Design Your Own Fireworks Show!

A Context and Problem Based Learning Activity for Chemistry Undergraduates

Guidance for Project Leaders

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Acknowledgements:

The activity was developed and written by Emily M. MacCready and Dr Gan Shermer at the University of Bath. Ideas and research support was provided by Dr Roy Lowry of University of Plymouth, Mr Glenn Plume of Alchemy Fireworks and Mr Matthew Tosh of Skyburst the Firework Company. Mr Will Harvey from Finale Fireworks provided helpful ICT support and information about the software programme. The activity was trialled at the University of Bath with year two chemistry undergraduates.

Introduction:

This resource was developed by the University of Bath with funding from the HE STEM Southwest Spoke to provide an engaging context in which to help undergraduates develop some of the transferable skills which employers feel are lacking in many STEM degree programmes.[1,2] The activity asks undergraduate students to budget for and design their own simulated fireworks show for the University's graduation.

The students are divided into small groups which act as fireworks manufacturing and display companies by taking on one of four roles: Managing Director, Creative Director, Site Manager, and Dangerous Goods Safety Officer. They then work with their company as a team and create a proposal to bid for the display. This involves creating a risk assessment, site plan, budget and a simulated fireworks display. PhD students are used as facilitators, who act as "experts" in each role and support the students throughout the process. The information the experts are provided with has come directly from industry and so can take the place of having a real industrial sponsor at every session. The students are then required to present their proposal and simulated display and compete against the other teams for the bid, while explaining how they achieved their results.

The Fireworks Challenge is designed to be delivered in five one-hour sessions, preferably at one session per week: An introductory week, manufacturing task, two weeks of display preparation and one week for presentations. About 5-10 hours outside of these sessions should be expected of the students to complete this project. The activity was carried out as a non-credit bearing additional project, however this document contains recommendations of how the activity may be assessed if required.

This document provides guidance for the person organising and running the activity, along with suggestions for adaptation to make the project more applicable to other HEIs. The complete resources include copies of student and expert documents, examples of real risk assessments and instructions on how to download and use the Finale Fireworks simulation software, along with a CD with electronic copies of all documents. For a detailed overview, the activity leader should review all these documents before running the event.

[1] "Skills Required by New Chemistry Graduates and their Development in Degree Programmes", Higher Education Academy, UK Physical Sciences Centre, November 2010: see http://www.heacademy.ac.uk/assets/ps/documents/graduate_skills/chemistry.pdf (accessed Jan 2012)

[2] "The Chemical Skills Pipeline", Warwick Institute for Employment Research, June 2009: http://www.rsc.org/images/ChemSkillsPipeline_tcm18-159365.pdf (accessed Jan 2012)

Preparation:

Who should be involved:

- Lecturer
- Experts, at least four
- Helpful to have industrial support
    - We had help from Mr. Matthew Tosh (http://www.matthewtosh.com/), who is a presenter and education and media consultant, and also works as a firer for Skyburst the Firework Company. You may be able to contact a local pyrotechnics expert or manufacturer but Matthew may be contacted directly for details and prices.

Location:

You will need:

- A lecture theatre or classroom with a projector and Wi-Fi access (recommended) or computers for the first 2 weeks of the project. Access to the internet will help with groupwork activities, since most students have access to some Wi-Fi enabled device.

- A computer lab or several computers with fireworks simulation software uploaded is recommended for the following 2 weeks.

- For the final session, a small room with a projector screen or OHP for presentations.

- Groupwork areas and tables for experts should be determined by each institution. We chose to let the students and the experts find their own spaces to work in, within the allotted rooms and timetable.

Student Materials:

The materials the students receive should be:

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<tr><td colspan="2">

- A student brief for every role: Managing Director, Creative Director, Site Manager, and Dangerous Goods Safety Officer.

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- Question sheet
- List of useful websites
- Inventory

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- Letter setting the scene
- How to use Finale Fireworks Software
- Writing Task and articles

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Recruitment of Experts and Materials:

We use PhD student demonstrators to act as experts in the various roles in the fireworks companies. This would particularly suit students who are interested in getting some teaching experience and improving their communication skills, or those who already have an interest in pyrotechnics or events organisation if available. One person with at least Maths A-level would be useful for the projectile motion equations. More senior undergraduates, particularly those with an interest in teaching, would also be suitable. It may be possible to use staff or other industry contacts (STEMNET coordinators; www.stemnet.org.uk) may be able to help locate industrial links.

Materials Supplied for Experts:

Job Role	Documents Required
Managing Director (MD)	MD Expert Brief Handy website sheet
Creative Director (CD)	Creative Director Expert Brief How to use the Finale Fireworks Software
Site Manager (SM)	Site Manager Expert Brief Maths of Fireworks Example of a past site plan
Dangerous Goods Safety Officer (DGSO)	DGSO Expert Brief Example of a past risk assessment

Recommendations for training of experts:

For the most part, the briefs, other resources and list of handy websites for information should provide enough information for your "experts".

In our experience, it is important to recognise the difference between the traditional PhD student demonstrator role and the expert or facilitator role required for this task, and this should be addressed during training. Both students and "experts" may have a tendency to interact in a *demonstrator*/student relationship where the "experts" existed only to answer question, instead of a *facilitator*/student relationship, where the "experts" encourage the students, question them and guide them through the process. For further information on how to train for facilitation instead of demonstration, please refer to the Higher Education Academy's document, *PossiBiLities*.[3]

Running the activity with fewer than four experts:

Depending on the size of your student cohort it may be possible to divide up the roles so that experts cover two roles each if necessary.

[3] "PossiBiLities: A Practice Guide to Problem Based Learning in Physics and Astronomy", Higher Education Academy, Physical Sciences Center, March 2005, see: http://www.heacademy.ac.uk/assets/ps/documents/practice_guides/ps0080_possibilities_problem_based_learning_in_physics_and_astronomy_mar_2005.pdf m (accessed Jan 2012)

ICT requirements:

You will need:

A data projector, laptop, screen and audio equipment.

CD from this project pack, or download the required presentations and resource sheets etc., from the HE STEM Southwest spoke website. http://www.hestem-sw.org.uk/

Computers with a fireworks simulation game software program added, such as **Finale Fireworks Basic Game**. (http://www.finalefireworks.com/buygame). It is not necessary to download one copy for each group as students can easily share computer access. We used 10 programmes for a maximum of 84 students, but this can be adapted to your university and the number of students participating.

Additional Notes for ICT:
We would recommend buying a fireworks simulation program as students really enjoy this part of the project and it makes the activity much more realistic. If budgets do not stretch to this minimal cost, students could use photos or drawings to depict their plan or use the free trial version of the software.

Issues with downloading the Finale Fireworks software:

The key thing to making this programme work on several computers at once is fairly simple, but not straightforward. There must be one username, one password and one email address for all the computers. The students will need access to the username and password, however these can be used on several computers simultaneously. The project leaders email address can be used as this will not be required by the students.

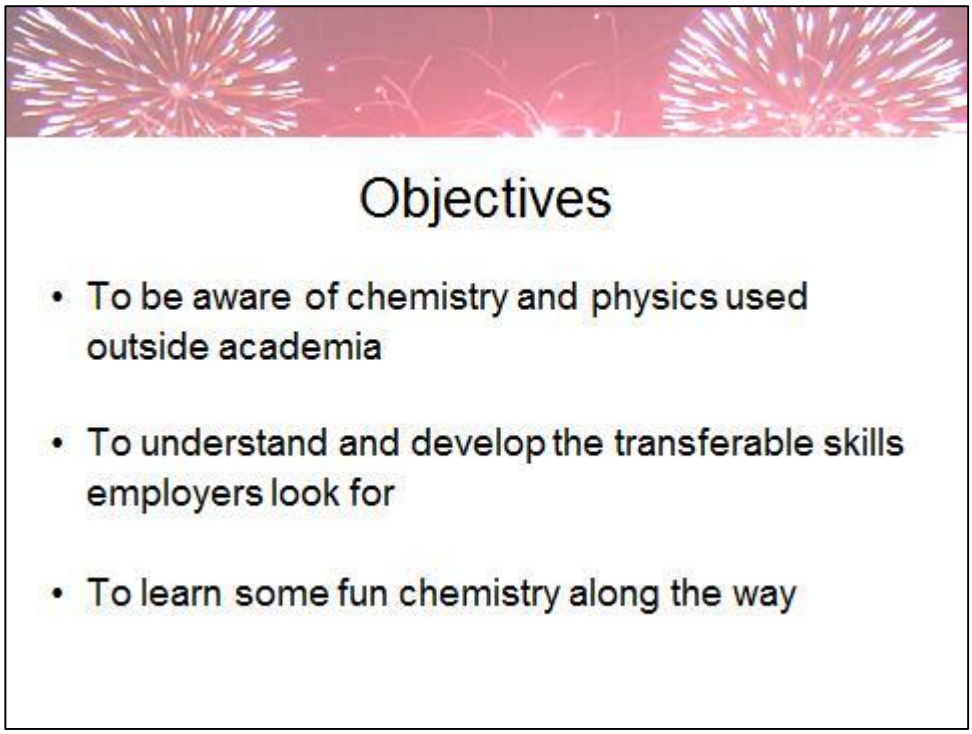
If several licences are bought, you **must be careful**, when downloading the free program onto the computer. After buying the software, the FIRST computer to be logged into with the username and password will take the FIRST licence, the second computer logged onto will take the second, etc. So, we recommend you determine which computers will have the program on them before you buy your licences.

Our recommendation: choose an email address to use along with a username and password. Determine which computers will have the Finale Fireworks software programme downloaded onto them. Buy the correct number of licences then download the software to each computer that you chose for having software. To double check that the game has been downloaded, there should be 115 fireworks available in the full software version compared to 25 in the free trial version.

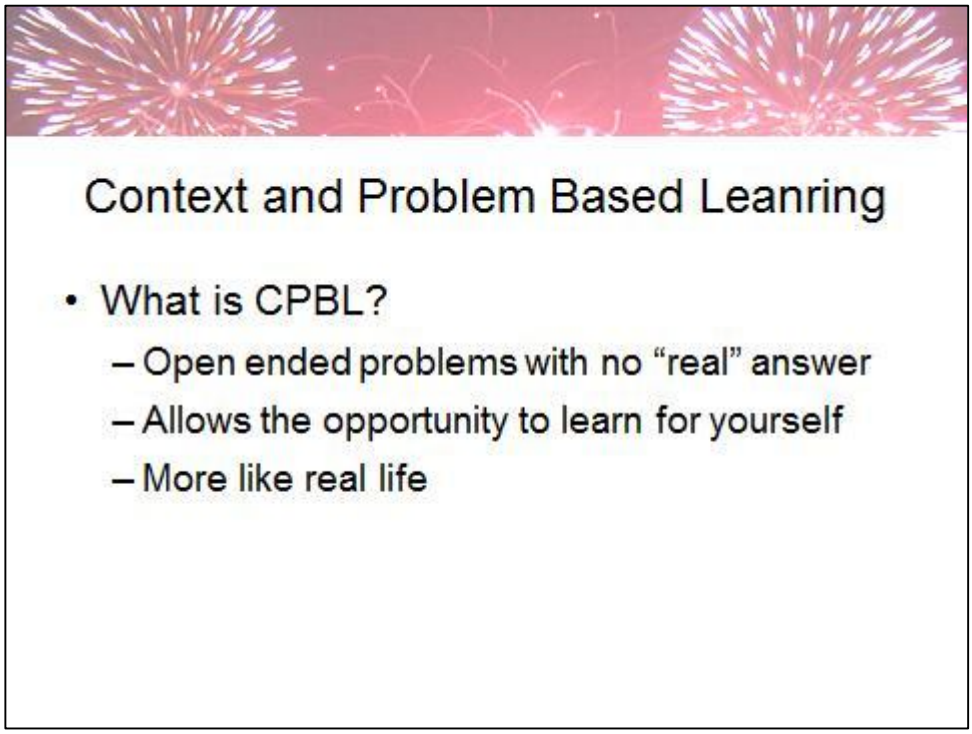
For any queries regarding the download and installation of software please contact;
service@finalefireworks.com

Slides for Week One:

Use these links to play videos of good fireworks shows as the students enter the room. This should hopefully set the mood and get the students interested.



Discuss the RSC and HEA studies and how employers feel the need for transferable skills from chemistry graduates and that they are lacking in many chemistry degrees.[1,2]
RSC report suggested using CPBL to incorporate these skills into normal curriculum

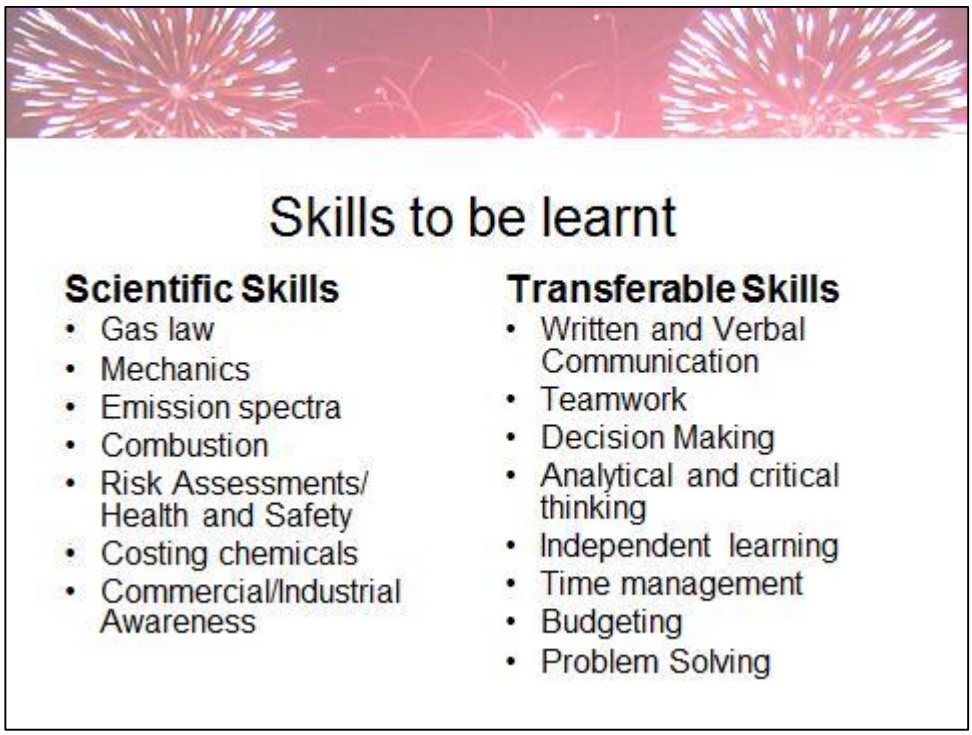


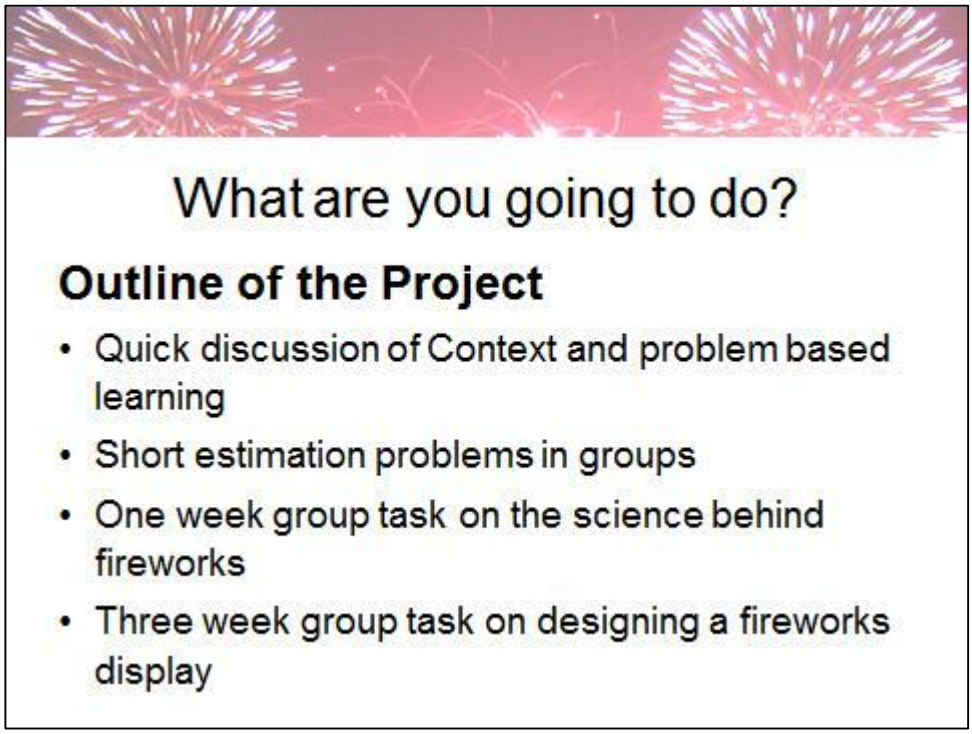
This slide is specifically targeted our programme. The notes about what we said during this slide are below. We recommend telling the students why you are doing it, but you will need to adapt this slide for your own institution and timing.

- Our year two students
- These are all skills that you will need in employment.
- This will give you some examples you can talk about in application forms and interviews
- The skills and activities you will be using in this are all areas which will be assessed in year 3 (e.g. oral and written communication) – this gives you a chance to have a go and get some practice and feedback from us first
- Also CBPL is a style of teaching which will be used in Year 3- e.g. open ended research problems so gives you some practice at this
- CPBL allows you to do the activities and gain the skills rather than just hearing about them. Feedback from student surveys is that you would prefer it if skills sessions were more active rather than listening to lectures.
- If this wasn't enough incentive (!!!) there are prizes for the winning team.

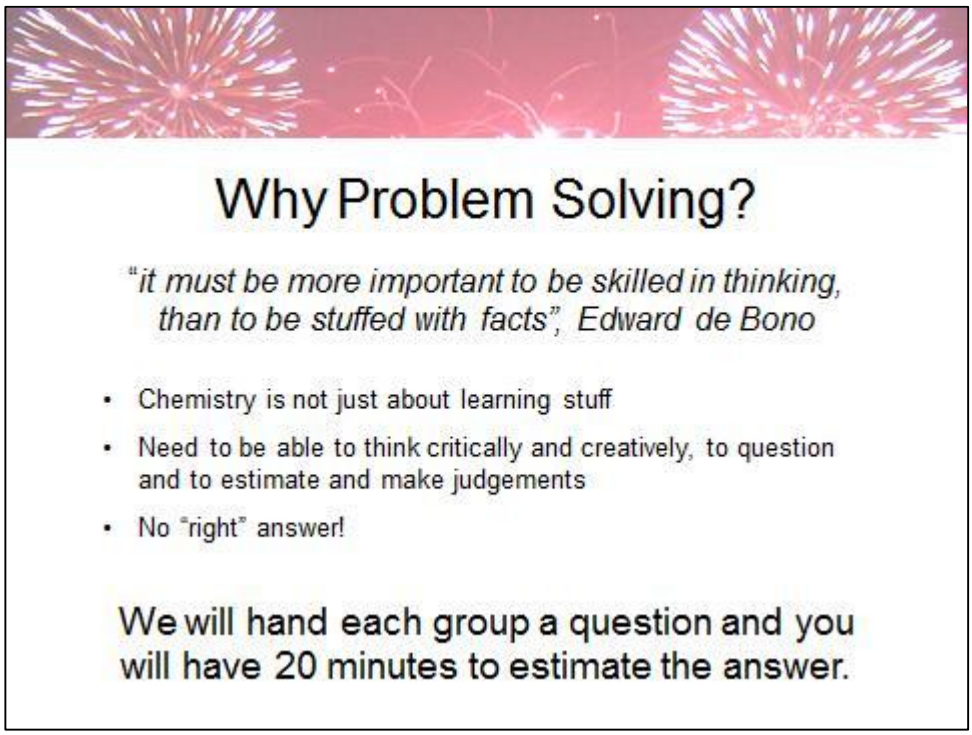
It is also useful to have an older student (undergraduate or postgraduate) to talk about skills which they needed on placement or in the final year and how this activity may be relevant.

We offered a small cash prize (£100) to the winning team but feedback from students was that most who completed the task would have done so without the prize, and the prize was not enough of an incentive for those who did not complete the task.





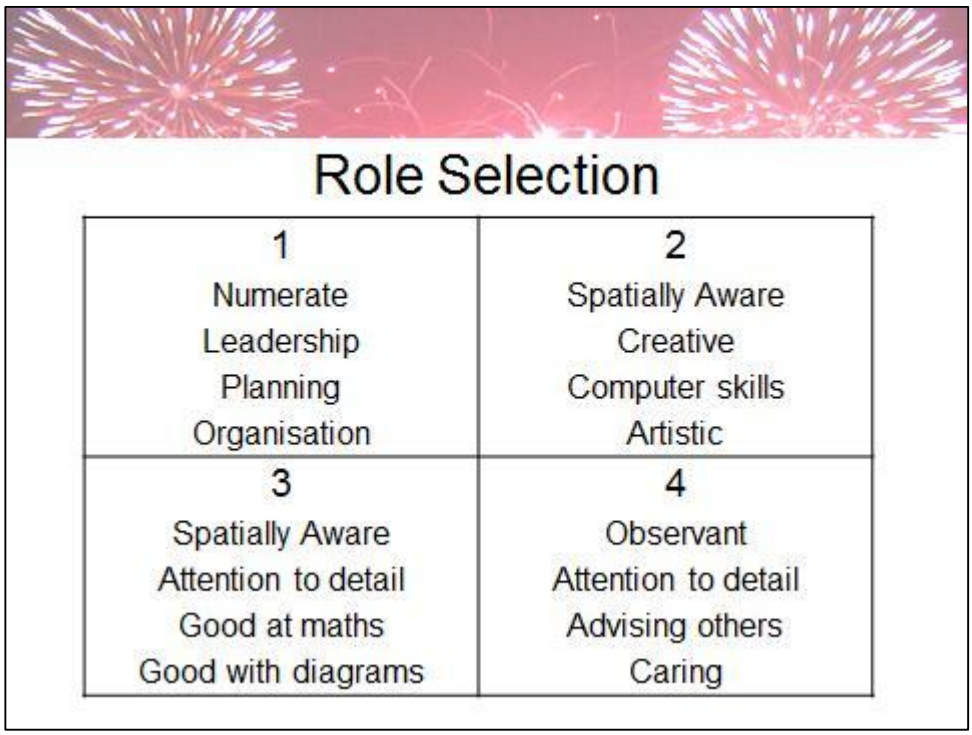
This is just to give the students a quick overview of how the weeks will unfold. Feel free to adapt this to the scheduled time allotted by your institution.



We chose a series of estimation problems in groups of approximately 6, e.g. "What is the concentration of a needle in a haystack?". This was used as an example of an open ended problem with no right answer and to give students some experience of working in groups.

For more examples of problems like this, see *A Question of Chemistry*, J. Garratt, T. Overton and T. Threlfall, Pearson Education, Harlow 1999

Any small group task can be substituted here, such as building a bridge out of various materials or other open ended problems.



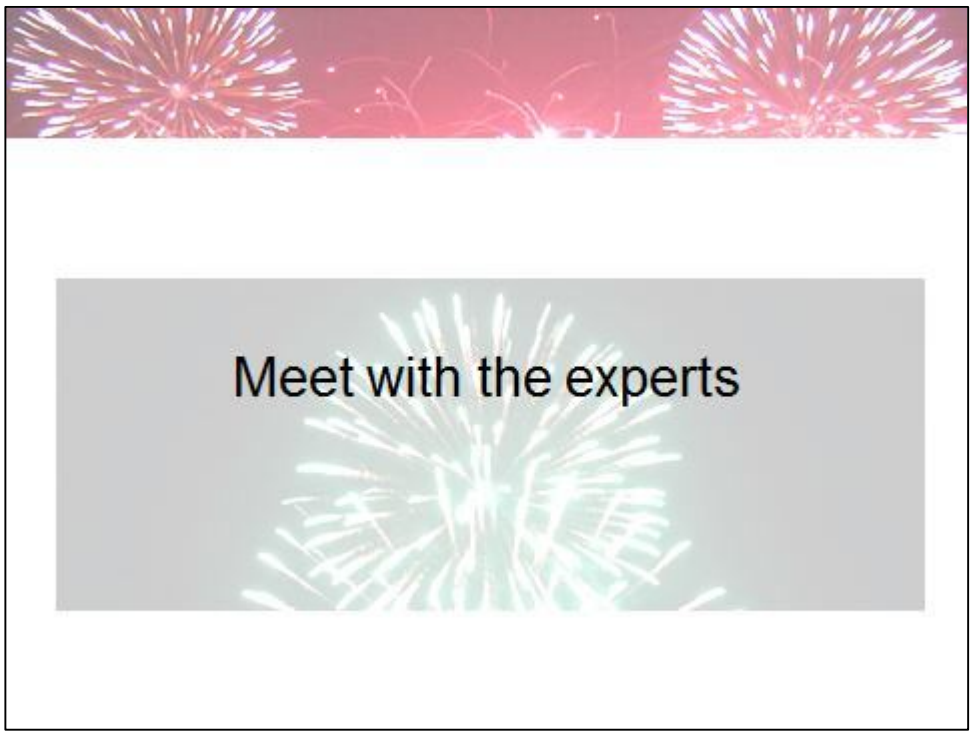
Students should be asked to select their roles based on these skills sets, before they know what the role titles are. Students can choose either skills that suit them best, or skills they would most like to work on.

Experts can be located in each corner of the room and numbered according to the skills sets, and students told to move to each corner.
Company groups are not assigned at this point but it gives you an opportunity to count the numbers of students and decide if there is an even split.

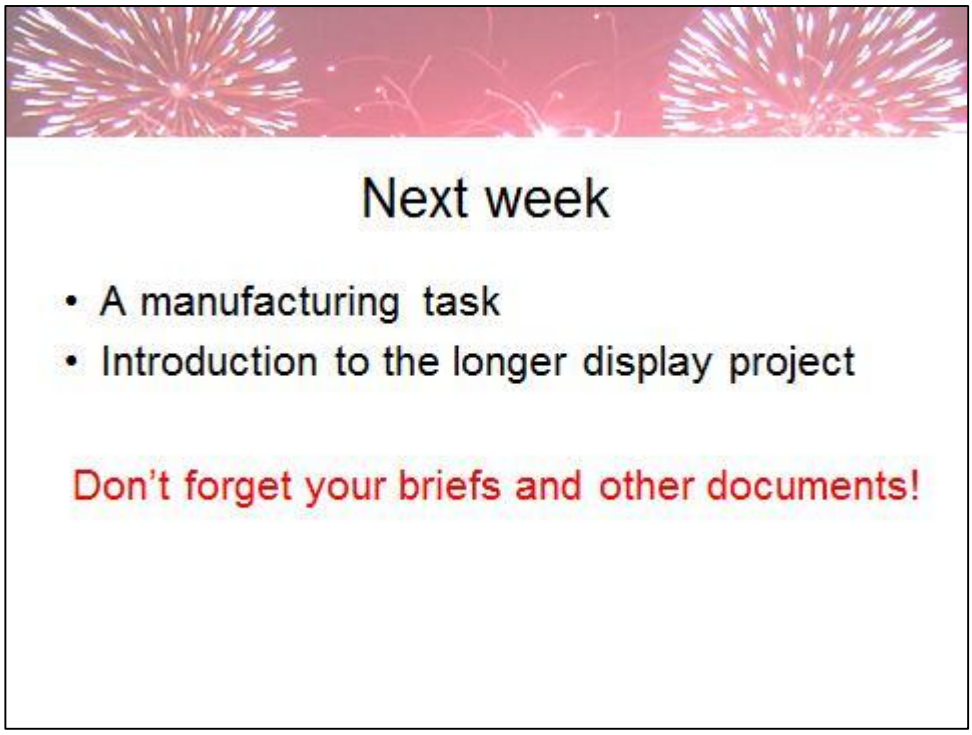
Students should meet with their experts and spend the rest of the lecture time with the students reading the briefs and allowing the experts talk with the students about the job role. The experts should try to lead the students to get started in the right direction, such as:

- MD – start thinking about the budget, perhaps suggest the idea of profit, but leave it open – during our trial the budget was where most students struggled and came up with the most creative ideas, so we suggest leaving it very open ended.
- CD – perhaps start thinking of song choice and any colour choices they might want to make – during our trial, the whole group got involved in the song choice and ended up spending way too much time debating song choice. Reminding the CD that it is their choice, or possibly the MD, could be helpful here.
- SM – get them to think about what kinds of information they will need to find out about the site, what maths they might need. Perhaps the expert could take their students out to the site, if it is close.
- DGSO – have the students think about the site and get some basic health and safety ideas down on a page – there will be many H&S concerns, so getting a good head start would be useful.

Handouts: Student briefs, list of handy websites



This is just as a possible slide to have up while the experts brief the students.

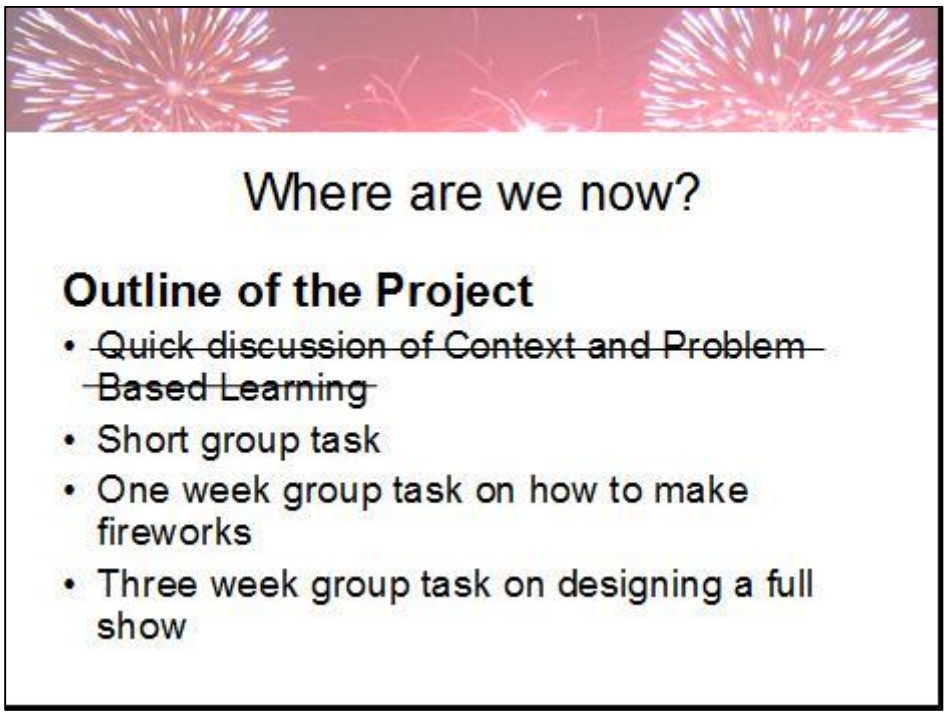


Slides for Week Two:

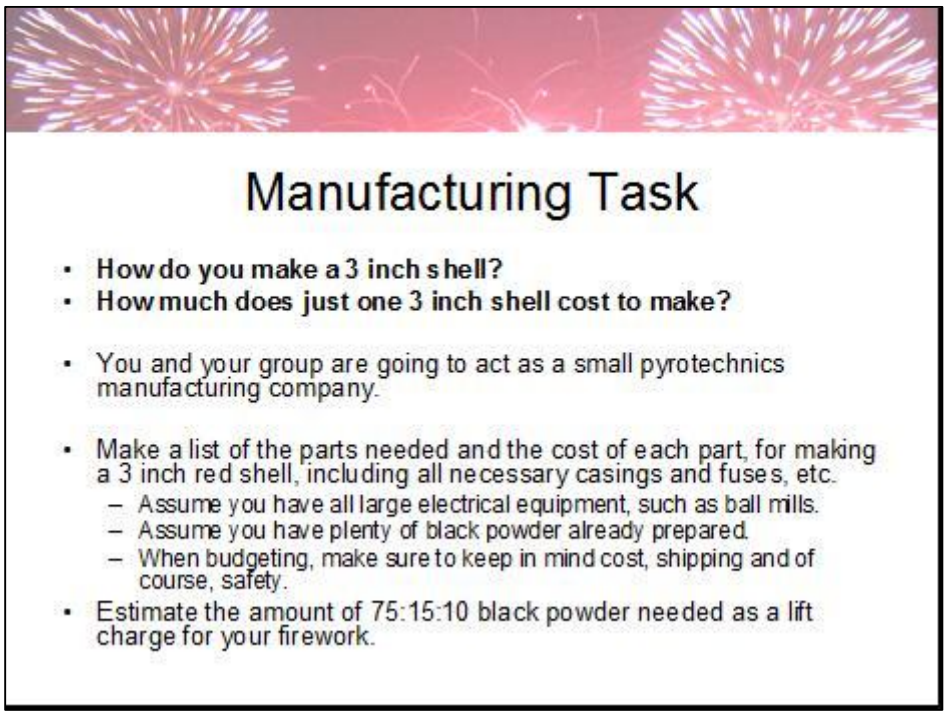
Video can be playing as students arrive.

As students to return to the corners they were in for each job role. Assuming numbers are fairly equal groups can be easily formed by assigning students in each corner a group number, 1, 2, 3, etc. It is recommended that students are allocated to groups randomly rather than allowed to work with their friends. If numbers are not equal it can be possible to form teams of five rather than four.

Spend about 5 minutes having the groups decide on a company name. Students can sign up to take part with their company name and the "employees".



Feel free to adapt this to the scheduled time allotted by your institution.



The manufacturing task can be used as an icebreaker in their new companies. It may be worth reminding students that they do not need to work in their official roles to complete this task.

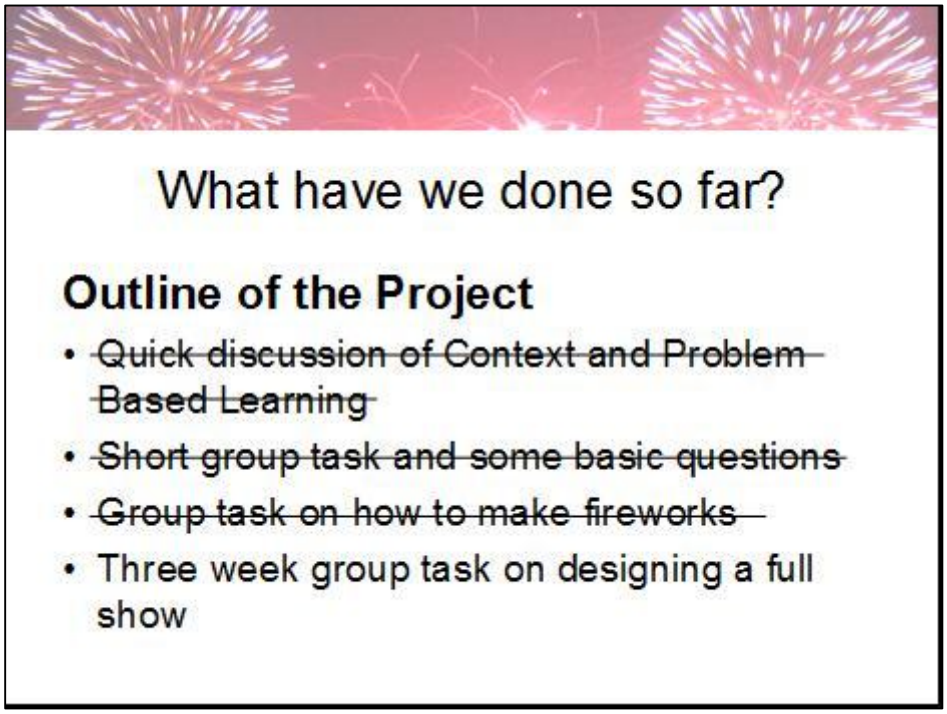
Experts should be on hand to help with this task, as students are likely to struggle with where to start. This will also give experts practice facilitating instead of demonstrating.

Use most of this session, except for the last 10 minutes or so, to work on this problem. The students may not get a full answer to the problem in the time frame allotted, but the first steps of research can be done. The rest can be done in another session or on the students own time.

There are also some additional pyrotechnics and safety questions provided. You can decide how much you want to focus on the chemistry behind this depending on your own learning outcomes.

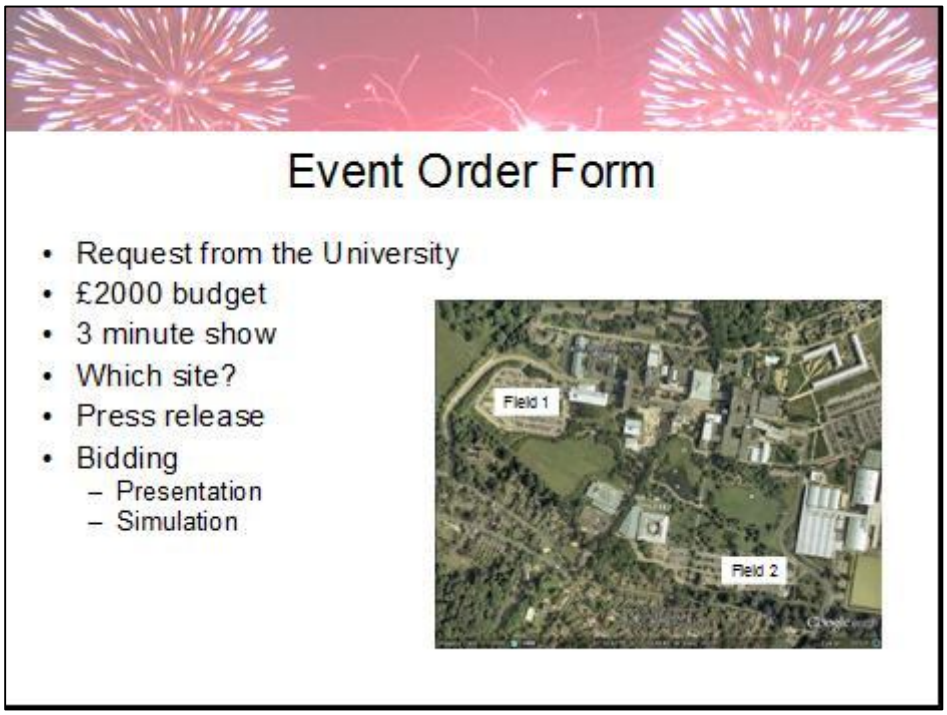
Handouts: Manufacturing Task Question sheets (make the groups get different colours). Spare handy website list. Have spare student briefs to hand, for all of those who may have switched roles or forgotten sheets.

Just a few questions to ask the students, either as time goes on or just before the final project is set. If they do not finish the problem in this time frame, they could continue in another week, do the task outside of the timetabled slot or it can be left as just an icebreaker and beginning problem solving question.



This is just to recap where everyone is and what has been done, before the longer project starts and to let the students know they are about to start the full project.

Main project:



This slide sets out the main problem for the students, more details are given on the briefing letter and details of the proposal.

They have a £2000 budget to produce a 3 minute show. This will need to cover fireworks, manpower, profit, etc. They need to choose which site to run the show in.

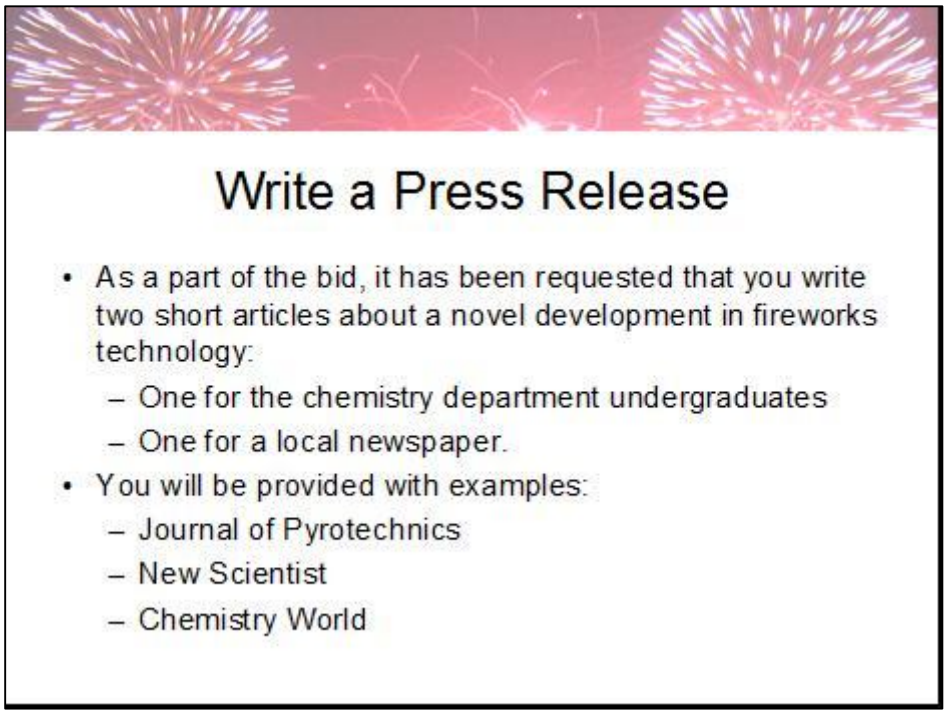
We recommend replacing our picture with a Google Earth view of your own University campus, or local fields. This way the project is more relevant to the students and they can do a physical site visit, if they would like. Giving students a choice of field is preferable, and this could be more than 2 options.
Detail the writing task and how they will have to present their show and budget with a real simulation programme at the end of the project.

If you are including any summative assessment this should also be made clear.

Handouts: Briefing letter, Fireworks inventory sheet, How to use Finale Fireworks Software, Journal articles, Writing task assignment, Details of the proposal**.**

This slide introduces the simulation software. The students should be told which computers have the software package and when they can use them. Any song in mp3 format can be used, but it should be geared towards the theme of graduation. Students should save their completed videos as an mp4 video.

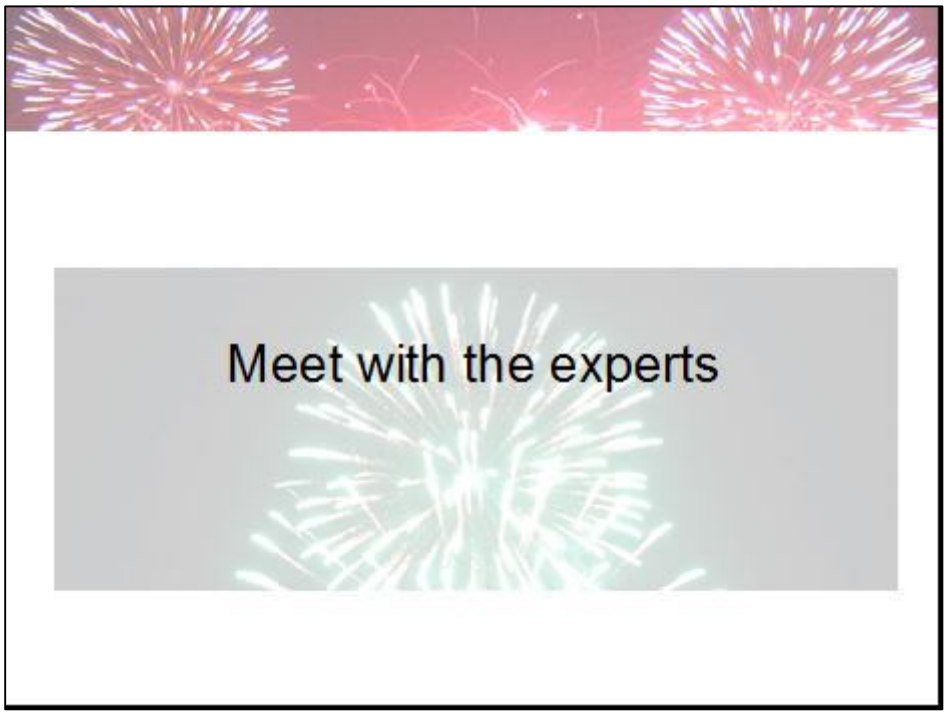
An example video produced by students from our trial is provided on the CD with this pack. This can be shown here to give students a taste of what can be done.



Students can see from the examples how a journal article can be changed to suit a range of audiences. They should discuss this in their groups and then pick another article to write their press releases on. If appropriate, a session on how to search for journals using databases could be incorporated to support this task.

Replace this slide with your own schedule and any extra details you require.

It would be useful to include deadlines for handing in work. We would recommend that students hand in paperwork and a copy of their video before the final presentation day to avoid any last minute technical issues.



If you feel it is necessary you could schedule more structured time to meet with the experts, or timetable additional drop in sessions. This will depend on how many students you have and how they are progressing with the project and interacting with the facilitators.

If you are incorporating summative assessment into the activity it is important to be clear about the marking criteria, deadlines etc.

Assessment:

This project was carried out as a non-credit bearing activity. Students were given detailed formative feedback on all aspects of the task.

There are many potential points of assessment if the activity is to be used as part of a credit bearing unit. These should be chosen to reflect your own desired learning outcomes but our suggestions include:

- Manufacturing task – cost, realistic manufacture, appropriate chemicals and amounts
- Presentation – general factors such as style, clarity etc. in addition to how well the brief was answered
- Writing task - how well is the scientific content communicated and how appropriate is it to the audience?
- Paperwork – each document, e.g. site plan, budget, risk assessment
- Group work – there should be some component of assessment associated with how students have worked in each of the sessions and engaged with each other and the experts. This could be done by the expert facilitators.
- Individual contribution – it is worth getting the students to peer-assess their individual contributions to make sure that students who don't "pull their weight" do not receive unfairly high marks.

For more information on effective assessment of CPBL problems, see the HEA good practice guide, *PossiBiLities*.[3]

Common questions to ask in the final presentations:
Questions should quite naturally arise when watching the final presentations and students should be encouraged to question each other. Some common questions provided by our industrial experts are:

- What size is the biggest shell you used?
- How long are your safety areas?
- How wide is your firing site?
- What would you do if the wind changed direction on the firing day?
- How are you going to deal with the proximity of railway lines, flight paths, waterways, etc. (whatever is suitable to your site).
- What is the separation between firing sites?
- What are your launch angles?
- How did you choose the wind direction?
- What category of fire extinguisher would you have on site?
- What other safety equipment do you have on site? Where?
- How level is the site? How will you manage the site if the site is not level?
- What would you do if one of the shells did not fire from the mortar?
- What would you do if one of the shells fired from the mortar, but did not explode?
- So if you decide to cancel the show, how are you going to explain to your paying client that it needs to be cancelled?

Appendix:

Project Leader Checklist:

Preparation:
Have you:

- Recruited the Experts?
- Emailed the relevant documents to the experts?
- Booked locations?
- Arranged prizes (if needed)?
- Booked computers?
- Downloaded and paid for the Software?
- Decided on your judging panel for the final presentations (perhaps including an industry expert)?

Week One:

- Is the PowerPoint Loaded?
- Is there sound for the videos?
- Are the experts aware of how the students will be divided into groups?
- Student documents to hand out:
    - Handy Website Sheet
    - Student Briefs for each job role
- Do you have the relevant materials for the short group task?
- Are the experts prepared with how they will brief the students on their job role?

Week Two:

- Is the PowerPoint Loaded?
- Is there sound for the videos?
- Are the students divided into groups?
- Student Documents to hand out:
    - Manufacturing Task Question sheet
    - Other question sheet, if using
    - Opening Letter to the Display Task
    - Writing Task
    - How to Use Finale Fireworks
    - Journal of Pyrotechnics Article, New Scientist Article, Chemistry World Article
    - Fireworks and Staffing Inventory
    - Spare Documents from Week One
- Do the students know where to go for the next few sessions?

Week Three and Four:

- Are the computers available with the software programme?
- Are the experts facilitating properly?
- Remind the students to hand in their paperwork and videos well before the presentation day.

Week Five:

- Have the students turned in their paperwork in advance?
- Are the students presentations and videos loaded to the desktop?
- Is there sound for the videos?

Timetable:

Week One:

- Introduction to project and divide students into Job Roles
- Have the experts brief the students on their job role.

Week Two:

- Divide the students into their teams and have them determine a company name
- Work on the manufacturing task
- Introduce the main project to the students

Week Three: Support Day

- Use this time to just support the students
- Experts should be available to answer questions and to guide the students in the right direction

Week Four: Support Day

- This extra week is optional
- Use this time to further support the students and make sure they are on the right track
- This additional day may or may not be necessary depending on how students are progressing and interacting with facilitators.

Week Five: Final Presentation

- Judging sheet
- List of common questions to ask the students

This activity was undertaken as a part of the National HE STEM Programme, via the South West Spoke. For more information on South West Spoke projects, please see www.hestem-sw.org.uk. For more information on the overall national programme, please see www.hestem.ac.uk.