1 Teaching AP Chemistry the English Way

ChemEd 2003, Auburn, AL, 07/27/2003
SERMACS, Atlanta, GA, 11/16/2003
GISA, Atlanta, GA, 11/07/2005
NSTA, Boston, MA, 03/29/2008
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2 I trust that many of you will be familiar with the Noel Coward song, “Mad dogs and Englishmen go out in the midday sun”. It was written in 1932 by the English, wit, bon vivant, Coward, as a stab at the slightly ridiculous attitude and behavior of the English when living in the colonies. It has been suggested to me that whilst at least some of the English have evolved enough to know to stay out of the midday sun, some of us haven’t yet reached the point of realizing that our teaching philosophies while living and working in former colonies are also “Mad”, and we should know better. That’s what I’ve come to talk about today.

Before I start I should state my disclaimer. There are probably plenty of people in England who disagree with me, and certainly the English do not have a monopoly on the philosophy that I am going to talk about. Having said that, I think it is true to say that I would likely find a more sympathetic audience for this presentation in London rather than in Virginia! The title of today’s presentation has been given to me by others who have rationalized my seemingly outlandish and unpopular ideas about teaching AP Chemistry as simply being because “he’s English”.

3 My own Quote – “I refuse to discuss anything in this class that is not related to the AP exam”

4 Two Strands – Context & Background and Method

5 **A: The Context and Background**

- **The English System**

Prior to emigrating to the USA with my American wife in 2000, I spent 10 years teaching in England. In that time I taught at a number of different institutions including public and private; all girls and mixed and, most relevant to what I intend to talk about today, in the tutorial college sector. To understand the place and relevance of the tutorial college sector to this presentation one needs to understand the English system as a whole, and that’s where we should start.

6 Here is an overview of the English system of public, private, external standardized examinations and what they mean.

7 Further Resources: Much more information available at the web sites of;

QCDA – The Qualifications and Curriculum Development Agency **http://www.qcda.gov.uk/**
OFQUAL – Office of Qualifications and Examinations Regulator **http://www.ofqual.gov.uk/**

– the government agencies that oversees standards

The National Curriculum **http://curriculum.qca.org.uk/**

– the national curriculum implemented in England

8 & 9 Depth versus breadth

There are many arguments on both sides in the battle of breadth versus depth, none I which I intend to address here. Rather I want to concentrate on the A level/AP chemistry content differences. The A level includes largely the same content as the AP, plus;

Extensive Organic Chemistry (including nomenclature, isomerism, mechanisms, reactions, structure determination and synthesis)
Group I, II & VII chemistry
Born-Haber cycles
Transition metal chemistry
Industrial Processes

In general by the time a student leaves high school in the UK they will have been exposed to four solid years of chemistry and prior to that some degree of earth science too. Coupled with the fact that during an A level course in the UK a student may have experienced twice eh contact time of a similar AP student in the USA you can begin to appreciate the deepening of exposure in one subject at the expense of others.

10 Exam grades

There is no such thing as a high school transcript and the consequence of the system is that academic life and death depends upon the result of these public exams. This gives a certain emphasis to much of the teaching in the final four years of schooling in the UK that is not the same on this side of the Atlantic.

11 The Tutorial College system

The tutorial College system is essentially an exam grade factory. The whole marketing ethos behind these institutions is the exam grade. Parents pay for small classes and expert exam preparation. The colleges are purely and simply designed to facilitate college entry to the most completive courses (Medicine, Vetineary Science) and most competitive colleges. All kinds of kids come to these colleges but hey fall mainly into two groups. Those who have decided to opt out of the regular school system and its more pastoral and nurturing environment for a much more “corporate” feel to their final years of education, and those who are attempting to improve their grades, the retake students. Both groups are motivated by the exam grades and little else.

- **Motivation and the reason for this presentation**

12 Origins

The root of me speaking today comes from the horror that I felt during my first year of teaching in the USA in 2000-01. That year I had two profound experiences that gave me a rude awakening in terms of the differences between the system that I had come from and my new home and environment.

During the academic year that started in August of 2000 I was asked to deliver a Regular Chemistry course and an honors Chemistry course. I had a fairly good idea of what the regular course would entail but was less sure about the level to pitch the Honors course. In any case I wasn't worried because I assumed that I would be able to base my courses on an internally available syllabus document that laid out in detail all the specifics of what each course should cover. I was in for a shock! When I asked to see what I thought would be a standard standardized document I was told nothing existed! I was horrified. The questions I started to ask were, "How do we compare courses?", "How do we compare experiences", "How do we compare grades", "How do we maintain standards?"

The second bad experience I had was when, in March of that same academic year, several students informed me that it was their intention to take the SAT II in chemistry in June. I was utterly aghast at this suggestion. For a start I had been enjoying my new found liberation by not teaching my classes as specific examination preparation classes, secondly we had not been following any kind of external syllabus so I had no idea what could be asked and thirdly there appeared to be no specific external syllabus document anyway! This is when I realized I was operating in a culture with a whole different set of expectations and philosophies regarding external standardized tests and exams.

13 Personal

From a purely personal point of view I feel AP Chemistry is not necessarily about;

> Chemistry in the real world
> Entertaining students in the classroom
> Inspiring students to be chemists

And that teaching to the test is a valid philosophy;

> This has become increasingly important to me as it is something I had never questioned until arriving in the USA and seems to be so unpopular and diametrically opposed to much philosophy here. I'm not shy about declaring my philosophy as a legitimate goal for two reasons. Firstly the AP syllabus (with the possible exception of organic chemistry) represents pretty much exactly what should be taught to students at the upper level of high school chemistry - so, by definition, a high score will mean that a student has a wide body of, relevant, chemistry fundamentals on which to build, and secondly if you are offering and teaching an upper level high school chemistry under the banner of AP it's quite reasonable and proper for all parties (administration, parents and students) to assume that you as the teacher are doing absolutely everything in your power to maximize the scores.

14 Goals

What you should know is that I am not espousing this method, simply telling my story. I've been encouraged by others, notably my colleague at Westminster, Penney Sconzo, who will delivering the Reg Friesen lecture later this week, and by veteran reader and AP consultant Steve Thompson, to pass on my thoughts and ideas as they seem to think they may be of some interest to AP chemistry teachers in general.

Now why am I not suggesting that you all take these ideas away with you and use them? That's simple. Firstly what I'm suggesting seems diametrically opposed to the high school education culture and fairly unpopular, and secondly all of us find ourselves in unique circumstances. Facilities, administration, history, caliber of student, experience and 1001 other parameters all vary to such an extent for everybody in this room that *any* one size fits all approach is unlikely to work. So I'm simply telling my story. Why is my story any more interesting then anybody else's, well, it seems as though mine is fairly unusual. We are all an amalgam of a thousand and one different methodologies, philosophies and pedagogies, so take what you want (if anything) and move on.

15 B: The Method

- **Before you start to teach**

Know your subject (at this level) inside out

Are there chemistry high school teachers with a deeper chemical knowledge than me? No doubt. Does that automatically mean they can do a better job of preparing the kids for the AP exam? Absolutely not. And here is the crux of the matter. For me (not all of you) there is a distinct difference between teaching chemistry and preparing the students for the AP exam. In my Honors and Regular classes I truly "teach", in my AP class I prepare.

Having a deeper love and understanding of the subject can be unhelpful! We all know that there is very little time for tangential discussions (I refuse to talk about anything not on the AP in class) or more "interesting" activities.

There is also no need for understanding that is not required. We are all aware that an understanding of a topic usually leads to being able to produce better answers to questions than rote learning, but this NOT always the case. I am constantly walking a very fine line between adding a greater degree of explanation because it helps understanding, and adding no explanation because it does not. Obviously I err on the side of not going into greater depth if I feel there is no benefit in terms of the exam.

In order to illustrate what I mean when I say at this level, consider the teaching of entropy.

If you know anything at all about entropy you realize it is actually a horribly complex subject. So, why bother with it at all. Well it's on the exam so we HAVE to cover it. What do we need to know, do we need to "understand" entropy? Absolutely not, we need to be able to answer the questions on the AP exam that might be asked. There is a profound difference. Frankly I suspect that most high school teachers don't truly "understand" entropy at all, and certainly no high school student do either, so why get in a tangle attempting to unravel this incredibly complicated subject? Here are the nuts and bolts for the exam.

Entropy = degree of disorder.
Use state symbols in equations to predict increase or decrease
Understand that it as well as ΔH effect the likelihood of reaction ($\Delta G = \Delta H - T\Delta S$)

Move on! Is Entropy a more complicated thing than that? Yes.
Need it be at this level for AP exam success? No.

As long as the questions do not ask for any deeper understanding then there is no need (in terms of the AP) to go any deeper.

16 Building of the syllabus

This is extremely problematic because of the very loose structure that is given. For example, compare the College Boards published AP Chemistry Topic Outline (five pages of "a guide to the level and breadth of treatment rather than a syllabus") to the document published by one of the English equivalents A level Chemistry specification (approximately thirty pages of specific objectives with incredible detail). For example consider the difference in detail of each of these documents in relation to two areas, shapes of species and acids and bases. They are like night and day and the Acorn book's deficiencies lead to questions from relatively experienced teachers in the middle of an academic year that I find absolutely extraordinary. For example, "Are molecular orbitals something we should teach?" The answer should be, "look in the Acorn book", but because of its hopelessly loose structure, it is difficult to feel confident that you will find a definitive answer there. I find this extraordinary on two levels, firstly how on earth can we be teaching to a standardized test when there is no official clear definition of what's in and what's out, and secondly who has started teaching a course in preparation for a standardized test having not made an unambiguous decision about EXACTLY what they are going to teach? As helpful as some may find it, the very idea that the College Board web site has *example* syllabi is utterly bizarre to me!

17 Any student and teacher preparing for a standardized test HAVE to know what can be asked on the test. It's a completely fundamental starting point of any course that is preparing fro any external exam. There is a very common misunderstanding of what an external syllabus is and the influence it has on day to day teaching. This needs to be clarified to take the angst out of a more prescribed, narrowly defined syllabus. **All the syllabus does is tells you what can and cannot be asked on the examination. Under no circumstances does it tell you what to teach, nor what to emphasize, nor how to deliver the material that you choose. A narrowly prescribed syllabus does not remove any classroom autonomy**.

My syllabus includes very specific bullet points of required knowledge and understanding. This not a wish-washy document, it is designed to tell students exactly what they do and just as importantly what they don't need to know for the exam. It has been derived by my careful analysis of the last 25 years of AP exam questions and covers what I considered to be every reasonable possibility. As the exam changes, new emphasis comes to light and other possibilities raise their ugly head (Beer's Law!) it evolves. It's a dynamic document.

18 Building of the schedule

Obviously a fundamental! You should really only have to do this once since every school year calendar is much the same as the last. Work backward from the exam and build in as much time for review as possible. I like four solid weeks of review. I often take a lot of flack in this regard as I always pour scorn upon those teachers who choose to pursue some of the more entertaining aspects of high school chemistry at the expense of completing the syllabus prior to the exam.

I believe that as the teacher of an AP class you have a specific responsibility to finish the syllabus on time with time for review. You will probably have to drop tie-dyeing T-shirts, National Mole Day festivities and some labs to get there. Please be assured that I have Nothing against any of these activities per say, it's just that I find it very confusing and frustrating when I hear people say that they spent a week preparing fro National Mole Day and then could not finish the syllabus. If you can incorporate them and still you all you need to do in order to get to the point you need to be before the exam you are a better person (and probably a more inspiring teacher) than I am.

I devote only two hours of my whole year outside the normal schedule to my AP classes, on the Saturday morning before the exam. If you feel you have to be doing extra in order to get the syllabus completed in time then something, somewhere is wrong. It may be the teacher's inability to organize his or her time, or perhaps the unrealistic nature of the schedule, but there is a problem. You owe it to your students, their parents, yourself and the profession to bring any such problems to light as soon as possible.

- **The Teaching**

19 Emphasis

The emphasis of the course has to be about exam preparation. That means everything I do in class is for a reason that is related to improving your score on the AP exam. You must be specific. For example, I don't teach kids to write equations, I teach them how to write the equations that come up in question #4 on the exam. There is a subtle yet profound difference. A great tip that was passed on to me by Steve Thompson was the idea of evenhandedness. For example it is a common misconception that dealing with acids and bases that acids are more important than bases. Look in any textbook and you'll see something like a three to one ration of problems about acids compared bases. Don't be lulled into a false sense of security; emphasize everything to the correct amount. Take another example. I teach organic chemistry equation writing because it ahs come up x times in the last 20 years on the exam, that's why I do esterification, addition, combustion, substitution and acid base reactions, but I spend about 20 minutes in the whole year on it because of it's relative importance.

20 Homework

Has to be motivated by increasing the AP score and for me is therefore driven by old AP questions. This is how they will ultimately be assessed by their answers to AP questions, not by how hard they have worked, nor by the effort they have put in throughout the year, nor by how wonderful a person they are, it all comes down to those three hours in May. I issue my student with copies of all the AP exam questions since 1990 on day one of class. Much of the homework is simply these questions, and all other homework is based upon this style and level of difficulty. An interesting note is that I deliberately have thee questions copied on to green paper!

Another culturally difficult hurdle to overcome in the USA was/is the idea of setting homework and then teachers not grading it critically. In my experience there appears to be a culture of setting the homework and then doing a number of things. Some teachers would simply check to see if it had been done, others would not check at all, some might institute random checks, I do none of this. Every single question that a student does for homework is individually graded by me in a critical fashion. I award points for each problem and generate a % grade for every single piece of homework they do throughout the year. In my opinion homework MUST be graded critically otherwise what's the point, they could have done it all, but all incorrectly?

21 Testing

Once after each Topic – 17 tests in total plus two mock exams, one internal school exam and the real thing. Each one as close the AP as possible. This means in each case they get the equations and formulas in exactly the same format as they do on the AP exam from day one.

22 Grading

AP questions and their grading – you must know the points and how they are allocated. This means studying the scoring standards and understanding how they work. Don't let internal grading procedures influence how you grade you students AP questions and AP work. If need be create two separate grades; one to satisfy the official manner of grading and one to give you and the students the real idea of where they stand in relation to their final score.

23 <u>Exam Preparation</u>

(i) The Mock Exam an essential pre-cursor the real thing. It's self explanatory but here's what I do.

Make the logistics and rubric exactly the same as the real AP

One week before on the same day as real AP
Exactly the same time as the real AP
Same room with the same seating as the real AP

I do this because it is entirely possible that without your knowledge there could be a regular weekly occurrence of the testing of fire alarms or a marching band practicing in the adjacent room! Also students sitting in certain seats might have an annoying shadow or shaft of sunlight bothering them in their particular seat.

(ii) **24** Predicting grades

This is a useful tool. It is a great indicator of you own perception of what you've achieved and where the kids really are, not what you may have achieved and where the students may be.

(iii) **25** The actual AP Exam

Make sure that 24 hours before the exam you have discussed at length;

Clothing - the need for layers to adjust for temperature
Calculators & Batteries – check!
Transport – ensure that
Breakfast – eat it! Eat the right things
Payment – If possible arrange payment at some other time than the morning of the exam
Fire Alarms and other potential disasters– discuss the procedure and consequences of such an event to ensure they are not thrown by such an event
Extended Time – Ensure all those who are receiving it know the precise procedure and allowances.

(iv) **26** After the exam

Personally I close the chemistry book in mid-May and never open it again until mid-August. I don't like to discuss the exam with the kids after the event nor do I like to involve them in projects after the exam. Once the exam has come and gone my work is done. Quite frankly if the students have done all that I have asked of them during the year it is highly unlikely that they will want to spend another minute in my company anyway!

27 Summary

If you teach a course with AP in the title you are obligated to attempt to maximize your students' scores
The most narrowly prescribed syllabus does NOT tell you what to teach nor does it tell your students what to learn
Don't be shy about teaching to the test. AP is the gold standard in high school, so if you are you TTTT you ARE setting high standards
Never forget, that regardless of every other factor, your students (and to some degree, you) will be judged by what happens in a three hour period in May and the score that their performance translates into

Adrian Dingle
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Age and English Grade Level	American Equivalent	Course of study and external standardized examinations taken	Notes	Essential differences between UK and USA
15-16 years old Year 10 and Year 11 (final two years of compulsory schooling)	Freshman & Sophomore in High School SAT II	Two years of classes in preparation for GCSE (General Certificate of Secondary Education) exams. Students will take any number between 0 and 12, with most taking approximately 8-10. These are graded on an A*-G +U scale, and usually involve some kind of coursework option (20%, continually assessed) and a series of modular examination papers over the course of both years. Religious Education and Physical Education are compulsory during this time too, but not necessarily examined	There is a degree of choice here, where students get to drop subjects that they don't like at the end of Year 10. In state schools they still need to follow the National Curriculum, in the private sector there is more flexibility. The GCSE results determine the students destination and course of study in years 12 and 13 and a minimum of five GCSE's are required for university entrance later	• Exam preparation and importance of standardized test results in-bred into the educational culture of the UK • Teaching in High School much more exam focused in the UK
17-18 years old Year 12 and Year 13	Junior and Senior in High School AP	Two years of classes in preparation for GCE A2 (General Certificate of Education Advanced Level) and GCE AS (General Certificate Education Advanced Subsidiary Level) exams. Most Students will take 4 AS levels during Year 12, and then drop one of them in order to convert three of them into full A Levels (A2's) in Year 13. These are graded on an A-E +N and U scale and are assessed via a series of modular examination papers over the course of both years	Choosing 3 or 4 subjects at this stage leads to a greater emphasis on depth rather than breadth. These results are absolutely critical in terms of university entrance. Offers to students from universities are based upon these results, and academic success and failure here can determine life's path at his point!	• Earlier specialization in the UK • Much greater emphasis on depth rather then breadth in UK • Results much more critical to higher education placement and subject choice in UK
18+ years old Higher Education (University)	College	Students choose their course of study in advance. i.e. they select their "major" before ever setting foot in the HE establishment. In fact there is really no such thing as a major, as students only have courses in the subject they have chosen	There are many courses that offer flexibility, joint honors (e.g. Chemistry & Law)	• Most Bachelor degrees studied over three years in the UK since courses in disciplines outside of "the major" are never studied • Again, much greater emphasis on depth rather than breadth

	COLLEGE BOARD AP TOPIC OUTLINE	TYPICAL (EDEXCEL) A LEVEL SPECIFICATION
Shape & VSEPR	I. B. 2c.VSEPR I. B. 3. Geometry of molecules and ions	a. demonstrate an understanding of the use of electron-pair repulsion theory to interpret and predict the shapes of simple molecules and ions b. recall and explain the shapes of $BeCl_2$, BCl_3, CH_4, NH_3, NH_4^+, H_2O, CO_2, gaseous PCl_5 and SF_6 and the simple organic molecules listed in Units 1 and 2 c. apply the electron-pair repulsion theory to predict the shapes of molecules and ions analogous to those in 2.3b d. demonstrate an understanding of the terms bond length and bond angle and predict approximate bond angles in simple molecules and ions e. discuss the different structures formed by carbon atoms, including graphite, diamond, fullerenes and carbon nanotubes, and the applications of these, e.g. the potential to use nanotubes as vehicles to carry drugs into cells
Acid & Bases	III. C. 2. b. (1) Constants for acids and bases; pK; pH (2) Buffers	a. demonstrate an understanding that the theory about acidity developed in the 19th and 20th centuries from a substance with a sour taste to a substance which produces an excess of hydrogen ions in solution (Arrhenius theory) to the Brønsted-Lowry theory b. demonstrate an understanding that a Brønsted–Lowry acid is a proton donor and a base a proton acceptor and that acid-base equilibria involve transfer of protons c. demonstrate understanding of the Brønsted–Lowry theory of acid-base behaviour, and use it to identify conjugate acid-base pairs d. define the terms pH, *K*a and *K*w, p*K*a and p*Kw*, and be able to carry out calculations relating the pH of strong acids and bases to their concentrations in mol dm^{-3} e. demonstrate an understanding that weak acids and bases are only slightly dissociated in aqueous solution, and apply the equilibrium law to deduce the expressions for the equilibrium constants *K*a and *Kw* f. analyse the results obtained from the following experiments; i measuring the pH of a variety of substances, e.g. equimolar solutions of strong and weak acids, strong and weak bases and salts ii comparing the pH of a strong acid and a weak acid after dilution 10, 100 and 1000 times g. analyse and evaluate the results obtained from experiments to determine *Ka* for a weak acid by measuring the pH of a solution containing a known mass of acid, and discuss the assumptions made in this calculation h. calculate the pH of a solution of a weak acid based on data for concentration and *Ka*, and discuss the assumptions made in this calculation i. measure the pH change during titrations and draw titration curves using different combinations of strong and weak monobasic acids and bases j. use data about indicators, together with titration curves, to select a suitable indicator and the use of titrations in analysis k. explain the action of buffer solutions and carry out calculations on the pH of buffer solutions, e.g. making buffer solutions and comparing the effect of adding acid or alkali on the pH of the buffer l. use titration curves to show the buffer action and to determine *Ka* from the pH at the point where half the acid is neutralised m. explain the importance of buffer solutions in biological environments, e.g. buffers in cells and in blood (H_2CO_3/HCO_3^-) and in foods to prevent deterioration due to pH change (caused by bacterial or fungal activity).