Electrical circuits, Lesson sequence using 5Es (Engage, Explore, Explain, Elaborate, Evaluate)

Note: This is a sequence for 5 lessons for a Year 10 class. Prior knowledge of what current and voltage is and the different components of a circuit are assumed. Most misconceptions will be addressed, however, the concept of batteries will be examined briefly and generally, as it is not part of the syllabus and will be difficult to explore, explain and elaborate without addressing Year 12 Chemistry. Lesson sequence shown below:

Key:

Green boxes highlight the parts of the lesson sequence that demonstrate Standard focus area 3.2.1.

Timeframe of lesson:	Students do:	Why?	Teachers do:	Possible issues/misconceptions:	Extra comments:
Lesson 1 Introduction (**Engage** + some aspects of **Explore**)	• Quick activity (15 mins) of where students need to make a light globe glow from crude items (Appendix 1) • Students need to read the scenario of the activity and using what they have on the table make the light globe glow. • Students will work in small groups of around 4. • Then they would discuss the concepts they have created with their groups to gain an initial understanding in this topic.	• Start of this topic - introduce the topic with some fun. • Students use everyday materials (batteries, aluminium foil etc.), as this would relate to everyday situations to which students can get meaning from. • Social learning is the most beneficial type of learning, thus in groups, members can learn skills from each other and pool together to solve problems (Wertsh & Tulviste, 1990). • This initial activity would **engage** the students as it introduces circuits with fun and they must work together to solve difficult problems using everyday items that they might take for granted. • Students will start to [critically] think and **explore** about electrical circuits and why some configurations they made were not successful. Start to address misconceptions.	• Monitor students and see how they are faring with this activity. • Should not tell students the answer, as this initial activity's purpose for teachers is to examine the various misconceptions students may have and then structure subsequent lessons accordingly. • Prompt students with hints to help them on the right track.	• Students may not grasp how to make a correct circuit using battery and foil. • Students may only use one piece of foil and only attach to one pole of battery– sink model. • Short circuit the battery without even lighting the globe – short circuit model. • When trying to make the globe brighter, students may not think to provide more voltage by adding extra batteries, but choose to shorten the foil – empirical model. Or they may choose to make it thicker in hopes more electrons may pass. • Students will think when lighting 2 globes in series fashion will not cause light globes to be dimmer – attenuation and sharing model • May not know how to correctly make a parallel circuit and instead mis-conceptualise series as parallel. • See table 1	• Teachers need to examine each group and understand where the misconceptions lay, otherwise this activity is not useful. • Do not give answers as again, makes this activity redundant.

Activity 2 (**Explore**)	• Quick revision of circuits learnt in previous years. • Worksheet about symbols of circuits (Appendix 2)	• Gets students on the same page as they would know symbols of circuits. • Individual work so teachers can see each student's ability. • If students do not know, they can **explore** expressions of circuit.	• Monitor students • Go through the answers and explain after students finish • Try to make interesting ways for students to remember different symbols	• Not many issues can arise from this – just simply students not knowing the different symbols.	
Activity 3 (**Explore** + **Explain**)	• Activity where now they use actual wires and power packs etc. (30 mins) • See appendix 3 for further instructions • The overview is that students make different types of configurations of circuits and then they will need to discuss why these phenomena occurred.	• Addresses the various misconceptions listed in table 1. • Using first-hand experiments is more beneficial to **explore** concepts than with transactional teaching. This is not a restrictive task, thus students are able to **explore** beyond what is required in order to **explain** concepts. • Students are able to with their peers start to develop their own conception and remove their misconceptions. • Using this method, not only is engaging but develops critical thinking skills. • Group work and hands-on activities are more likely to reinforce knowledge.	• Monitor and give prompting questions if groups are stuck • Again do not give answers (that would be later in this sequence) • Try to let students make their mistakes and from that to explore conceptions, as transactional teaching is less beneficial	Some misconceptions that can be addressed and explained: • Sink model – students will quickly explore that one wire will never allow a globe to light. They will find they need at least 2 wires • Attenuation and sharing model – explore with an ammeter that current is never used up and is constant across the circuit. Through a voltmeter they would see that this is changing • Empirical model – they will see that the length of wire does not change the current or volts and the brightness of globes • Parallel circuits local reasoning model – through ammeter and voltmeter, they can see that current does not split when there are branches but voltage does • Sequential model – when adding resistors, they can see that in a series circuit, it affects the entire circuit	• Do not give answers as it makes this activity redundant as students need to remove misconceptions themselves. • Students may still have significant misconceptions or their conceptions are not the accepted versions. Teacher needs to explain and elaborate in subsequent lessons, otherwise 'their conception' would be etched. • Misconceptions are difficult to alter as we have

				instead of places 'ahead'. Also see how different configurations can affect resistance of the circuit • Can clearly explore and explain differences between parallel and series circuits. Account for observations such as different brightness	developed it through many years of personal experience, so for a teacher to change it into conception would need a lot of hands-on work and be knowledgeable in this topic (Moodley, 2013)
Lesson 2 Activity 4 (**Explain** + **Elaborate** + **Evaluate**)	• Diagnostic test/revision. See appendix 4. (45 mins) • In groups, they need to answer questions from online quiz, and they may make circuits to assist.	• Students can **evaluate** where they have misconceptions and address them • The use of hands-on task along with the online quiz allows them to **explain** their answers and possibly **elaborate** on where they went wrong. • If they get question wrong, they can refer to their circuit to **explain** and **elaborate** their error. • Again, group work and hands-on tasks are beneficial. • It is always important for teachers to have constant assessments to check if students are on the right track.	• Monitor students • Now teachers can explain concepts to students • Starting from now, teachers need to mould still existing misconceptions into conceptions. • Evaluate students and note pressing misconceptions that need to be addressed subsequently	• Many misconceptions can be addressed (listed above). • However, there are still a few misconceptions that are difficult to explain and elaborate using online quizzes and hands-on practical. • Short circuit model – It is dangerous for students to be short-circuiting a power pack and should not be done • Schools usually would not have different thickness of wires, so trying to test if charges move faster in thicker wires is limited, so this misconception is difficult to explain • Difficult to explain misconception of battery workings without going into year 12 chemistry about galvanic cells etc.	• After teachers evaluated students, they need to mould subsequent lessons • Misconceptions listed in the previous column will be attempted to be addressed later

		More testings means higher precision, thus teachers can address issues quicker, earlier and to more accuracy (Kelley et al., 2003).			
Lesson 3 Activity 5 (**Explain** + **Elaborate**)	• Teacher will be doing demonstrations and **explaining** and **elaborating** various concepts – especially ones that teachers have determined students hold the most misconceptions • Students should take notes and be active in discussions	• Students have attempted to their best ability to try and **explore** some misconceptions and to **explain** the correct conceptions. • It is now time for teachers to address the remaining misconceptions and incorrectly developed conceptions. • Using demonstrations can make a usual transaction type of teaching more **engaging**, thus allowing students to take in more information. • There would be significant parts where there would be discussions, and allowing free-flowing of various opinions is beneficial.	• From last lesson's **evaluations**, teacher can mould the lesson plan to target specific problem areas • Address various misconceptions and explain correct conceptions • Use various demonstrations and videos if needed to explain and elaborate	To address (teacher demo): • Short circuit model – take aluminium foil and attach one end to one pole of a battery and the other to the other pole. Get students to feel the aluminium foil and if it gets hot. Compare it to normal made circuit and if the aluminium foil heats up. Then explain that current is still flowing even if there's no globe signified by hot foil. • Thickness of wire – again use aluminium foil and make different ones in different widths. Then attempt to light the globe. Look for observations and it shows that the brightness of the globes is same with any wire. Means that current is constant. • With battery workings, use a video to explain how batteries work (does not need to be complicated). This would be much easier as it is not practical to dissect a real battery in the classroom.	• There will be other misconceptions that need to be explained and explored. A lesson plan cannot account for all of these, thus it is up to the teacher's discretion to have **evaluations** to know what areas to target. • The examples in the previous column can be used as a template/scaffold to explore other misconceptions.
	• Research task • Research the	• Group activity is beneficial as it allows for understanding of	• Monitor • Provide hints where	• Misconceptions should not be as often at this stage, however, if there	• Teachers need to be flexible, thus

Lesson 4 Activity 6 (**Elaborate**) Computer lab	where parallel circuits are used in everyday appliances and where series may be used. • Also research about the various batteries that are out there and how they are different. • See appendix 6 for further instructions	various views. • Research task is a good method to **elaborate** on knowledge that they have learnt. Students learn about things beyond the syllabus and understanding why certain circuits are used in certain ways, and what advantages and disadvantages there are. • This elaboration reinforces the knowledge that they have learnt • Engaging as doing something different, research at a computer lab and also getting to discuss which improves their speaking skills	applicable • If students are having misconceptions about certain points, patiently explain it	are, they are most likely to be misconceptions list above and in table 1. • Other issues that may arise are students being distracted with the computers. Teachers need to monitor students closely to prevent this. • Students may be uncomfortable coming up to the front of the classroom to talk about what they have researched.	having different types of lessons can keep students engaged, hence why this research task at a computer lab is used.
Lesson 5 Activity 7 (**Evaluate**)	• Students do assessment as a final part of this sequence • Many assessments could be done – various ones online can be suitable or teachers can develop their own	• **Evaluation** of student's ability and knowledge of the content • Students themselves can see what misconceptions they may still hold and then work to amend that	• Teachers can precisely know where students still might hold misconceptions and have issues. • To have this **evaluation**, teachers can then either extend lessons on this topic to address misconceptions held by students • Teachers will know which areas to target	• Evaluation is very important to complete a lesson sequence on a particular topic as it will allow teachers to effectively understand which areas need more targeting and which misconceptions have effectively been changed to accepted conceptions. • Evaluations need to occur throughout lesson sequences, not just at the end as it increases precision, thus allowing teachers and also students to accurately pinpoint trouble areas.	