilitator asked T4 what classes he taught and T4 told him that he taught standards 9 and 10. When asked about the practical work at his school, T4 told the facilitator that he had only one opportunity to perform practical exercises, but he did not elaborate where and how this had happened.

T3 stated that they had a laboratory at his school but the laboratory had no equipment. Since

there was no equipment, they seldom performed any experiments. [In the interview, T3 reported that there was no practical work in S3 because there were no laboratories. Perhaps having no equipment in the laboratories was the same to him as having no laboratories.]

In response to this, the facilitator said that it was impossible and also expensive to give each pupil their individual apparatus on the conventional scale. He went on to say that it was for this reason that comboplates were designed. He added that these comboplates served as both small and big test tubes. He also added that with RADMASTE microchemistry, laboratories were not necessary. He explained to the teachers how the wells of the comboplate were named. He then told them that the propettes served as burettes and pipettes and he showed them how to use the propettes.

The facilitator showed the teachers new (i.e. latest development) items found in the RADMASTE microchemistry kit. These had not been available at the orientation workshop. He then showed the teachers how these pieces of apparatus worked.

When this part was completed, the facilitator invited questions from the teachers. T3 asked how he could heat in a comboplate. T3 was told that matches could not be used directly on the comboplate but hot water could be used in its place. He asked how one could heat using hot water. The facilitator demonstrated to T3 how to heat substances in a comboplate using hot water and a stirring rod.

b) Report-back

T3, being the only teacher who attended the orientation workshop, was asked whether he had used RADMASTE microchemistry equipment with his pupils. T3 answered that this was not possible since after the orientation workshop, he still had a chapter on electricity (in physics) to complete before he could start on the chemistry component of the physical science syllabus. [In both Duduza and Soshanguve, the teachers were unable to introduce RADMASTE microchemistry to their pupils before the second workshop. In both cases, the teachers mentioned the timing of the workshops as their major hindrance.]

c) Teachers' exposure to more experiments

The facilitator told the teachers that they would perform an experiment on the effect of concentration on the rates of chemical reactions. [This experiment was chosen by the teachers in Duduza, and in Soshanguve, the facilitator selected the experiment for them.] The teachers were then asked to perform the first two parts of this experiment. The facilitator took out his worksheet and read out the focus question of the experiment to the teachers. After he read the focus question, he then read out the requirements of the experiment. As he read out these, he took them from their various containers and showed them to the teachers. He asked the teachers to follow the instructions of the experiment step by step. Before the teachers could start on the experiment, the facilitator demonstrated how to take one spatula of a substance as this was what they were going to do in the experiment. The two teachers attempted the experiment individually. [The facilitator demonstrated his way of performing RADMASTE microchemistry experiments to the teachers. He, however, did not say anything about whether that was the best style to perform the experiments or not. Nor did he say whether the teachers should make their pupils do the same.]

As the teachers went through the procedure of the experiment, T4 was seen to struggle with using the propette. T4 practised getting drops from the propette on his own for some time. When seeing this, the facilitator added that the teachers should give their pupils some time to practice using the propettes. [The facilitator could have realised at this time that practice was necessary and so he gave the teachers some hints.] He said that for practice purposes, the pupils should use water to avoid wasting chemicals. [For most people, using the propette posed problems, especially in the first encounter.]

c) Discussion

The facilitator asked the teachers some questions on the content of the experiment. He also included some examples to which the teachers predicted outcomes.

When this was completed, T4 was given RADMASTE equipment and he signed for it.The workshop was then complete and participants dispersed.

4.6.1 Setting the scene in the schools

N.B. The discussion in this section will be related mostly in the way that it happened in the actual setting of the particular school. The researcher's comments regarding certain statements and events are given in square brackets.

Setting the scene in S1 took two days (i.e. there were lessons on the two days each stretching for about one hour). To prepare his pupils for the experiment, T1 introduced the pupils to acids, bases, dissociation of some acids and titration. The detailed discussion of this event is reported in the following paragraphs.

The first day that the researcher visited S1 was the first day of the school term after the midyear vacation. There were 21 pupils in the class and the class was conducted in a science laboratory. The laboratory had eleven working benches each of which could accommodate two pupils. These benches were arranged into three rows. Many pupils set on the first row of benches and very few pupils set in the second row of benches. The third row of benches was along the wall and no one sat there.

In the introductory remarks, the teacher (T1) told the pupils about microchemistry which was '...developed by people at the University of Witwatersrand'. T1 introduced the researcher to the pupils as a person who was interested in observing the pupils use the RADMASTE microchemistry kits.

T1 told the pupils that he was going to introduce acids and bases. The pupils were then going to perform experiments under this topic using the RADMASTE microchemistry kits. According to the teacher the pupils were each going to have their individual kits.

T1 first told the pupils that there were two types of acids and these were industrial and household acids. He said that both house-hold and industrial acids are organic acids. [He did not mention inorganic acids]. He gave the pupils examples of both types of acids and bases (i.e. household and industrial) and told them that the industrial and household substances (i.e acids and bases) differed in strength.

T1 showed the pupils how to make what he called '...a rough preparation' of a 1 mol dm^{-3} solution of sulphuric acid. To a test tube half-filled vith water he added several drops of concentrated sulphuric acid. He then placed a label on this test tube which was written H_2SO_4 and he placed the test tube on a test tube rack. He added one spatula of commercial tartaric acid to water in another test tube. He said this was an example of a weak acid. T1 told the pupils that he was demonstrating rough preparations of the substances because he had not accurately measured the substances he used.

T1 wrote on the board the formulae of the different acids. As he wrote down these formulae, he called their names out. The formulae of the acids that the teacher wrote on the board with their names in parenthesis (i.e. as the teacher called them) were the following:
HCl (hydrochloric acid), H_2SO_4 (sulphuric acid), HNO_3 (nitric acid), $C_6H_6O_6$ (benzoic acid) [sic], and CH_3COOH (acetic acid). T1 asked the pupils what was common with the acids (i.e. their formulae) that he had written on the board. The pupils answered that the acids all had hydrogen. T1 then added that this point also forms the first theory of acids.

To continue his lesson, the teacher told the pupils that when the acids are dissolved in water, they dissociate to form hydrogen ions. Next to each formula of an acid, the teacher wrote out the ions that form when the acid dissociates (e.g. next to the formula H_2SO_4 he wrote $2H^+ + SO_4^{2-}$). [T1 ignored the ions being in aqueous solutions.] T1 then mentioned that some acids did not dissociate completely and this characteristic of acids could be used to distinguish weak acids from strong acids.

T1 made the pupils aware that there was a difference between concentration and strength of acids. He gave the pupils examples that concentration was expressed in terms of g/l or M/l [actually moles/l or M. This reports what he wrote on the board.] Then T1 made the pupils aware that they needed to understand the above concept before they could perform the experiment he had told them about. The pupils were also cautioned to distinguish between volume and concentration. To show this difference, T1 used some problems which he asked the pupils to solve. To end this particular discussion, T1 also made the pupils aware of the fact that a large volume was not equivalent to a large concentration. [T1 was possibly trying to give the pupils a hint about the experiment they were about to perform.]

T1 talked about the properties of acids. He said that litmus paper turns red in acids. This he showed by adding the two pieces of litmus paper (i.e. the red and the blue litmus papers) in a solution of tartaric acid and in water. Both pieces did not show any change in colour. [Possibly the solution was to weak to give any colour changes.] He took two more pieces and put them into vinegar, the red litmus paper retained its colour while the blue litmus paper turned red. T1 continued on indicators and he said that an indicator '...indicates whether a solution is acid or not'. So he said litmus paper was a '...chemical on its own'. He said that it is a chemical dried on paper. He said litmus paper only indicates '...whether a solution is acidic or not' but it does not tell the strength of the acid. He added that it was important for the pupils to know all the different colours of the indicators.

To summarise the lesson, T1 then mentioned the following points:

(i) acids dissociate to give hydronium ions and from these ions, one can get the strengths of the different acids [he did not elaborate on how this could be done]; and

(ii) most acids have hydronium ions which indicate the acidity of the solution. He added that a large number of the hydronium ions gives a concentrated acid.

T1 gave the pupils some more problems to solve. Some pupils took out their workbooks to solve the problems. It is at this point that T1 realised that some pupils were not taking down any notes during the lesson. Some were writing on their school bags, some at the back of some old book and some were not writing at all, they just looked at the teacher. T1 cautioned the pupils that the lesson was in the syllabus and also that the term had started and he was therefore teaching and was not going to repeat the lesson again. Some pupils started to scribble something and others asked for pieces of paper from other pupils to write on. T1 allowed the pupils to work for a few minutes and then he solved the problem on the board himself. As he solved the problem, he tried to explain the problem to the pupils. He also explained some concepts about how to prepare a more and a less concentrated solution and also the effect that addition or elimination of water) had on the concentration of a substance. This he did in Zulu and the pupils nodded their heads as he talked. At 11h50, the lesson ended, when it had started at around 10h10.

T1 had promised the researcher that on the second day (i.e. the next day), the pupils would perform the experiment on acid-base titrations. The researcher came to S1 again the following

day at the time that T1 had said he would be having his lesson (i.e. in terms of the time table). To begin this second lesson, T1 told the pupils that there was a difference between macro- and micro-experiments. He said that only qualitative experiments could be performed using the RADMASTE microchemistry kits, no quantitative experiments could be performed with the kits. [He, however, did not explain the difference between macro- and microscopic experiments.]

T1 demonstrated titration on a macroscopic level. [This is what he had planned to do in his interview.] He prepared a 1 mol dm^{-3} hydrochloric acid solution and a 1 mol dm^{-3} sodium hydroxide solution using measuring cylinders. He poured some of the acid into a test tube and he added bromothymol blue to the acid. The solution became yellow. He then added the base from a measuring cylinder, where he had prepared it, to the acid in the test-tube in small quantities and shook the mixture continuously as he added the base. He kept asking the pupils what had happened. In the first instance the pupils answered that the yellow solution of acid and indicator turned blue as the base was added. The pupils also said that the yellow colour of the acid was fading away. When asked why the yellow colour faded, the pupils answered that it was because '...the acid was becoming weaker'. T1 added that '...the acid was getting destroyed'. T1 then wrote on the board '$HCl \rightleftharpoons H^+ + Cl^-$'. [The states of the substances are ignored.] The acid turned blueish green and then later a blue colour persisted. When he asked the pupils what had happened, one pupil answered that the hydronium ion was completely destroyed. T1 did not respond to this. He wrote on the board the different ions that the following bases formed: potassium, sodium and ammonium hydroxides. He then wrote down the chemical reaction he claimed took place while he was titrating as follows: '$H^+ + Cl^- + Na^+ + OH^- \rightleftharpoons$ ...'
The equation was never completed on the board.

T1 continued to write:

Acid	Neutral	base
yellow	green	blue

[These were the different colours obtained for bromothymol blue indicator.] To check the colour of the bromothymol blue indicator in a neutral solution, T1 added the indicator to tap

water and it gave a greenish colour. The teacher emphasised that the colour was neither yellow nor blue.

T1 then added more acid to the greenish-blue solution he had just 'neutralised'. The blue colour of the solution faded away and only green was left. The teacher showed this around to the pupils. T1 informed the pupils that the colour faded because the hydronium and the hydroxyl ions combined to form water while the sodium and the chloride ions formed sodium chloride but these remained as ions in the solution. T1 concluded the demonstration by saying that it was '...more or less a titration...' but it was qualitative. For a quantitative titration, he would have to:

(i) know the exact volumes of the solutions used, and this would be done using burettes and pipettes; and

(ii) know the volume of the base used to neutralise the acid. [This is also part of point (I) above.]

He said that any acid plus any base give salt and water and also that neutral means '...when endpoint is reached'.

At this point the teacher invited questions from the pupils but the pupils spoke softly amongst themselves and asked no questions.

Setting the scene in S2

The introduction of RADMASTE microchemistry where T2 was setting the scene in S2 took a one hour lesson. [Setting the scene here was specifically for the acid-base titration experiment since the pupils had used RADMASTE microchemistry kits and allied materials before.] Previously the researcher spoke with T2, and they agreed that a day would be arranged for the pupils to be introduced to acids, and titrations. On this day the researcher went to school 2 where T2 informed her that he had already started the topic on the previous day. T2 volunteered to give the researcher some notes for that 'first' lesson. As can also be seen from T2's interview (see Appendix 7.7.2, page 1, lines 16-17), the pupils had been introduced to the RADMASTE microchemistry kit and also used it to perform an experiment. [This meant that the researcher did not have the opportunity to catch a full impression of the approach as most of the information obtained would be second hand.]

Before the lesson began, T2 introduced the researcher to the pupils as a visitor who had come to the school to '...see...' the pupils' behaviour. He added that some of the pupils should have been `eliminated' since they were '...ill-behaved..'. The pupils just laughed at what T2 said. [The researcher canno' say why T2 did not tell the pupils the truth about the researcher's presence in the classroom. T2 probably wanted the pupils to behave in a certain way.]

T2 wrote on the board 'Acids and Bases'. T2 talked about several issues that can be classified under several topics. Each topic was followed by what he said about it:

(i) substances containing acids and those containing bases;

T2 claimed that acids are found in the `basic food staffs' which are eaten daily. He said examples of such foods are sweets, fruits, vinegar and drinks and they have sour taste. T2 also said that bases on the other hand are found in washing detergents and they feel slippery.

(ii) properties of acids;

Acids have the following properties, they:

(a) react with metals to form salt and hydrogen;

(b) they contain the element hydrogen;

(c) they react with metal oxides to form salt, water and carbon dioxide [sic];

(d) they react with a base to form salt and water (he added that a base is sometimes called an alkali).

(iii) ionisation of some acids in water;

T2 told the pupils that there were two types of acids. These he said were hydrochloric acid and acetic acid or ethanoic acid [the teacher gave examples of the two types of acids (i.e. strong and weak acids) but he called these examples the types]. T2 said that when the acids are in water, they split and he said the scientific word for this splitting is 'dissociation', and when dissociated the acids form ions.

On mention of the word 'ion', he then asked the pupils what it meant and no one answered. T2 told the pupils that an ion is a positive or a negative charge. He gave

them the example of hydrochloric acid. He wrote on the board

$HCl \rightleftharpoons H^+(aq) + Cl^-(aq)$

T2 told the pupils that for the word 'dissociates', he preferred ionises. Then he told the pupils that hydrochloric acid ionises in solution to form H^+ and Cl^- ions and these ions in solution conduct electricity. He said that in the case of hydrochloric acid, HCl is the solute and water is the solvent. He claimed that hydrochloric acid ionises completely so that the ions are greater in solution. He also claimed that it is for this reason that hydrochloric acid is referred to as a strong acid.

(iv) the effect on equilibrium of increasing one species in a solution;

He said that the system demonstrated in iii) (i.e. $HCl \rightleftharpoons H^+(aq) + Cl^-(aq)$) was in equilibrium. T2 then wanted to know what would happen to the equilibrium if the concentration of hydrochloric acid was increased. Many pupils said that the equilibrium would shift to the left and T2 said that they were guessing and he asked them to look at numbers of moles [but he did not specify the species whose number of moles they should look at]. He went further to demonstrate the idea of shifting by giving an example where he had his two arms stretched out. He raised his left arm and lowered his right arm and asked the pupils again as to what would happen to the equilibrium in that case. The pupils then said that the equilibrium would shift to the right. T2 added that if hydrochloric acid, (which he called HCl) was removed, there would be hydrochloric acid formed since there would be an empty space. T2 talked to the pupils in Zulu and told them that equilibrium is equated to a water pass and that when the left side was increased the equilibrium would shift '...where...?'(asked T2). No one answered. T2 ignored this point and proceeded to another subject -weak and strong acids.

(v) weak and strong acids;

T2 talked about the dissociation of acetic acid. He wrote on the board

$CH_3COOH \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$. He told the pupils that in this case there would be a low 'degree' [sic] of H^+. The reason for this behaviour of ethanoic acid is because ethanoic acid is a weak acid. T2 asked the pupils why ethanoic acid was a

weak acid and the pupils answered that it was because it dissociates incompletely in water.

(vi) reactions of acids with bases;

While still talking about weakness of ethanoic acid, T2 then told the pupils that they could drink small quantities of acetic acid and he asked the pupils why that was possible. One pupil answered that it would help in the digestion. He also asked the pupils the name of the reaction between an acid and a base and also the products formed. One pupil answered that it was protolic reaction [the researcher does not understand the statement] and T2 disagreed with that. Another pupil said hydrolysis and T2 said that hydrolysis referred to the reaction between an acid and a salt [sic]. Another pupil said they would be investigating which one between the acid and the base was a catalyst. T2 did not respond.

He gave the pupils an example of having boiling water in a bath and he wanted the pupils to tell him whether it would be possible to bath. Many pupils answered that they would need to add cold water to the boiling water first. T2 agreed with them and added that this would be done so that '...the 'degree' [sic] of hot water and cold water is suitable to bath'. T2 revisited his question of why the acid react with the base and then wrote on the board that it would be to 'neutralize them'. He also said a similar principle to the one of having to add cold water to boiling water in order to be able to bath is the reason why a strong acid is used to neutralise a strong base. [T2 seemed to be comparing an acid to hot water and a base to cold water. He also seemed to be implying that water which is 'suitable to bath...' is similar to a neutral solution.]

(vii) revision:

T2 gave a summary of the above points. In the summary, he stated the following points:

(a) hydrochloric acid is a strong acid because it dissociates completely in water and because equilibrium shifts to the right to form a strong electrolyte [sic?];

(b) ethanoic acid does not dissociate completely. It forms [sic] a weak electrolyte and therefore it is a weak acid.

(viii) dissociation of water (H_2O)

T2 told the pupils that water could be used as an acid and he wanted to know how this could be done. One pupil answered that this could be done by boiling the water. [Could this come from the example that T2 gave in section (vi) above on adding hot water to cold water while he wanted to know why acids react with bases?] T2 made a sound of disagreement when he heard this. He also asked the pupils to refer to the periodic table and wanted to know the element that forms the centre of the periodic table. The pupils answered that the element was carbon [this is not clear to the researcher why the teacher and pupils chose carbon to be the central element of the periodic table]. T2 said that carbon can be referred to as a neutral element because '...it is neither a metal'. He told the pupils that even with water, it can become both an acid and a base. Water can be an acid if it is made to react with '...another water...'. He then wrote on the board $H_2O \rightleftharpoons H^+(aq) + OH^-(aq)$. He said this would be forming a solution of '...water in water'. When he elaborated on this he said it is similar to having water in a beaker and bubbling H_2O gas in the form of steam into the liquid water. There would then be a reaction between H_2O gas and H_2O liquid. He said that in this case, the equation of this reaction would be $H_2O(g) \rightleftharpoons H^+(aq) + OH^-(aq)$. And this shows $H_2O(g)$ acting as an acid then ionising into the two ions (i.e. H^+ and OH^-).

'T2 then talked about the equilibrium constant and gave the pupils the formula for K_c and he said there is K_c for both solids and liquids. The formula he gave was

$$K_c = \frac{[H^+aq][OH^-aq]}{[H_2O(l)]}$$

(ix) solution and compound;

T2 asked the pupils what the difference between a solution and a compound was. One pupil answered that it `...was taking a solid...'. Before the pupil could complete the answer, T2 told them to answer in terms of concentration. When the pupils could not answer, T2 said he was making the question simpler and he asked the pupils to consider the situation in terms of volume. Still the pupils could not answer and T2 told the pupils that one can not change the volume of a compound. He said with a solution on the other hand, the volume can be increased and decreased. One pupil said that the

volume of a compound can be increased by adding more of that sample. [T2's point is not clear.]

T2 then asked three questions in a row and he never allowed time for the pupils to answer these questions. He asked:

(a) whether the compound had a volume;

(b) what the concentration of sodium chloride was; and

(c) whether the concentration of sodium chloride could be increased or decreased.

One pupil then asked what 'aq' meant. T2 answered that it meant '...in solution'. Another pupil asked about the 'g' that was written with water in the form 'H_2O (g)'. T2 never answered this question. He asked the pupils to reflect back on what he had said to them about the concentrations of liquids and solids. He asked the pupils whether the concentration of a solid could be changed. He answered his own question and said that the concentration of a solid cannot change, he said that it is 'stable'. He added that this depends on the ratio with which '...they combine'. [He never explained what 'they' referred to.] Another pupil asked about the volume. T2 asked the pupil whether the volume of a compound could be changed. The pupil answered that it could not. T2 said that liquid [he did not clarify whether he meant the volume or the concentration] could be changed slightly by adding another liquid although this would not satisfy the three factors. [What the three factors were, was inaudible and was not able to be recorded. The point that T2 was trying to emphasise is not clear]. T2 asked the pupils again whether the volume of a liquid in a closed container changed. The pupils answered 'yes'. T2 asked them what the new volume of a 100 ml liquid would be after applying pressure. The pupils answered 'no change'. T2 then said that the same thing applied to the concentration of a liquid. That it changes slightly but it actually remains constant. [It was however not clear to the researcher under what conditions this would happen.] He claimed that this implied that the equilibrium constant for water '..will be constant'. He asked the pupils what would happen to '..K'. of the product formed. T2 wrote on the board $[H^+aq]$ $[OH^-aq]$ = Constant. He said that this is the case because the concentration of water 'H_2O' is constant. After saying all this, he said that he could see that the pupils were lost and then he asked for questions speaking in Zulu. No one asked him a question. The lesson ended at this point.

The researcher met T2 after the lesson. T2 raised his concern about most of the pupils who were struggling in physical science, but all the same, who had taken physical science at Higher Grade level for the external examination. He added that some of these concepts he had to teach to them e.g. equilibrium constants which could not be understood by the pupils.

The notes that T2 had promised to give to the researcher since he had started without the researcher being present, were not produced. This was the end of day 1. [The researcher does not believe that there was anything done on this topic the previous day.]

The researcher and T2 arranged another day that the lesson would be continued and completed. On the second day that the researcher visited the teacher at S2, the teacher was preparing the lab for the pupils to perform an experiment.

Setting the scene in S3

A day was arranged by the teacher (T3) and the researcher for T3 to introduce the RADMASTE microchemistry kit and allied materials to the pupils. This introduction took three science slots (i.e. based on the time table, each slot taking about an hour) over three days. Introduction to RADMASTE microchemistry itself (i.e. setting the scene) was done in one day. The details of the lesson are discussed in the following paragraphs.

First T3 told the pupils that they were going to talk about acids, bases and dissociation. T3 wrote the following formulae on the board:

HCl

H_2SO_4

HNO_3

CH_3COOH

H_2CO_3

H_3PO_4

T3 then wrote the following equations:

$HCl \text{ ---> } H^+ + Cl^-$

$H_2SO_4 \text{ ---> } 2H^+ + SO_4^{2-}$

CH_3COOH ---> H^+ + CH_3COO^-

[T3 left out (aq) indicating that the ions were in aqueous solutions.]

T3 wanted the pupils to show how water dissociates. He wrote on the board:

H_2O

Then he asked one pupil to write the ions found in water. One pupil wrote:

$2H^+$ + O^- [sic]

T3 asked the pupils whether they agreed with that. The pupils said they disagreed and one pupil came to the board and wrote:

H^+ + OH^-

T3 agreed with this and then he said this happens because oxygen dominates the Lewis structure [sic].

T3 wrote a formula of another acid on the board and asked the pupils to show its ions when dissociated. Another pupil completed the equation as follows:

HNO_3 ----> H^+ + NO_3^-

T3 asked the pupils what would happen in the following situation:

NaOH + HCl --->

One pupil answered that chlorine would be liberated. T3 asked the pupil to show that on the board to the rest of the class. The pupil declined to go to the board. Another pupil came forward and wrote on the board:

NaOH + HCl ---> NaCl + H_2O

T3 asked the pupil to show the ions involved in the reaction. T3 also asked the pupils whether the fact that there was water as part of the products implied that the product was a basic or an acidic solution. Many pupils answered that it would be a basic solution. T3 again asked one of the pupils to show the ions involved. When none of the pupils volunteered to show the ions involved, T3 wrote on the board:

Na^+ + OH^- +

Another pupil completed this and wrote:

H^+ + Cl^- ---> Na^+ + H_2O + Cl_2.

So the complete equation on the board was:

Na^+ + Cl^- + H^+ + Cl^- ---> Na^+ + H_2O + Cl_2 [sic]

T3 asked the other pupils whether that was correct. The pupils did not answer. T3 asked the

pupil what was common in the acids [probably referring to the ones he listed at the beginning of the lesson]. Many pupils answered that it was H^+. T3 asked which ions should balance for neutralisation to occur. When the pupils could not answer, T3 wrote on t e board 'H^+' and he said these ions are for acidic solution and then wrote OH^- and said these ions are for a basic solutions. He told the pupils that these two ions will '...neutralise to form water'. He made the pupils aware that they were still left with Na^+ and Cl^- ions. He showed them that this meant then that the products would be $Na^+ + Cl^- + H_2O$. Then he wrote beneath this: $NaCl + H_2O$. [T3 did not use (aq) indicating that the ions were in solution.]

T3 asked the pupils whether the products formed after sodium hydroxide and hydrochloric acid have reacted would be basic or acidic. Some pupils answered that they would be basic and others said they would be acidic. T3 asked the pupils whether they all agreed on the product that would be formed. The pupils did not respond. T3 wrote on the board:

$NaOH \text{ ---> } Na^+ + OH^-$

$HCl \text{ ---> } H^+ + Cl^-$

He then asked the pupils which one of the two substances was an acid. One pupil answered that it was the second substance. T3 asked why the pupil thought so. Before the pupils could answer, he added that water is neutral and he wanted to know from the pupils what that meant. The pupils answered that it meant '..neither acid nor base'. He wrote on the board the ions found in H_2O, these being H^+ and OH^- [still not indicating that the solution was aqueous]. Then he went back to the situation of sodium hydroxide and hydrochloric acid and asked the pupils which one between H^+ and OH^- was more in number. The pupils answered that they were equal. T3 added that the product was therefore neutral. He asked the pupils again whether the product was acidic or basic. The pupils did not answer. T3 asked the pupils which ions were in majority in a basic solution. The pupils answered that it would be the negative ions. One pupil said it would be hydrogen ions but T3 ignored him. T3 asked the pupils which ions would give an acidic solution. The pupils answered that hydrogen ions would. T3 then asked the pupils what would happen if they had both the acidic and the basic ions in equal amounts in solution. One pupil answered that they would have a neutral solution.

T3 then asked the pupils why the product of the reaction of an acid and a base gave a neutral solution. One pupil answered that it was because basic sodium and acidic chloride formed a

neutral solution [sic]. T3 asked for another answer. Another pupil answered that it was because water neutralises sodium chloride [sic]. Another pupil said that the oxidation number of sodium was equal to that of chloride and therefore they were neutral.

T3 gave them an example of two boys-James and Peter- fighting and they say that Charles is to be neutral. T3 wanted to know what they could say about Charles. One pupil answered that it meant that Charles is the mediator and he is not involved in the fight. T3 asked whether not being involved meant that he was helping either of the two boys. The pupils answered that he was not. Then he wanted to know what would happen if he helped James. The pupils said the two would '...overpower Peter'. T3 asked what would happen if Peter also had a friend called Aubet who was '...equally strong..'. The pupils said that the fight would '...be a draw'. T3 asked whether the pupils all agreed to this and the pupils said they agreed. Then T3 told them that in the case of ions the ions would neutralise each other, there would be the same number of OH^- and H^+. So the solution would be neither acidic nor basic, it would be neutral. The lesson for the first day ended at this point.

4.6.2 Hands-on in the schols

Hands-on in S1

It was the second day of visit to the school and the teacher had completed the introductory lesson to acids and bases on the same day. [This is reported under `Setting the scene in S1, section 4.6.1.] T1 gave the following instructions to the pupils before they could start working on the experiment. To:

(i) read the worksheet;

(ii) avoid asking too many questions to show that they understood [this instruction does not encourage pupils to voice their problems which could give an indication of the clarity of the worksheet];

(iii) note that sulphuric acid releases two H^+s and hydrochloric acid releases one H^+. [The teacher gave a hint on the experiment that the pupils were going to perform];

(iv) share the worksheet with one other pupil [encourage working in pairs although he earlier-on said the pupils were going to work individually];

(v) place the comboplate on a clean piece of paper;

(vi) remove everything from their work benches; and

(vii) copy the tables found in the worksheets for recording results into a clean piece of paper. The pupils were told that the researcher was going to collect these pieces of paper so they were told to write neatly. [Instructions (iv) and (v) are evidence of T1 imitating the facilitator to some extent.]

The pupils were then divided into pairs by the teacher so that on each bench there was only one pair of pupils.

T1 then remarked on the materials the pupils were going to use. Each item he talked about is described below.

Comboplate

The teacher showed the pupils that the comboplates were labelled alphabetically from A to F and that they were also numbered from 1 to 12. When reading the comboplate they would have wells A1 to A12 (and he added that this meant that each well of the comboplate was numbered alphabetically plus a normal number). The letters A to F are labelled down the comboplate and

the numbers 1 to 12 are across the comboplate). The pupils were also told that if they made an error in a certain well during the experiment, they should repeat that procedure in the well directly below the one in which they made an error. They were given an example that if when working in well A4 they made an error, they should repeat this in well B4 which would be lying directly below well A4 but in a different row (i.e. B row). They should do this rather than spilling all the contents and washing the whole comboplate clean as this would waste some of their time.

Propettes

T1 showed the propette to the pupils and told the pupils that they were going to use them to suck up '...micro-solutions'. [The teacher probably referred to small solutions which are used in microchemistry experiments. Not implying that they are microscopic.] He added that in the conventional titration procedure, they would use pipettes. He asked the pupils to raise the propettes high when dispensing solutions from them so that they could ascertain whether a bubble within the liquid or the actual liquid came out of the propette. [Sometimes the bubbles may be trapped in the stem of the propette and one can believe that a drop came out whilst in actual fact, an air bubble came out. T1 could have noticed this in the orientation workshop since he does mention it in his interview that he would need to get used to handling the propette so that he knows for certain that a drop of the solution is released (see Appendix 7.7.1, page 1, lines 23-28. When the stem of the propette is raised upwards, one can see the bubble or the drop coming out.]

Mixing rods

The teacher raised one of these mixing rods for the pupils to see. He cautioned the pupils that the rods did not have any holes on them. [This is unlike the glass tubes that have holes on both sides.] T1 asked the pupils to keep the mixing rod in the solution if they happened to use the rod to stir, until the titration was complete since taking out the rod would remove some of the solution from the well of the comboplate and therefore reduce the volume of the solutions.

Chemicals

The teacher told the pupils that they were not going to get their individual solutions which would be needed for the experiment. Instead the solutions were kept in the chemicals kit which

he raised upwards for the pupils to see. He mentioned that all the chemicals bottles were labelled on the lids of the bottle. [These labels also appeared on the worksheet instructions next to each chemical (see Appendix 7A, page 1, under the requirements. Next to the name of each chemical is a reference in square brackets.]

The pupils were going to need two acids and a base for the experiment (this was stated by the teacher) and that the names of the acids were not necessary to the pupils at that stage. [The acids were labelled acids A and B in the worksheet and on their container bottles.] T1 then told the pupils that the two acids and the base they were going to use had the same concentration of 0.1 mol dm^{-3}. He distributed acid A, then acid B, then sodium hydroxide [the base, which ran out somewhere along the way] and then methyl orange [an indicator]. He took each pupil's propette and sucked each chemical and told the pupils the specific wells of the comboplate where they should place their propettes [these were the larger wells that would not be used for the experiment and which were large enough to hold the propettes]. He also asked the pupils to label each propette with a pen. [This could have arisen from the fact that some pupils raised their concerns that they were not going to be able to tell what was in each propette especially when the substances had the same colour. The researcher tried labelling the propettes with a pen and seeing that this could be read, then informed the teacher.] For the sodium hydroxide that ran out, T1 took one propette of base from those pairs that had both received the base and gave it to the groups that had no base at all.

As the pupils were about to commence with the experiment, T1 told them that he expected them to know how to calculate an average for three titrations. T1 told the pupils that they were going to perform each titration three times which would allow them to analyse for errors since '...the more number of times, the more accurate'.

The pupils worked in pairs. As the pupils continued with the experiment, the noise level rose [possibly due to discussions taking place within the pairs]. In some pairs the pupils shared the worksheet, but each one performed the experiment on their individual kit. Some pairs shared both the kit and the worksheet. The pupils shared the kit in two different ways. In the one case, one pupil added the solutions to the comboplate and the other pupil was stirring. In other instances, one pupil added the acid whilst the other pupil added the base then one of them

would stir.

Regarding the propettes, there were three pairs who were seen to struggle with getting uniform drops from the propette. Five pairs were observed to be able to use the propette fairly well. Two pairs seemed to battle with the instructions in the worksheet. Some of such groups called the researcher and told the researcher that they were obtaining the same colour all the time. The researcher tried to establish the contents of each well. They showed the researcher the part in the worksheet that instructed them to add water and the indicator. They then showed the researcher the part instructing them to repeat steps 1 and 2 but using a different substance. So they said they had repeated those steps. [But they had not changed any of the chemicals (i.e they had not substituted the water with an acid like they were instructed to).]

Answering the questions in the worksheets (on precision and accuracy) gave a number of students some difficulty. In most instances, the pupils called the teacher to their rescue. When the experiment was completed and the pupils had their results recorded, the researcher collected the pupils' workbooks for analysis. The class was over at 14h25 when the pupils had commenced the experiment at 13h15.

Hands-on in S2

The entire introduction of RADMASTE microchemistry in school 2 took six days. It commenced on the second day of researcher's second visit to the school. [According to the information obtained from the teacher interview, this was not the pupils' first encounter with the RADMASTE microchemistry equipment. The teacher had introduced the RADMASTE microchemistry and allied materials to the pupils after he had obtained them from the orientation workshop, before the second workshop.]

To introduce RADMASTE microchemistry T2 claimed to have told the pupils what microchemistry was and then he showed the pupils how to use the RADMASTE microchemistry kits. [The fact that the first lesson on setting the scene and the first lesson on introducing the RADMASTE microchemistry kits to the pupils were missed by the researcher means that the researcher missed the opportunity to obtain the full impression of the approach in this school.]

When the researcher arrived at S2, T2 was distributing the RADMASTE microchemistry equipment. The pupils were grouped in the way they were seated. Each bench was given a worksheet or two (i.e. the researcher could not identify any particular pattern followed by T2 when distributing the worksheets).

The pupils performed an experiment chosen by the teacher. The experiment was on determining the different colours of three indicators [these were universal, phenolphthalein and methyl orange indicators] at different concentrations of hydrochloric acid and sodium hydroxide. The details of this experiment are discussed in the following paragraphs.

The pupils were asked to collect the chemicals individually from beakers which were on the main desk and to place the propettes in their comboplates. T2 told them which chemicals to collect and the pupils did as they were told. T2 then read out each instruction of the experiment and then told the pupils what to do. As the pupils did what they were told to do, T2 moved amongst the pupils looking at their work. He also asked the pupils what they had done at strategic points and the pupils told him the steps they had taken. Both T2 and the pupils spoke in Zulu. At certain points, mostly after T2 identified an error with pupils' procedure, T2 referred the pupils to their worksheets. Some pupils actually followed the instructions straight from the worksheet and not what T2 told them to do. T2 later told the pupils to continue with the experiment following instructions from the worksheet. He also asked the pupils to consult him if they could not understand the instructions after he found one pupil using a syringe instead of a propette. Another pupil was unsure about the contents of some of the propettes, so one pupil helped him to determine the contents using universal indicator and the problem was solved.

As T2 moved amongst the pupils he found that one pupil confused the chemicals. He went through the first two steps of the procedure with the pupil and then asked the pupil to continue from the third step. The pupil read the worksheet and then claimed to have realised where his mistake was. Later on, some pupils completed preparing all the solutions and T2 brought one complete comboplate to discuss it with the researcher. The researcher raised some concern about the colours obtained. T2 said this could have been caused by the sizes of drops that the pupils dispensed. He then announced that the pupils should always clean their stirring rods as

the contaminated rods could affect the concentrations of the solutions. T2 then went to the board and copied from the teacher's manual which he obtained from RADMASTE, the expected colours for each concentration. As more groups completed the experiment, the colours obtained were similar to the one T2 discussed with the researcher. T2 asked the pupils to repeat the experiment but to try and be accurate in the second trial. The pupils cleaned their propettes. T2 prepared fresh set of solutions and the pupils collected these with their propettes. The pupils performed the experiment all over again. They obtained colours similar to the ones they obtained in their first attempt. These colours were different to what was listed in the teachers' manual supplied by RADMASTE Centre. [The universal indicator that T2 used for this experiment was one that he had kept for quite some time in his store room. This was not the universal indicator supplied by the RADMASTE Centre.]

The siren marking the end of the lesson rang and T2 asked the pupils to leave everything as it was and to complete it in the afternoon. The pupils did as they were told and left the laboratory. The researcher could not attend the afternoon session due to time constraints. There was no confirmation whether the session actually took place or not.

When the researcher arrived at S2 on the day agreed on by the researcher and the teacher (day 3 visit), T2 was found distributing some microchemistry apparatus to the pupils. T2 then told the pupils that the procedure for the experiment was the same as the one they had followed the previous day and the only difference was that they were going to use a different indicator - phenolphthalein. The pupils collected chemicals from the front bench and started working. T2 also asked the pupils to read instructions carefully and to avoid asking questions. As the pupils were working T2 walked around and helped or corrected errors made by some pupils.

A few minutes later. T2 wrote a summary of the procedure on the board and told the pupils that he had tried to simplify the procedure for them since he found the worksheet to have too many words. [Could this imply that the worksheet was inappropriate or too complicated for T2's pupils to comprehend?] The pupils performed the experiment and at some points, T2 found errors made by some pupils. In such instances, T2 asked the pupil to relate what steps they had followed and also helped the pupil identify the errors. The pupils went through the experiment and one of the complete comboplates that seemed correct to the teacher was shown

on the overhead projector to the rest of the class. Increasing numbers of pupils obtained the same results as the sample shown on the overhead projector. This lesson ended at this point.

The researcher came to the school on the fourth day. It is on the fourth day that the pupils performed the experiment on acid-base titrations. T2 distributed the pieces of apparatus and the worksheets. He told the pupils that they were going to do experiment B2 (see appendix 7.4), which was an acid-base titration experiment. The pupils worked in groups of three, four or five pupils per worksheet and per RADMASTE microchemistry kit. The pupils worked among themselves with few questions being asked the teacher. Many pupils were able to use the propettes and to get uniform drops from them. The pupils also showed some familiarity with the instructions of the worksheet. Some pupils were heard arguing over the instructions and then finally were able to convince each other what the right procedure was. [Some practice from previous experiments could have helped the pupils in handling the propettes.] T2 was however uneasy with the results that the pupils obtained. For acid A pupils obtained in the range of 11 to 18 drops of sodium hydroxide. For acid B the pupils obtained values ranging from 25 to 40 drops of sodium hydroxide when titrating 5 drops of each acid. [Because the pupils had to use so much sodium hydroxide to neutralise the acid, the pupils were using the big wells of the comboplate since the small wells could not hold that much liquid. The worksheet however instructed them to use the small wells. This alone should have indicated to the teacher and pupils that there was an error in the procedure.]

At the end of the lesson, T2 and the researcher had a discussion of what could have gone wrong with the chemicals that the pupils had used. T2 said he had prepared the sodium hydroxide solution himself (i.e. he did not use the chemicals prepared and supplied by RADMASTE Centre). He said he had used 4 grams of solid sodium hydroxide in 100 ml of water. [This was a 1 mol dm^3 and not a 0.1 mol dm^3 solution which was required. T2 had also prepared the 0.1 mol dm^{-3} concentrations of acids A and B from their respective concentrated acids. He, however, could not remember what dilutions he had made to prepare these acids but he claimed to have the feeling that they were also wrongly prepared. T2 then decided to try fresh preparations of these solutions and to let the pupils repeat the experiment all over again.

Although the researcher and T2 had agreed that the experiment would be performed again, when the researcher arrived at the school (on day 5) to observe this T2 said that he was running out of time so the experiment had to be done in the absence of the researcher and the pupils had obtained reasonable results. The researcher then asked T2 to ask the pupils to collect their workbooks for the researcher to analyse. The pupils did not have these workbooks with them on that day. T2 asked the pupils to bring them on the next day. The researcher obtained these workbooks from T2 on another day.

Hands-on in S3

This was the second day that the researcher came to the school to observe the class. T3 distributed the kits to the pupils. Each pupil received their individual kits. The pupils were in a classroom with class desks and chairs only. On each desk there were two pupils. [T3 stated in the interview that the school did not have any laboratories. Both lessons and practical sessions were conducted in the classroom]. The teacher had brought the chemicals and the kits to the classroom. The experiment the pupils performed was about the effect that the concentration of copper nitrate and hydrochloric acid have on the equilibrium formed by these two reactants. A brief description of this event follows.

The pupils performed the experiment in pairs. They followed the instructions from their worksheets. They recorded their observations in their workbooks. As they worked, T3 walked around and observed what the pupils did.

When all the pairs had completed the experiment, the teacher asked for a class discussion of the experiment. T3 read out the focus question to the experiment. The pupils answered this question correctly. T3 went through each step of the experiment (i.e. he performed each step of the experiment for the pupils to observe) and asked the pupils to give their observations. The pupils told T3 what they observed. T3 then asked the pupils the questions in the worksheet. The pupils answered to the teacher's satisfaction [this is in the researcher's view]. T3 wrapped up the experiment and the class dispersed. The researcher and T3 arranged another day that the pupils would perform the experiment on acid-base titrations.

The researcher then came to S3 on the arranged day. T3 had divided the pupils into three big

groups of different sizes. One group had nine, the second had ten and the third group had eleven pupils. In each group there was one microchemistry kit and five worksheets. T3 told the pupils that they were going to perform experiment B2 (i.e. the acid-base titration experiment). The pupils were left to follow the instructions in the worksheet and to discuss the experiment as they wished. The groups were asked to give each member of the group a chance to perform at least one task with the microchemistry kit.

The pupils followed the instructions in the worksheet to the end. No group asked for help regarding the instructions in the worksheet. The pupils also gave each other a chance to perform a task of the experiment. When the experiment was completed, the groups then answered the questions which followed. Two groups out of three could not answer these questions on their own. They asked for help from their teacher. T3 declined to give them any answers. He asked the pupils to write down what they believed was the answer and these answers would be discussed later. T3 told the researcher that he did that because most pupils became lazy to think when they were always supplied with answers. The pupils answered these questions and the group workbooks (i.e. three workbooks from three groups) were collected and handed to the researcher. The class then dispersed.

PUPILS' EVALUATION

Please fill in this evaluation form after you have completed some or all of the practical experiments using your own RADMASTE Basic microchemistry kit.

1. General information:

a) School name: S1 (10 PAIRS & 2 INDIVIDUALS)

b) Did you work alone or with a partner? [2] [10]

c) How many experiments did you do? 2 (12)

d) List the experiments you did: B1 & B2 (12)

Please circle the number of the option you most strongly agree with in the following statements.

Scale: 1 - Strongly agree 3 - Disagree
2 - Agree 4 - Strongly disagree

2. Previous practical experience:

	YES			NO
a) I have performed many experiments by myself while at school.	1	6	3	3
	1	2	3	4
b) The teacher has demonstrated many experiments for me while at school.	9	–	2	1
	1	2	3	4
c) It's not necessary to have had practical experience at school to understand chemistry	2	–	–	11
	1	2	3	4

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

3. I found that microchemistry equipment:

	YES			NO	
a) Was easier to use than beakers, burettes etc.	9	3	-	-	
	1	2	3	4	
b) Was safer to use than beakers, burettes etc.	6	4	1	-	No response (1)
	1	2	3	4	
c) Is not real chemistry equipment.	-	3	4	5	
	1	2	3	4	
d) Developed my confidence in practical work.	8	4	-	-	
	1	2	3	4	
e) Required a great deal of my attention to use.	7	5	-	-	
	1	2	3	4	
f) Was fun and exciting to use.	6	3	2	2	
	1	2	3	4	
g) Was too small and clumsy to use.	1	1	3	7	
	1	2	3	4	
h) Developed my practical skills.	10	-	-	1	No response (1)
	1	2	3	4	

i) Any further comments?

- Microchemistry easier to use & safer (1)
- need more equipment to improve skills in chemistry (1)
- Micro kits are best (1)

4. Microchemistry worksheets:

	YES			NO	
a) Have clear and easy to understand instructions	6	5	-	-	No response (1)
	1	2	3	4	
b) Have clear drawings.	3	5	-	2	No response ( )
	1	2	3	4	
c) Are too long.	-	3	6	-	No response (1)
	1	2	3	4	
d) Have too many questions.	-	-	5	4	No response (1)
	1	2	3	4	

e) Any further comments?

- enable individual hands-on and [illegible] are to chemistry
- not many questions asked
- need to see possible solutions in the worksheet

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

5. Microchemicals kits:

	YES			NO	
a) Have chemicals which are adequately stored in their container.	4	4	—	—	NO RESPONSE (4)
	1	2	3	4	
b) Are safer to use than using chemicals directly out of the store-room.	6	4	—	—	NO RESPONSE (2)
	1	2	3	4	
c) Have chemicals which are clearly labelled.	9	1	—	—	NO response(2)
	1	2	3	4	
d) Have too many chemicals in each kit.	1	—	3	6	Noresponse (2)
	1	2	3	4	
e) Are confusing to use.	—	—	2	8	No response (2)
	1	2	3	4	

f) Any further comments?

- would like to use the kits again (6)
- they are easy and safe to use (2)
- need a way of identifying chemicals in the propette
- easier to study chemistry
- results are seen clearly

PUPILS' EVALUATION

Please fill in this evaluation form after you have completed some or all of the practical experiments using your own RADMASTE Basic microchemistry kit.

1. General information:

a) School name: S2 (INDIVIDUALS)

b) Did you work alone or with a partner? [4] NO (8) [6] BOTH (2)

c) How many experiments did you do? 1 (12), 5 (5), 7 (2) NO response (1)

d) List the experiments you did:

- Acid-base titration (8)
- (11) experiments (2)
- Concentration or chemical (9)
- No response (1)

Please circle the number of the option you most strongly agree with in the following statements.

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

2. Previous practical experience:

	YES			NO
a) I have performed many experiments by myself while at school.	5	15	–	–
	1	2	3	4
b) The teacher has demonstrated many experiments for me while at school.	7	11	3	–
	1	2	3	4
c) It's not necessary to have had practical experience at school to understand chemistry	–	2	5	13
	1	2	3	4

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

3. I found that microchemistry equipment:

	YES			NO	
a) Was easier to use than beakers, burettes etc.	6	14	—	—	
	1	2	3	4	
b) Was safer to use than beakers, burettes etc.	9	7	4	—	
	1	2	3	4	
c) Is not real chemistry equipment.	—	4	4	10	no response (2)
	1	2	3	4	
d) Developed my confidence in practical work.	7	11	—	—	no response (2)
	1	2	3	4	
e) Required a great deal of my attention to use.	8	11	—	—	no response (2)
	1	2	3	4	
f) Was fun and exciting to use.	5	9	2	4	
	1	2	3	4	
g) Was too small and clumsy to use.	—	1	7	11	no response (1)
	1	2	3	4	
h) Developed my practical skills.	9	11	—	—	
	1	2	3	4	

i) Any further comments?

- Kits must be supplied at the schools (2)
- Kits were good to use

4. Microchemistry worksheets:

	YES			NO	
a) Have clear and easy to understand instructions	10	8	2	—	
	1	2	3	4	
b) Have clear drawings.	3	11	4	1	
	1	2	3	4	
c) Are too long.	—	7	9	3	no response (1)
	1	2	3	4	
d) Have too many questions.	1	7	8	3	no response (1)
	1	2	3	4	

e) Any further comments?

- worksheets too long to perform, answer and understand experiment
- Solutions to experimental questions necessary

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

5. Microchemicals kits:

	YES		NO		
a) Have chemicals which are adequately stored in their container.	8	8	2	1	no response (1)
	1	2	3	4	
b) Are safer to use than using chemicals directly out of the store-room.	6	10	3	1	
	1	2	3	4	
c) Have chemicals which are clearly labelled.	8	11	1	-	
	1	2	3	4	
d) Have too many chemicals in each kit.	3	1	13	5	
	1	2	3	4	
e) Are confusing to use.	1	1	13	5	
	1	2	3	4	

f) Any further comments?

- more kits should be supplied to school for individual students (4)
- advanced kits should be supplied to schools (5)

PUPILS' EVALUATION

Please fill in this evaluation form after you have completed some or all of the practical experiments using your own RADMASTE Basic microchemistry kit.

1. General information:

a) School name: S3 (PAIRS)

b) Did you work alone or with a partner? [-] [20]

c) How many experiments did you do? 3 (14), 4 (4), 2 (2)

d) List the experiments you did:

- Acid with base (10)
- Concentration of acid (9)
- Titration (15)
- copper nitrate (3)
- Fountain experiment (6)
- Protolytic reaction (1)
- Redox reaction

Please circle the number of the option you most strongly agree with in the following statements.

Scale: 1 - Strongly agree 3 - Disagree
2 - Agree 4 - Strongly disagree

2. Previous practical experience:

	YES		NO	
a) I have performed many experiments by myself while at school.	2	14	3	1
	1	2	3	4
b) The teacher has demonstrated many experiments for me while at school.	4	11	4	1
	1	2	3	4
c) It's not necessary to have had practical experience at school to understand chemistry	-	-	4	16
	1	2	3	4

Scale: 1 - Strongly agree 3 - Disagree
2 - Agree 4 - Strongly disagree

3. I found that microchemistry equipment:

	YES			NO	
a) Was easier to use than beakers, burettes etc.	5	10	4	1	
	1	2	3	4	
b) Was safer to use than beakers, burettes etc.	4	13	3	-	
	1	2	3	4	
c) Is not real chemistry equipment.	1	2	8	8	no response (1)
	1	2	3	4	
d) Developed my confidence in practical work.	9	11	-	-	no response (1)
	1	2	3	4	
e) Required a great deal of my attention to use.	7	12	-	-	no response(1)
	1	2	3	4	
f) Was fun and exciting to use.	7	7	-	1	no response(4)
	1	2	3	4	
g) Was too small and clumsy to use.	2	2	10	4	no response (2)
	1	2	3	4	
h) Developed my practical skills.	7	11	-	2	
	1	2	3	4	

i) Any further comments?

- More equipment for experiment (5)
- need to practice
- need advanced kits
- need more chemicals for practice

4. Microchemistry worksheets:

	YES			NO	
a) Have clear and easy to understand instructions	9	10	-	-	no response (1)
	1	2	3	4	
b) Have clear drawings.	1	8	1	7	no response (3)
	1	2	3	4	
c) Are too long.	7	6	2	1	no response (3)
	1	2	3	4	
d) Have too many questions.	1	4	6	5	no response (4)
	1	2	3	4	

e) Any further comments?

- Not many questions to ask since teacher gave instructions (1)
- Size of equipment should be improved

Scale: 1 - Strongly agree
2 - Agree
3 - Disagree
4 - Strongly disagree

5. Microchemicals kits:

	YES			NO	
a) Have chemicals which are adequately stored in their container.	8	7	-	2	no response (3)
	1	2	3	4	
b) Are safer to use than using chemicals directly out of the store-room.	1	8	1	7	no response (3)
	1	2	3	4	
c) Have chemicals which are clearly labelled.	7	6	2	1	no response (3)
	1	2	3	4	
d) Have too many chemicals in each kit.	1	4	6	5	no response (4)
	1	2	3	4	
e) Are confusing to use.	-	2	9	6	no response (3)
	1	2	3	4	

f) Any further comments?

- Need more kits for pupils to work individually
- Not enough chemicals (2)
- Less chemicals used to perform and understand experiments

4.6.5 Pupils' interviews

In this section the responses of the pupils to the interview are discussed. The pupils were interviewed using the Pupils' interview protocol (see Appendix 7.9). The interview was based under three sub-headings. These were:

(i) attitude towards RADMASTE microchemistry kits (which were labelled KITS);

(ii) understanding the worksheet instructions (labelled WORKSHEETS; and

(iii) understanding the experimental content [these are the concepts involved in an experiment] (labelled CONTENT).

The analysis of the interview transcripts was, however, carried out under four sub-headings. These were: KITS; WORKSHEETS; CONTENT; and COMMENTS. [Comments referred to any other information that the researcher could comment on.

In each school, two pupils were interviewed. The pupils were labelled pupils 1 and 2, depending on the order in which they were interviewed. So in each school there was a pupil 1 and a pupil 2. In school 2, three pupils were interviewed therefore there were pupils 1, 2 and 3.

S1 pupils' interviews (2 pupils)

The experiment was completed at around 14h25 in the afternoon. The pupils could not be interviewed on the same day since they wanted to go home. Another day was arranged for the researcher to interview the pupils. Two pupils, selected by the teacher, were interviewed. The researcher had asked for a low and high achieving pupils. According to the teacher, the experiment had been discussed with the pupils (i.e. before the interview).

Pupil 1 interview (Appendix 7.10.1): (S1P1)

Pupil 1 claimed to have liked everything about the kits and found them good.

Pupil 1 claimed that the worksheet was clear, and she was able to follow the instructions and answer the questions on the worksheet. She was however confused by the statement that they should answer, namely `...the focus question 1'. They could not tell which question 1 was being referred to. It would have been better if the two questions were rather labelled Question 1 (a) and Question 1 (b) (she said) (see Appendix 7.10.1, pages -2, lines 37-39, 41-42). She

however said that they were able to sort out the instructions. She added that the worksheets specified everything that they were supposed to do.

[Regarding what the experiment was all about, pupil 1 gave an incoherent description of the procedure.] She said that they first added water and indicator. She also said that they added water and acid and compared it with a solution of water and sodium hydroxide. When asked about the differences that they observed in their results, she said that although the concentrations were the same, the volumes were different (see Appendix 7.10.1, page 3, lines 74-86, 88-89).
She named the process of adding the acid to a base, a titration.

Pupil 2 interview (Appendix 7.10.2): (S1P2)
He loved the kits. He mentioned that he have experienced problems with getting solutions `...inside the combo...' (he did not finish his sentence). But then he also agreed that it was difficult to get solutions inside the propettes when the researcher suggested this (i.e. the propettes instead of the comboplate), see Appendix 7.10.2, page 1, lines 18-20. [The researcher could have used previous experience obtained in the interviews (i.e.with teachers and pupils) that propettes are not easy to handle. Pupil 2 could have had difficulties in transferring solutions from the propettes to the comboplate, which is a similar problem to what other people experienced.] He also suggested that he would have found it easier to work with the kits if there was a way to mark the contents of the propettes used for a particular experiment (page 1, lines 22-24).

He claimed that the worksheet was easy to follow and also that everything was clear. He was also interested in getting the solutions to the experiments that they had performed (see Appendix 7.10.2, page 2, lines 39-41).

The experiment was on titration. The other parts that he added to this statement were inaudible on the tape recorder and so only bits that did not make sense to the researcher came out. The other part on the content was not recorded on the tape. It is unfortunately not available (page 2, lines 56-57).

S2 pupil interviews

After T2 informed the researcher that the experiment had been performed again using the correct concentrations of the acid and base and pupils obtained `reasonable' results, the researcher then asked T2 to allow two pupils of specified achievements to be interviewed. As the researcher and T2 walked to the room that was to be used for the interview, T2 met several of his pupils heading for the laboratory where the science lessons were conducted. He called two girls from this group and asked them to go with him. One of the girls went into the room with the researcher and was interviewed.

Pupil 1 interview (Appendix 7.10.3) (S2P1)

Pupil 1 said that she liked the kits very much and she also found them quite interesting since it was the first time they used such equipment (see Appendix 7.10.3, page 1, lines 17-19). She claimed that there was nothing that she did not like about the kits.

Regarding the worksheet, Pupil 1 claimed to have understood everything. She said that the worksheet was very clear on that acid-base titration experiment. [The researcher showed her the worksheet of the experiment of acid-base titration (see Appendix 7.10.3, page 1, lines 26-27).]

When asked to elaborate on the experiment, Pupil 1 then claimed not to remember anything. The researcher reminded her the day that the experiment was performed, and she claimed to have been absent that day. The researcher reminded her the day that the teacher had claimed the experiment had been repeated, the pupil then claimed to have been sick for the whole of that week (see Appendix 7.10.3, pages 1-2, lines 30-40). On getting these responses, the researcher then thanked and dismissed the pupil. This was not relayed to the teacher informing him that the pupil could not answer some of the questions. [The researcher cannot was trying to avoid answering the questions since she could not recall the experiment or whether she really had been sick.]

Pupil 2 interview (Appendix 7.10.4) (S2P2)

Pupil 2 was not the other girl whom T2 had selected on the way to the interviewing room. He had sent a boy instead. The researcher interviewed this pupil. [The researcher has no idea why

T2 swapped the pupils.]

Pupil 2 said that he liked the idea of the kits because then they had the chance to work individually and also they had no chance to copy from each other (see Appendix 7.10.4, page 1 lines 16-19). When asked about what he did not like about the kits, he expressed his unfamiliarity with some of apparatus. In particular, he was still not familiar and found it difficult to get adequate drops from the propettes (see Appendix 7.10.4, page 1, lines 23-26). He however believed that with time, he could improve that skill.

Regarding the worksheet, pupil 2 claimed to have understood `some' of the instructions on the worksheet. He however could not understand the words `monoprotic and diprotic.' But he claimed to have been able to follow the instructions (see Appendix 7.10.4, page 3, lines 86-96). On the other hand, pupil 2 put part of the blame on himself for likely not to have paid attention to the teacher when he explained these. [T2 never made an attempt to explain these terms in the researcher's presence.]

The pupil was then asked to give a brief explanation of the experiment. He reported the experimental procedure and still maintained that he understood what the instructions wanted him to do. But he did not understand why they did what they did (see Appendix 7.10.4, page 2, lines 53-56). He gave a general description of the experiment, that they were adding two things in order to see what would come out of that. When the researcher asked him to elaborate on that, he related some parts of the procedure. [The researcher believes that he did not understand the theme of the experiment.] Pupil 2 named the procedure that they followed a of titration.

The researcher thanked the pupil and let him go. Immediately after the pupil left, a third pupil came in. The researcher had no idea why this pupil was sent as only 2 pupils were requested from T2. [The researcher however met one of the pupils (pupil 1) informally (i.e. this was off the record, the researcher taught Pupil 1 in a second chance programme the following year). The researcher asked the pupil what happened that day, she informed the researcher that she had gone back to class and when she got there T2 sent another pupil out to the interview room. She claimed not to have informed anybody that she was not able to answer questions related

to specified experiments. [The researcher did not follow the methodology stipulated in this case. An interview was conducted with this third pupil, since Pupil 1 did not answer the questions.]

Pupil 3 interview (Appendix 7.10.5): (S2P3)

Pupil 3 said he liked the kits because they helped him, especially in calculations. When he was asked if there was anything that he did not like about the kits, pupil 3 said she had not yet found anything that he did not like about the kits.

Regarding the worksheet, pupil 3 said he was able to follow everything in the worksheet. [The experiment in question was shown to pupil 3 and he said he understood the experimental procedure.]

Pupil 3 said that the experiment was about checking the concentrations and also comparing the ratios of monoprotic and diprotic. [He did not say monoprotic and diprotic referred to. The researcher could not make sense out of the whole statement. The pupil could be confusing more than one experiment that they had performed (see Appendix 7.10.5, page 1, lines 29-32.] He said that they were using two acids whose ratio's were not the same. [The researcher could not make sense whether the pupil meant the ratios of the two acids with sodium hydroxide or something else.] He also mentioned: having used bromothymol blue and phenolphthalein; and checking time, reaction, volume and colour changes [some of which things were never done or used in this experiment.] The researcher tried to focus the pupil on the acid-base titration experiment and then asked the pupil what they were doing there. The response the pupil gave was not audible from the tape (Appendix 7.10.5, page 2, line 56). The pupil also could not say the name of the procedure they had followed.

[It is the feeling of the researcher that T2 did not select pupils of different achievements. He tried to chose his best achievers in the class.]

S3 pupil interviews

After the pupils preformed the experiment, the researcher collected the workbooks and arranged another day with the teacher when the interviews would be conducted. The researcher

came on another day.

Pupil 1 interview (Appendix 7.10.6): (S3P1)

Pupil 1 said that he liked the kits because they could help him prepare for further studies in chemistry (see Appendix 7.10.6, page 1, lines 15-17 and 19). He said that there was nothing that he did not like about the kits.

Regarding the worksheet, he said he was able to follow the instructions of the worksheet.

He said the experiment was about a 'titration'. He said the experiment was to show which acid between the two 'concentrated' acids that they used was strong. He said that acid B was stronger than acid A because he added 5 drops of sodium hydroxide to acid A and this changed its colour, but acid B needed 10 drops to give the same colour change (Appendix 7.10.6, page 2, lines 41-42, 60-61, 65-66). [There is evidence that they obtained experimentally determined results in this experiment. But Pupil 1 was still not clear why they did not obtain the same volumes for the two acids.]

Pupil 2 interview (Appendix 7.10.7): (S3P2)

Pupil 2 liked the kits because they (i.e. pupils) were able to see these things when otherwise they had been talking about the things that they could not see [the pupil could have liked the idea of practical work on the whole] (see Appendix 7.10.7, page 1, lines 21-24). There is nothing that he did not like about the kits.

Regarding the worksheet, pupil 2 did not remember encountering any problems. Even after looking at the worksheet to remind himself of the experiment, he could not remember encountering any problems with the worksheet instructions (see Appendix 7.10.7, page 2, line 38).

When asked about the experiment they performed, Pupil 2 said that they mixed five drops of water with one drop of methyl orange. In a different well, they mixed six drops of sodium hydroxide with acid A and ten drops of sodium hydroxide with acid B, they obtained the same colour as that of five drops of water with one drop of methyl orange (see Appendix 7.10.7, page 2, lines 45-47, 49-50, 52, 60, 65, 80-82). He then concluded that acid B was stronger than acid

A because they used more drops of sodium hydroxide in acid B to obtain a colour similar to that of water (see Appendix 7.10.7, page 3, lines 86-89). He could tell that the name of the procedure was titration. [Pupil 2 could have understood the experimental procedure although the concept behind the two acids (i.e. monoprotic and diprotic) was still not clear.]

4.7 THIRD WORKSHOP OUTCOMES

Duduza third workshop outcomes

The workshop was held on the third of August, 1995 at the Duduza Resource Centre in Duduza. Present at the workshop were T1 and T2, the facilitator and his assistant, and the researcher.

The workshop was divided into two major parts. These were: the report back from teachers with possible assistance from the facilitator; and the experimental exercise.

i) Report-back from teachers and possible solutions

The facilitator first asked the teachers to report on their experiences in their schools. T1 reported that he found that the pupils understood the instructions in the worksheet well. He believed that for the former practice they did not understand the objective of the experiment. He also believed that the problem was that the pupils were used to being given experimental set-up followed by questions. His view was that when pupils were exposed to mentioned setting, they were not involved and they, therefore, easily forgot what happened. What he found out from using RADMASTE microchemistry equipment with his pupils was that the pupils understood the experiment and he also believed that they could still remember what happened in the experiment. His concern was that the pupils experienced problems with handling the RADMASTE microchemistry apparatus. He also found that they '...mixed-up and messed-up the chemicals...'. The pupils however understood the colour changes.

T2 reported that it took a long time for the pupils to complete the experiment. He however claimed that the pupils enjoyed the experiment they performed. He found that when the pupils performed the second experiment, whose title was not mentioned, the rate at which they worked improved. T2 also reported that his pupils completed the evaluation forms that they were expected to complete at some point after performing some experiments using the RADMASTE microchemistry equipment.

T2 said however that after the pupils performed experiment B2 (based on acid-base titration) he asked his pupils some questions which they could not answer correctly. He concluded from this behaviour that the pupils did not understand the experiment. He also believed that the experiment was very advanced for the pupils. He then gave them experiment B1 (based on equilibrium) to

perform and he found that the pupils were able to pick up the trend and could answer his questions. He informed the facilitator that he found his pupils unable to answer some of the questions on the worksheet. These questions related to 'precision and accuracy' were not in the syllabus. He believed that such things should have been formally taught to the pupils. T1 also agreed with what T2 was saying by commenting that some of the questions in the worksheet were above the pupils' level.

T2 also said that experiment B1 was too long and it had too many questions. He, therefore, decided to focus his efforts on helping the pupils to be familiar with handling the apparatus than to answer the questions in the worksheet. In response to this the facilitator advised the teachers to identify what the pupils can understand since they know them better and then to 'adapt' the experiment to suit their personal needs. The teachers were not bound to adhere to the worksheet from beginning to end. The teachers were also allowed to choose those experiments that they could use.

The facilitator invited more questions from the teachers. T2 told the facilitator that he ran out of chemicals during some of the experiments. The facilitator told T2 that the money available for RADMASTE microchemistry only catered for what they had received and that to get more chemicals, they would have to pay for them.

The facilitator also asked the teachers to clarify with their pupils any errors that they could identify in the worksheets.

(ii) Experimental exercise

The facilitator asked the teachers to select an experiment from the microchemistry list they wanted to perform. The teachers selected experiment B5 (which was based on the production of hydrogen sulphide). This experiment happened to be the same one the facilitator had planned to ask the teachers to perform although he finally decided to let the teachers make their own choice.

The worksheets that the teachers used in this workshop were slightly different from what the teachers used in the previous workshops. In the old worksheets there were spaces provided for answering the questions. In the latest worksheets, an icon of a hand was used to indicate that something had to be written down (i.e. either to record an observation or to answer a question).

The 'space within the worksheet' style was changed so as to allow the use of the worksheet as a guideline and not something that had to be followed rigidly. The facilitator asked the teachers which style they preferred and the teachers chose the one that had spaces provided to record responses. [There was, however, no final decision taken regarding this matter.]

The teachers then performed the experiment and completed it without any serious difficulties. No discussion of the chemistry content related to the experiment was held after the experiment was completed.

The facilitator then closed the workshop by thanking the teachers for their time. He also asked the teachers what perceptions they had regarding the workshops. T2 responded that these workshops were going to be useful for the pupils. The workshop was concluded and the participants left.

Soshanguve third workshop outcomes

At the second workshop the participants all agreed on the 18th of September for holding the third workshop. [The reason for this could be provided.] When the facilitator and his assistant together with the researcher arrived at S3, there were no teachers available for a workshop. The facilitator decided to come again the next day in the morning to try and run the workshop. On the following day T3 was found at S3 but T4 was not present. [T4 was the teacher from another school who only managed to attend the second workshop and not the first workshop.] After some discussions between the facilitators and T3, they agreed to all go to S4 and if possible they could then hold the workshop at S4. T4 was found at S4 and he was available for the workshop and agreed with the facilitator's proposal that the workshop could be held at his school. The workshop was held at S4.

The workshop was divided into three major events. These were:

(i) preparations for the workshop format;

(ii) experimental exercise; and

(iii) discussion of the experiment.

(i) Preparations for the workshop format.

T4 was found teaching his standard 10 class. The facilitator wanted to invite T4's pupils into the

workshop to be participants with the teachers. T4 did not agree to this suggestion that the pupils had been in a lesson for a long time and he believed they needed their break. The facilitator then suggested that he run the first part of the workshop with the teachers and when the pupils come back from their break, the teachers could then take control of the experiment being performed and the pupils perform the experiment as well. [No one responded to this suggestion and it never took place.]

T4 informed the facilitator that he had not yet had the chance to use the RADMASTE microchemistry equipment.

(ii) Experimental exercise

The facilitator selected experiment B1 [which was based on chemical equilibrium]. He was reminded that the experiment was performed in the second workshop. He then selected experiment B4. This experiment was based on the rates of chemical reactions.

The facilitator briefed the teachers about the experiment. He told them that it was based on a cross made on a paper that disappeared when the reaction was completed. He told them that the reagents involved in the experiment were hydrochloric acid and sodium thiosulphate to form sulphur and other product The precipitation of colloidal sulphur was responsible for the disappearing of the cross. He then told them they would record the results on the time taken for the cross to disappear. He also suggested that the teachers allow their pupils to perform the experiment in pairs so that as one looks at the cross, the other person concentrates on the time it takes for the cross to disappear. He also told the teachers that the experiment involved constant and changing variables and the teachers should find out the effect these variables had on the rate of the reaction. [Note that the experiment did not work as expected. The cause could have been contaminated solutions.]

Everybody had their individual worksheets for the experiment. The facilitator mentioned the equipment needed to perform the experiment. He then told the teachers to select the chemicals they were going to need for the experiment. The facilitator also told the teachers that to perform the experiment correctly, they needed to check the time 'constantly or uniformly'.

He then asked the teachers about the factors that could affect the rate of a chemical reaction. The

teachers listed the following: temperature; concentration; and division of reagents. The facilitator informed the teachers that in that particular experiment, they were going to look at the effect of concentration. He also advised the teachers to prepare themselves to smell some gases during the course of the experiment.

The teachers then worked individually (i.e. each teacher having their individual worksheet and chemicals). Seeing that T4 battled with getting uniform sizes of drops from the propette, the facilitator suggested another way to handle and squeeze the propette. T4 practised this technique for some time and appeared to cope with it. The facilitator also believed that the teachers did not have a systematic way of keeping track of the contents of the propettes they used. He asked the teachers how they could identify what was in each propette. T3 informed the facilitator that he always knew what was in each propette because he worked with few propettes. The facilitator then advised them to place the comboplate on a piece of paper and next to each well [the big wells that could hold the propettes], on the piece of paper, label the chemical that would be placed in that well.

(iii) Discussion

When both the teachers completed the experiment and obtained their results, the facilitator wanted the teachers to tell him what had happened in each well. Before the teachers could answer, he told them that they were looking at the time taken when they had just the right amount of sulphur to cover the cross. He told them that this was therefore the rate which was obtained by the varying concentration of reactants over the time taken, for the completion of the reaction.

Looking at the results that the teachers obtained, the facilitator found that the teachers did not obtain consistent results. The facilitator added that due experimental problems the teachers were not able to 'observe the results'. He, however, asked the teachers then what kind of relationship they had expected to find. He showed them the relationship that they could have found if all went well and he told them that the relationship was not that of direct proportion. The facilitator told the teachers that if concentration increased, rate also increased and if it decreased, rate also decreased.

He then invited questions from the teachers. There were no questions for the facilitator. He then concluded the workshop by telling the teachers that he hoped they had noted the way he asked

his questions and that the teachers were going to use the same approach.

When the participants were about to disperse, T3 told the facilitator that he experienced problems with cleaning the propettes. The record of how the facilitator suggested several options to T3. [There is also no record of the facilitator asking for detailed feed back from the teachers of what happened at their schools regarding the introduction of RADMASTE microchemistry equipment. The only record available was that of T4 reporting not to have had the chance to use the microchemistry equipment.]

8

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