BRINGING EXCITEMENT INTO CHEMISTRY THROUGH ACTION RESEARCH

Karanam Bhaskar & Neeraja Raghavan

The Peepal Grove School (India) & THINKING TEACHER (India)

karanambhaskarpgs@gmail.com, neeraja@thinkingteacher.in

Abstract: *In his eighth year of teaching, a Chemistry teacher in a residential school confronted the monotony and tediousness that he experienced while teaching. He also recognized the challenge of getting his students to enjoy learning Chemistry. This paper describes his year-long Action Research that succeeded in turning things around – slowly but remarkably – from teaching passive, disinterested students to engaging with a bunch of enthusiastic and excited learners. His Action Research aimed to bring in a greater number of "AHA" moments in his students, during their learning of Chemistry. By the end of his journey, he had revisited some of his prior assumptions, gained several insights into his approach and noted that most of his students now enjoyed his classes. Above all, he had himself experienced "AHA" moments. The process of facilitation of his Action Research is described as also the evidence that the researcher gathered to validate its conclusion. This work attempts to overturn the popular assumption that an experienced teacher cannot significantly alter his/her teaching practice.*

INTRODUCTION

An experienced teacher of Chemistry in a residential school undertook Action Research (AR) in his eighth year of teaching. He was prompted to do so because of two reasons: first, his own experience of increasing monotony in teaching the subject, as well as the difficulty experienced by his students in learning it – a fact that had been brought to his notice by some students as well as the School Principal. The latter requested the second author of this paper to facilitate his AR so as to bring about enjoyable teaching-learning of Chemistry for teacher and students. This work was carried out over a period of a little over one academic year. Hereafter, the teacher will be referred to as the *teacher/researcher*, and the other author as the *facilitator*.

AR has been successfully employed to turn teachers into reflective practitioners [Nunan (1989), Elliott (1991), Perrett (2003), Raghavan & Sood, (2015)]. Although this teacher was himself very enthused about Chemistry, he was acutely aware of the fact that his students did not share his love for the subject and he could also see that he had settled into a mechanical mode of transaction. Despite his keen desire to effect a change, he was unclear about the way forward - and so AR was deemed an apt method to employ. The work of Humerick (2002), Avergil et al (2012), Tolentino et al (2009) and Dori & Barak (2001), amongst several others was referred to by the teacher-researcher so as to draw from their ideas and enliven his teaching of Chemistry.

METHODOLOGY

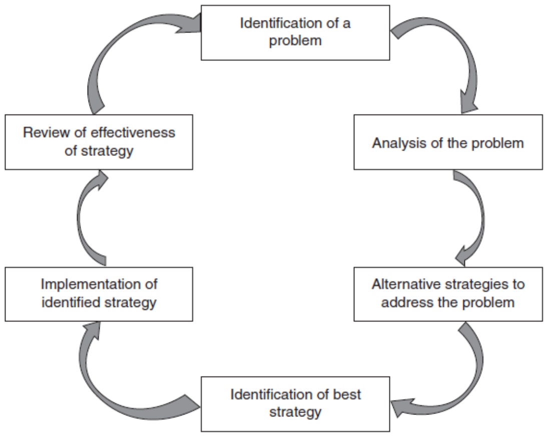

Figure 1: Framework of Action Research (Raghavan & Sood, 2015)

Beginning with an introduction of the framework of AR (see Figure 1) to the researcher by the facilitator, a sustained engagement between this researcher-facilitator duo began. The nature of engagement was one face-to-face meeting every month, a classroom observation by the facilitator [the teacher would know when the facilitator was going to observe his class] followed by sharing of her observations with the teacher-researcher in a face-to-face meeting. A couple of emails were exchanged roughly every quarter. The facilitator factored this researcher's newness to research into her mode of facilitation, by suggesting structured documentation only six months into his research, and referred a few research papers for him to read only at the very end of his AR.

Identification of the AR Problem

The researcher began by noting as follows: *Although I believe that I have always tried to reach out to the entire class, I often get the feeling that I fail. I also experience a sense of monotony and tediousness in transacting the subject. I need to make it more interesting - for me as well as for my students.*

Through the course of the AR, the facilitator observed about twelve classes, during each of which she noted her observations. As rapport between the duo increased, the facilitator began to share more and more feedback with the teacher (during the monthly meetings), who then took note of her suggestions and began to act on them. In her very first classroom observation, she made a note of his tendency to *"go back and forth, the thought sequence is not clear and logical. He is not cognizant of the priority of concepts, or the flow of logical thinking."* She did not share this feedback with the teacher just yet, however.

Framing the Problem After the second meeting, the facilitator noted: *It took some discussion for a concrete problem to emerge. The teacher slowly framed his AR Problem thus: How can I bring in a maximum number of AHA moments for as many students as possible, in each class that I teach? I was also touched by his honesty in owning up to having a poor understanding of electrolysis – probably one among many topics, he admitted. Which teacher owns up readily to not knowing something properly? He admitted that he had not been taught that topic well – having had limited exposure. With all these limitations, I am struck by his zeal to be a good teacher.*

Analysing the problem The facilitator then led the researcher through a process of analysing the AR problem, through a set of questions tabulated below:

Question posed by facilitator	Answer given by researcher
What is meant by an "AHA" moment?	"The sudden understanding or grasp of a concept is often described as an 'aha' moment – An event that is typically rewarding and pleasurable. Usually, the insights remain in our memory as lasting impressions." Rick Nauvert
Why are hardly any students currently experiencing these moments?	*I often solicited student feedback after tests. Many students in my class would frequently say that they found it difficult to remember so many facts, from a vast syllabus. Many also perceive Chemistry to be abstract - requiring visualization. It puts many people off. Metallurgy, numerical problems, mole concept, etc. are seen to be dull and boring, and valencies, chemical formulae and chemical equations difficult to memorize.*
What is *preventing* these moments from occurring?	*I find that I am mostly unable to gauge interest levels of students so as to then engage them. Sometimes, I notice that students do not like to get involved in activities, especially if they are not hands-on. It is even more difficult to get them engaged in written work. But then, every topic does not lend itself to hands-on activities e.g. Atom, Molecule, Mole, etc.*

Table 1: Analysis of AR problem

As can be seen above, the process of analysing the issue led the teacher to recognize his own inability to gauge student interest levels.

Identification & Implementation of Strategies As the teacher continued to share his observations of his teaching methodology, the space for examining them without judgment slowly opened up. The teacher began noting his own pattern of teaching in his emails to the facilitator: *I could see that I tended to jump from one idea to the next and often, children were unable to keep pace with me. Sometimes, while teaching, I would assume that there was no need to explain each step as these children know quite a lot about the subject. But in so doing, a certain sequential logic and flow would be missing.* Thus, the teacher had now realised for himself what the facilitator had initially noted (but had then refrained from sharing with him). Interestingly, this was not the first instance of the researcher being made aware of missing steps in his sequential logic. By his own admission, peer feedback had been given to him before he embarked on AR: *"One of my fellow teachers observed my class and alerted me. He told me that there was no continuity or flow in my teaching."* However, with the framework of AR, he slowly began to feel empowered to *actually address this gap*. Strategies that were discussed during the monthly meetings with the facilitator began to play out in the teacher's classes – and he could now slowly see their impact. The facilitator and researcher came up with the following list of strategies:

1. Introducing concepts from their historical origin
2. Use of concept maps
3. Hands-on activities

4. Audio visual tools
5. Projects to motivate disinterested students

Slowly, the teacher-researcher began implementing each of these strategies.

Incorporating the History of Science: While teaching the Kelvin Scale of Temperature, the teacher noted thus: *I started the lesson called Study of Gas Laws by showing videos*[1] *on how scientists derived the value of absolute temperature as* -273^0 *Celsius. I found that students were interested, as they appreciated the efforts of different scientists.*

Use of Concept Maps: The facilitator suggested that the teacher draw up a concept map while preparing the lesson plan, so as to address the missing steps in logical sequence. The teacher shared with the facilitator his concept map for balancing chemical equations, and this is presented below to exemplify the teacher's altered Lesson Planning with a Concept Map:

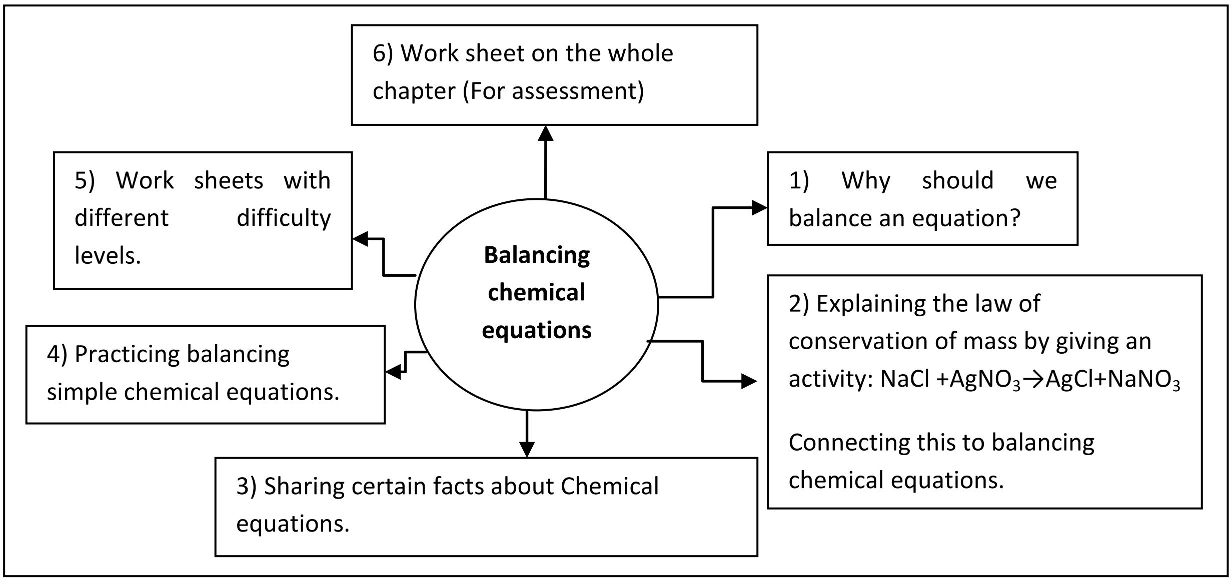

Figure 2: Concept Map for balancing chemical equations

The teacher soon noted the power of drawing concept maps thus: *Once I started using concept maps, I felt that I wasn't missing the logical sequence of concepts. It also helped me to cross check whether I had missed out any concept while delivering the lecture. I also made my students practice drawing such concept maps for the chapters which they found difficult. Two students benefited noticeably from this exercise.*

[1] https://www.youtube.com/watch?v=zY5OwnggnUE, https://www.youtube.com/watch?v=wl66BIgfHGk, https://www.youtube.com/watch?v=gBWn00X-1tQ, https://www.youtube.com/watch?v=W3Lk9aDMqpM, https://www.youtube.com/watch?v=HqbcZz-p7IQ

Hands-on Activity: The teacher transacted the class on balancing chemical equations by having students actually weigh reactants [NaCl and $AgNO_3$] and products [AgCl and $NaNO_3$] before and after mixing, *for them to be convinced* of the law of conservation of mass – the basis of balancing a chemical equation. He recalled that before embarking on AR, he would simply demonstrate this mass conservation to the entire class, but that he now felt compelled *to bring it directly into the field of experience of each student*. "If I have them experience the fact first, and *then* go into the law or definition, I feel it works better," he declared. The facilitator noted that this was the teacher's own 'Aha' moment.

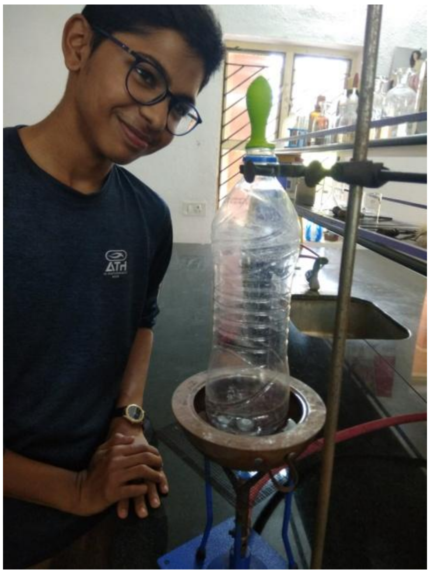

Figure 3: Student seeing relationship between Pressure & Volume

The teacher then documented thus: *After I saw the success of the above strategy, I began to employ more Hands-On Activities. I found that students got firsthand experience which helped them draw their own conclusions, instead of merely going by the textbook. Class IX was asked to play with a cycle pump, a bottle, a syringe and a balloon. When they pumped air into the bottle as shown below, the volume of air in the syringe decreased and the balloon got compressed. Now the students drew their own conclusions about the relationship between pressure and volume. Every student was involved and subsequently they were able to draw a graph and define Boyle's law on their own.*

Students went on to perform activities like making voltaic cells, observing how a dented tennis ball loses its dent upon heating, etc. Chemistry classes changed from lecture-demonstrations to interactive sessions. More importantly, the teacher's own reflections about his altered approach brought home to him many nuances of the teaching-learning process: *Previously, I used to show animations in the computer centre to help students see how these characteristics of gases are related to each other. I found that most students were having difficulty recollecting the laws and applying them in solving problems. After introducing the same lesson by using Hands-On-Activities, I noticed that all students were - at the very least - able to remember the Gas Laws. Some even tried to apply the concepts related to these, when they were promoted to X Grade. Above all, the entire class enjoyed learning.* Looking back at the various strategies that he had tried out, the teacher noted thus: *I personally found Hands on activities worked well because I was able to engage students with focus. At the same time they gained firsthand experience, which will help them remember what they learned, for a long time.*

Facilitator's Observations By the seventh month, the facilitator observed that the teacher had managed to turn around several inattentive students of his class through his changed methodology, and he had about 30% left to conquer. The facilitator probed the reasons for the teacher's altered approach, and received this response: *He said that when he reflected, he detected that he "was stuck." He had done the show-define-solve-problems routine to death, he realised.*

By the eighth month, the facilitator noted as below: *He shared with pleasure how he is the butt of envy of other teachers', as all his Class IX students have completed their Chemistry holiday HW! They haven't all done so in any other subject.* And after the classroom observation, she noted thus: *In his demonstration of the anomalous expansion of water [a difficult topic], he truly excelled himself. By freezing water in a plastic measuring cylinder, students noted that the volume had gone from 60 ml water to 67 ml ice! So they gathered actual evidence of the anomalous expansion of water.*

Teacher's Shift in approach The overall shift in approach was described by the teacher as below:

S. No	Topic Name	Previous Method	Current Method
1	Mole Concept	Lecture Method	Using different work sheets to define important terms and solve problems
2	Electrolysis	Lecture Method and using lab	Making voltaic cells. Using audio – visuals. Providing work sheets to practice chemical equations at anode and cathode.
3	Metallurgy	Lecture Method	Using audio - visuals to understand mining of aluminium.
			Giving group activities to understand the comparative study of metals and non - metals.
			Providing work sheets
4	Gas Laws	Lecture Method	Hands on activities - helps students understand the relationship between volume, temperature and pressure.
5	Introducing any topic	Lecture Method	Giving history behind the topic.

Table 2: Overall Shift in Teaching Methods – some examples

Audio-visual tools: As the teacher began showing more videos to illustrate topics like metallurgy and electrolysis, he found that the interest level of his students spiked. *One of my weakest students in Class X was able to summarise the entire lesson after watching the videos in both topics. Previously, I used to first get the students to perform the electrolysis and then explain the concept to them. But now, by first showing the video, it helped him understand what happens at the anode and cathode in the electrolytic tank. Movement of ions is shown in these animations. So I found that videos are more helpful here, than in gas laws.*

Projects: By suggesting different projects, students' active involvement was garnered. They succeeded in making electrolytic cells that produced 3 volts of current, and this raised their confidence levels and gave them a sense of achievement. Students were also excited to make rockets, even though that project failed.

Students' Own Feedback At the end of the AR cycle, the teacher solicited feedback from students about their attitude to Chemistry, through a written questionnaire. Comprising just three simple questions (what is your current feeling towards Chemistry, what did you feel at the start of the academic year, give reasons if there has been any change), the questionnaire revealed that seven of ten students experienced a positive change in their attitude to Chemistry. For want of space, only three are being quoted here: *"Initially, I found Chemistry very tough and I was afraid. I would not be able to attempt even one question. But I did well because of Bhaiyya's support and teaching." "There is a big change - now I can understand easily by reading it myself and I can form chemical formulas." "I started liking Chemistry when I did the experiments and when I noticed patterns."*

Observation and Reflection by Action Researcher and Facilitator Reflection was now becoming more and more part of the teacher's practice, and he shared these with the facilitator whenever they met. Their discussions now veered around alignment of the learning objectives with the assessment framework. The teacher increasingly felt the need for such an alignment and also saw the importance of including skills and attitudes in his learning objectives, which he now realised had thus far been almost wholly content-driven. By the ninth month, the facilitator noted: *I noticed with pleasure that he has now adopted the pedagogic flow of Demonstrate-and then-Discover, rather than his earlier pedagogy of Tell-and then-Demonstrate. This is a level higher than Demonstrate-and then-Tell, which is what he had recently arrived at - in his own articulation of what I called* ***his*** *Aha moment. It is heart-warming to see him becoming less of a 'teller' and more of a 'facilitator'.* For example, the classroom observation notes of the facilitator go thus: *He had really thought through the pedagogy of Periodic Trends in Atomic Size. Using tennis balls and then configuring students to represent 11 electrons around a sodium nucleus, he drew from them the conclusion that as the force of attraction for outermost electrons increases, the atomic size decreases. As soon as he would posed the question to students about such a Group trend (rather than tell it to them), they got it: that atomic size will increase down the Group. Later, in the dining hall, I asked the most articulate boy whether he had had prior knowledge of the trends of atomic size. No, he told me. But he seemed to know, I insisted. "I deduced it," he admitted. So the teacher had engineered an AHA moment for several students today. The teacher pointed out to the class that if they 'got' this trend in atomic size cross a period and down a group in the Periodic Table, then they would have no problem understanding all other periodic trends.* The teacher noted in his tenth month that perhaps he had tended to skip certain points in the past because of not using the textbook adequately – something he had now begun to use far more. He also revisited one of his earlier assumptions - that the students knew all the basics - by now taking the trouble to check if they have the pre-requisite knowledge before embarking on a new lesson. He admitted that now, he thinks hard as to how to introduce hands-on activities into *each and every lesson* as he has found this to be a great way of engaging the challenging Class IX. He acknowledged the palpable enjoyment that then results.

The teacher recorded as follows: *Students have slowly started responding to me and I can see them even discussing the subject while walking around the campus. I found one student reading a book called* Disappearing Spoon *by Sam Keen, after which he came up with so many questions. Two formerly disinterested students started taking the initiative to learn the* *subject by the second term…and even requested me to help them out of class…which I did, in the evenings.*

Student Performance It may be noted that the most significant shift was in students' perceptible enjoyment in learning the subject, which is, of course a subjective indicator. A greater tendency to connect across chapters was observed by the teacher: e.g. while learning Metallurgy, they connected the extraction of aluminium to the application of electrolysis. Again, they linked Gas Laws to the solving of numerical problems based on chemical equations. A more measurable indicator of the impact of the teacher's AR would be the grades of the students in tests/exams. Mention is only being made here of one significant shift: viz., the performance in three Unit Tests on the concept that (in the teacher's own experience) *students usually find to be the most difficult*, viz. Mole Concept. It was noted that more than half the class showed a significant improvement in these tests (more than 20% increase in score).

Conclusion Students who had shared that they were intimidated by Chemistry now asked for a Chemistry class if any other teacher was absent. Other teachers passing by the Chemistry laboratory noted with awe the intense absorption with which students were engaged. The teacher acknowledged the role of AR in this entire journey as lending him a structure to work his way through. He noted that he has now become more conscious of planning, presentation and the work that he gives his students. This has had its reciprocal effect in that students now complete their worksheets on time and he receives no requests for extensions. If he forgets to give a worksheet, the students come and remind him to give them worksheets: a rarity *particularly from this class*, as admitted by other teachers! However, the teacher noted wisely as follows: *Despite all the strategies I may use, it is difficult to woo a student permanently to a subject. Their interests are fickle and they want newer and newer tricks to capture their attention. So my challenge remains to keep thinking of newer ways to keep them engaged and interested.*

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