A Sticky Situation

Context-Based Learning Module

For the Royal Society of Chemistry

KKI Associates Ltd

Introductory Tutor Guide
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NB. The Tutor Guide for this resource comes in 4 parts. This is the introduction, which sets the background to the resource, describes how to run the activities and introduces material for the first workshop.

Two more guides then give detailed notes for the 8 worksheets, and then for the second and third workshops. The third workshop guide also contains criteria for assessing the final report produced by the students.

Finally there is a slide-pack that can be used to introduce the material to students in the first workshop.
A Sticky Situation – Problem-Based Learning Exercise

Tutor Overview

Welcome to our Context-based learning activity based around the chemistry of lubricants (‘engine oils’). This material was developed by the author Dr Kevin Parker (KP), at the request of the Royal Society of Chemistry in 2014-5. KP has a background in chemistry and spent 12 years in the oil industry, including 6 years in lubricants R&D and 3 years in lubricant commercial sales and marketing. Dr Dylan Williams of the University of Leicester has helped with consultation, advice and general sanity checking, from a teaching perspective. KP has also been assisted by discussion with Ian Bell at Afton Chemicals (who produce Viscosity Index Improvers) and Dr Gareth Dowd of BP Castrol who produce high quality engine lubricants.

Context based learning ‘aims to teach chemical concepts by starting with observations from real world contexts’ (from http://www.rsc.org/blogs/eic/2014/07/context-based-learning-icce2014). In this example, students will be carrying out a chemical investigation typical of a ‘real world’ problem.

Scenario: An Australian billionaire who owns various oil exploration, and refining & marketing companies, also has developed a new ski resort. After the launch press conference his exotic sports car breaks down in front of the world press. The engine of the vehicle has been completely seized as the oil has gelatinised. The billionaire sues Northland Petroleum (NP) who formulate the oil used in his car, and threatens to sever all his other commercial links with NP. The Chairman of NP asks his head of technology to set up a task to quickly investigate and respond.

The scenario turns on steps taken in Australia to reduce the cold flowing of Viscosity Index Improver (VII) polymer in storage at lubricants manufacturing facilities (or ‘blending plants’ to use industry terminology). One obvious solution is to introduce more crystallisation into the polymer. However, excessive crystallisation can either make the VII very difficult to blend, and/or can cause the formation of gels in the engine. Essentially, the oil can become more soluble in the polymer than the polymer is in the oil(!).

This presented the opportunity to develop a case study where students are investigating an engine failure ultimately caused by poor selection of VII polymer. The new case study has now been renamed ‘A Sticky Situation’…

Module Structure: The team are asked to investigate and report on 8 different areas relevant to the problem, from general information about engines and lubricants to detailed analysis of polymer solubility. These areas are set out as 8 separate Worksheets, which can be approached in any order, by a single team member or a group. Each worksheet will (hopefully) be informative and challenging in its own right, and teams are asked to write a short report about each one. However they each feed at least one factor into the overall question of ‘what happened to the billionaire’s car?’ For example in discussions with the car manufacturer it turns out that the car has a dry sump engine, with a heater that automatically warms the oil reservoir before start-up. And its on the same fuse system as the car’s heater which the billionaire has disconnected as ‘We’re in a warm country’…So after having jointly or individually completed each of the worksheets the teams can start to pool their information and use it to assess what happened to the car, report on it, and recommend better ways of formulating the oil in future.
The teams will meet in 3 formal facilitated workshops (and as many informal times as they wish) where they will co-ordinate the work and report back to each other.

**Workshop 1** will be a task briefing session where facilitators will clarify the task and teams can start some preliminary work on the topic.

**Workshop 2** will be where team members report progress to each other, structure their next series of tasks and request additional information (e.g. from Northland Petroleum’s chemical analysis laboratories). Worksheet reports should be submitted (8 per team) by the end of this Workshop.

**Workshop 3** will be where they finally pull all the information together, and produce a contents page of their final team report.

The final **Team Report Exercise** should identify the multiple, inter-locking failure factors hinted at or revealed in the 8 Worksheets. Other information may become available to the teams, via a number of routes, as the module progresses and they should take this new information into account in their report.

**Learning Outcomes:**
By the end of this course students should be able to:
- Outline and compare a range of analytical approaches used in engine oil testing and evaluation, including $^{31}$P nmr, Differential Scanning Calorimetry, and Size Exclusion Chromatography
- recognise and discuss the main components in engine oils, their functions and their degradation in use
- understand and explain the main factors determining polymer structure, its degree of crystallisation, and how that affects both its handling before blending and its behaviour in solutions
- analyse, summarise, and communicate complex information , using it to problem-solve a realistic technical service issue
- How to work with others on a team task and meet a joint deadline

The skills of problem-solving, team-work, and the ability to summarise and clearly communicate complex technical information are highly valued by employers. In 2012 KP carried out interviews with major industry employers who highlighted these skills as the difference between ‘getting the interview’ and ‘getting the job’. See [http://www.rsc.org/learn-chemistry/resource/res00000953/commercial-skills-for-chemists-introduction-and-overview](http://www.rsc.org/learn-chemistry/resource/res00000953/commercial-skills-for-chemists-introduction-and-overview)

**Potential Participants:**
- Year 1-2 students on chemistry, analytical chemistry or similar degree programmes.
- The resource can be utilised by either individual or groups of students. The groups could be up to 6 members per group.
- There is an opportunity to do a ‘Jigsaw Group’ exercise where each member of the team takes responsibility for one area and has to coach the others in their findings. See [http://www.jigsaw.org/overview.htm](http://www.jigsaw.org/overview.htm)

**Module Size:**
- The full resource will be equivalent to 5 credit value (= 50 hours of study).
- A sensible breakdown would be 10-12 contact hours (3 x 3-4 hour workshops) & ca. 40 hours of private (or group) study
**General Comments – Running the Modules**

All Workshops should be carried out in spaces suitable for break-out session/team activities and not in a formal lecture theatre. Students will need internet access, and ideally flip-charts and/or white boards to help share information. Having set the students the task it should be up to them how to organize their time and allocate work between themselves.

**Students will need fairly constant tutor interaction** as some are likely to ‘get stuck’ – this type of unstructured ‘self-driven’ learning presents difficulties for some. In a real business situation it is OK to say ‘I don’t know how to do this please can you give me some pointers’ (in fact that's regarded as positive behaviour), but some students think its ‘cheating’ to ask for help. With this in mind we have designed interactive activities as part of each Workshop, partly for their own sake, but partly to give tutors an opportunity to find out how students are doing.

**Choosing team members**

The modules should be carried out by teams of 4-6 students rather than by individuals. Our preference is to assign people to teams rather than just relying on ‘friendship groups’. Graduate recruitment processes in industry often put randomised groups of students into a team task to observe how individuals cope in this situation.

One interesting way of allocating students into teams is to use their characteristic ‘preferred team roles’. Given a team task, some people will naturally adopt a ‘come on let’s do this, leading from the front’ role, others will come up with bright ideas, while others will worry about details and deadlines ‘look we’ve got to get 4 hard copies and a pdf in by 12 o’clock, not 5 o’clock’. A good team needs people doing all of these roles (between them), but clashes can occur when two or more people all want to do the same role. The roles have been most famously systematised by Dr Meredith Belbin, and the Belbin test is widely used in business, military and sports team development. If you hear people talking about ‘Shapers’, ‘Plants’, ‘Resource Investigators’, or ‘Completer finishers’ then they are talking about the names Belbin gave to some of the team roles.

Although the formal test process probably costs too much to run on a large student population, the various Belbin team roles are well described in various publications and websites.

See here for an introduction:

and here
[http://en.wikipedia.org/wiki/Team_Role_Inventories](http://en.wikipedia.org/wiki/Team_Role_Inventories)

or here

for a description of the roles.

One idea might be to get students to look at these pages and identify what they think they are. The author (KP) is a ‘Plant’ and freely admits the comment on the Wikipedia page that having too many Plants in a team is not a good idea! The team role analysis works usefully for students of different nationalities: for example ‘Shapers’ from Japan and America will have similar innate tendencies, even if they express themselves in different ways.
‘Training the Tutors’
While the modules do not need external lecturing input, they do need facilitators to run the interactive sessions, drip feed hints to the students, and generally check that they are progressing. Not everyone will feel confident about facilitating this material, even though we have tried to write extensive tutor notes. At the various trials we have carried out we used a mixture of tutors – academic staff with relevant experience, students returned from industrial placements, business and admin staff from the university.

There is however, funding and expertise available for teaching business skills to postgraduate, postdoctoral and junior academic staff. Many resources, including trainers such as KKI, sources of funding, and on-line materials are available at the Vitae web-site. http://www.vitae.ac.uk/ For research council funded research students, attending these courses should be part of their ‘curriculum’. KP is also happy to consider giving briefing sessions and/or acting as an external examiner for HEI’s contemplating using this resource.

As a minimum, tutors/facilitators should read and thoroughly understand the Tutor Guides provided for this resource.

Assessment and Marking Criteria
This module is designed as a team exercise, and an overall score should be given to each team. Where formal %scores are required, these could be weighted at 30% for the 8 worksheet reports, and 70% for the final Team Report. If formal %scores are not required, the module could be marked to a broad 3 point scale – ‘fail/borderline’, ‘pass’ and ‘distinction’. This is in accord with the author’s (KP) experience of producing reports in an industrial context where the response from one’s boss is typically one of ‘that’s fine, good work’, ‘that’s OK, can you give me a bit more detail here and here’ or ‘this is rubbish, please start again’. If possible students should be encouraged to revisit and improve poor work, rather than just be told ‘you’ve failed’ – this is what is more likely to happen in a real business situation. NB this does not in any way imply lowering standards – it implies ‘keeping on at the students until they produce good work’.

Some teams expressed concern about the potential fairness of a team mark, so we have adopted the following procedure:
Each team is asked to suggest whether any members should be individually marked up or down one category
• Team gets distinction, but ‘free-loader’ gets pass
• Team gets pass, but outstanding contributor gets distinction

Generally as soon as students are made aware that this procedure is in place, it prompts effort from everyone – so a good idea is to let them know about it before the module starts.

As we are asking students to carry out what is termed ‘open’ CBL (by carrying out internet research for example) we have provided some hints for students and tutors about some of the interesting web sources they may find. Of course, one of the exciting things about open CBL is that students are quite likely to come up with new resources and findings that even we as course designers haven’t anticipated! What is does mean is that they should get more credit for the quality of their research and thinking, than for getting specific ‘right answers’ about the project. We have identified some key points they really should find as a minimum requirement, but beyond that it will be possible for different groups to reach different conclusions about a project, yet still both have done a good job. Some companies deliberately use this approach – for more details, Google ‘red team and blue team’.

KP once worked for a manager who asked for 17 rounds of revision in an important internal document
Trials at University of Edinburgh

This material was run through by two groups of third year undergraduate students in February-March 2015, as part of the University’s ‘Innovative Learning’ Programme.

Both groups completed each worksheet, and each produced a final presentation (not a written report due to timetabling constraints).

Copies of the student output, especially the final reports, can be made available to tutors. Here is a slide from one of the presentations:

And here is part of their feedback form:

- Was the Exercise Interesting and Enjoyable?  
  Yes, Yes, Yes, Yes!
- Was it ‘fair’  
  Yes, all group members looked at the booklet but not everyone managed to finish the work on the exercise. It was fair.
- Did the scenario seem ‘realistic’?  
  Yes, and quite business relevant.
- Did the exercise encourage you to work as a team?  
  Yes, due to the links between the exercises being needed and discussed.
- Did it get the balance between ‘spoonfeeding’ and ‘working it out for yourselves right’?  
  Yes, yes, on other exercises despite hints.

‘We all thought the topic was very engaging, very realistic and the right level of difficulty, and the teamwork aspect was very important (particularly the reports which required everyone to get together and teach each other what they’d learned etc.)’
Workshop 1 – Team Briefing Session

At the start of this workshop, facilitators should briefly describe the problem and what students are required to do.

Students should be assigned teams (see previous page) and will be given the following information, which everyone on the team should read and comprehend:

- Memo from the Chairman
- E-mail from the Head of R&D
- Letter from the Lawyers
- Background on Global Resource Energy Exploitation and Development Corporation (GREED Corp)
- Article ‘Open Mike’ defends refinery policy (Australia Daily Times)
- Article Konigsberg in the Mountains (Fastest Gear Magazine)

When they have done this, a facilitator who can give out the 8 worksheets. They will not be able to complete these worksheets at the first workshop. Rather, they should be planning how they will complete each one. Teams may organise work on these worksheets as they see fit. It may be simplest if everyone completes all the worksheets. That way everyone will have full information about the problem. If they decide to split up the worksheet exercise then tutors will to ensure they spend a considerable time briefing each other at the next workshop. Whichever way students choose to allocate tasks, all the work-sheet reports should be completed before the next Workshop session.

Get the students to draw up an agreed on a work-plan, detailing who is working on what activity. They should agree this with a facilitator before leaving the workshop, and send a copy to the course Tutor as soon as possible.
Memo from the Chairman

To: head@R&D.Northland_Petroleum.com
From: chairman@Northland_Petroleum.com

Jan,
Please see the attached lawyers’ letter from Australia. Our main lubricants reseller in Australia has had a major engine failure in his sports car right in front of the press and assorted TV cameras! Apparently it’s all over the internet as well (what on earth is a ‘trope’?). So he’s threatening to terminate our agreement over breach of contract.

This is pretty disastrous for us as lubricants is a very profitable business for us in Australia (they drive a lot!). We’ve never had any problems with the guy before, although he’s a pretty colourful character (Google ‘Open’ Mike and you’ll get the picture) with a lot of interests in the area.

Can you investigate and come up with
a) a report on what happened and b) some recommendations about what to do about it before the end of the month please?

To: lubes_tech_team@R&D.Northland_Petroleum.com
From: head@R&D.Northland_Petroleum.com

STOP WHAT YOU ARE DOING AND READ THIS
OK everyone, sorry to shout but see the chairman’s e-mail and the letter from the lawyers. We got a major problem here and a short time to do anything about it.

I suggest we need the following information before we can write the report to the chairman (and something to Mr Michael):

- Some background on Mr Michael and GREED Corporation (I’ll do that)
- A clear exposition of how engine oils are supposed to perform
- The issues in lubricating modern high performance engines (and the Chairman might need a tactful revision of ‘Suck, Squeeze, Bang and Blow’ as he’s not a technical man)
- A check that GREED are blending the oils correctly (didn’t we see something about their storage of Viscosity Index Improver – can someone dig that out?)
- A quick chat with the car manufacturers (though they’ll doubtless be keen to blame our oil)
- Any factors we can come up with about the failure (are there specific issues in Australia we haven’t taken into account when we formulated the oil?)

Get to it!
Dear Sir/Madam

We have the honour to represent the legal interests of Mr Hope N. Michael and the interests of his holding company Global Resource Energy Exploitation and Development Corporation (GREED Corp). Among his other interests, Mr Michael has purchased licenses from you to blend and market a range of high quality engine lubricants under the NP ‘Super Q’ brand name. These oils are represented as meeting the specifications of major engine manufacturers quality requirements.

However, on September 14 of this year Mr Michael’s car had a catastrophic engine failure as he attempted to drive away from a press launch at his new Ski Resort in the Snowy Mountains in New South Wales.

Subsequent inspection of the engine showed that the engine oil had almost completely solidified into a dark gelatinous mass (see picture), which clearly failed to protect the moving parts in any way. Mr Michael’s Car (a unique Konigsberg RV1) has suffered extensive damage to the gearbox as well as a complete engine write-off. The cost of replacing these parts has been estimated at over $50,000.
In addition, this episode, in front of a large group of media representatives, has caused Mr Michael, a well known figure in Australia, a great deal of negative publicity and derisive comments in papers, TV and social media. For those familiar with such things, ‘Mike Failure’ has apparently become an Internet ‘trope’.

Mr Michael feels that his judgement in entering a business deal with Northland Petroleum has been called into question. He cannot afford for his reputation to be compromised by selling products that do not meet their stated specifications.

Accordingly, unless we hear from you by the end of the month with proposals for compensation, we wish to alert you that we will be activating the ‘breach of contact’ clause to terminate GREED’s agreement with Northland Petroleum.

We understand that you may wish to investigate this matter further before replying in detail. We have therefore taken steps to send you samples of the oil used in Mr Michael’s car – both that recovered from the engine and new samples from Mr Michael’s factory (we believe the technical tem is ‘blending plant’) in Western Australia.

Yours faithfully,

Jo Ha-ang

Senior Partner
OK team, I’ve done a quick search on Mr Michael. Since taking over Global Resource Energy Exploitation and Development Corporation 20 years ago he has built it into one of the most important energy companies in Australia. GREED has interests in Oil Exploration, some Gas fields, and an Oil refinery producing a range of fuels from Atmospheric distillation and Cat Cracking. He’s recently invested in a new development of an exclusive Ski Resort in Australia’s Snowy Mountains.

He seems to be pretty forthright about environmentalists (see attached articles) and unapologetic about using rather old refining technology to make quite high sulfur fuels. Don’t see how that would help us at all, but bear it in mind anyway.

And there’s an article about his car. He’s actually had a private road made up to his ski resort so he can race up and down with his friends! Boys and their toys…

More seriously, I asked our NP representative in Australia to do some quiet digging about the problem. He seems to have found the news item about a spill or leak at their Lube Oil blend plant – it’s in one of the sheets below but I don’t really see how it helps us.

However, since I last heard from him he’s gone on long-term sick leave – he was hit by a fast-moving sports car while hiking last weekend and has been left unconscious. His assistant has looked through his office and all they found was a weather forecast of some sort and a page of scribbled internet links. Again, I don’t know how helpful that is, as I can’t tell whether it’s technical or purely private information. If you think it might be useful I’ll get it to you before our next meeting.

There is of course important information on that page, along with quite a lot of interesting but not totally relevant material…

We will attach pdf’s of the most important web-sites or reports, so Tutors can help Team that are completely stuck!

They should note the dates of the oil ‘spill’ and the car failure
‘Open Mike’ defends refinery policy

Fuel Quality Claims ‘Spurious’

In a hard hitting response to concerns expressed by environmentalists, Hope N. Michael, owner and CEO of GREED refining Corporation, refuted criticism of the fuel produced at his and other Australian refineries.

‘This spurious concern for fuel economy and engine performance is just another sneaky trick aimed at Australia’s petroleum industry by the ‘Eco-hippies’ he said at press conference yesterday.

‘I use our fuels in my Konigsberg, which is probably the fastest car in Australia’ he said, ‘no problems at all’

Students should be asking: What happens to sulfur in fuel? What does it produce when it burns? What will that do to the components of the oil? Also note that the industry still uses the ‘old’ spelling of sulfur – students may want to note this in their internet searches
Konigsberg in the Mountains

Special Feature: Petra Head

‘She’s a bit of a goer isn’t she?’ Hope Michael, commonly known by his nickname ‘Open Mike’ beams as we get out of his Konigsberg RV1 at Saxon Valley in the Snowy Mountains. We’re now at 6000 ft and the air is noticeably clearer and cooler than at the bottom of the twisty 19 hairpin road up to Michael’s new ski development.

I wonder about taking coaches up here but Michael is laughing at me. ‘No we’ve blasted a nice wide highway through the Forest on the other side of the hill for them. We’re going to keep this road as it is and only let cars on it. We’re trying to get a minimum speed limit on it to encourage sports cars to come this way. After all you have black runs on the pistes so why not a black run access route?’ I can’t quite decide whether he’s joking, but having been a passenger in the drive up I’m think he’s probably serious.

The Supercar screamed as we hurtled up the private road, that Michael has been sharing with a few motorspecs the last few weeks not to have to ‘compete’. And what a way to fancy taking the wheel on a beautiful sunny day?

‘They have some nice motors but nothing to touch this one with a hybrid twin turbo, KERS, and all the F1 stuff.’ Is it completely standard I wonder? My last drive in a Konigsberg didn’t seem quite as raucous and elemental as this one.

Michael looks a little evasive for a second before admitting ‘We’ve touched nothing much really, just taken a few electrical things out of circuit, heaters (well we’re in Australia) and all that sat-nav stuff. Won’t really change the performance just helps the KERS change quicker’

What else has he disconnected – perhaps accidentally?

Fastest Gear Magazine Australia