**Leanne Compton:** Hello, my name is Leanne Compton. I'm the Curriculum Manager for Design and Technologies at Victorian Curriculum and Assessment Authority. This video we've produced is entitled, ‘VCE Systems Engineering’, and it will focus on unpacking the assessment criteria for the 2021 School-assessed Task. This video is one in a series of videos that the VCAA has developed to support teachers in the delivery of their curriculum and assessment programmes for 2021.

Colin Chapman is the state reviewer for VCE Systems Engineering and Colin will take you through this presentation. Over to you, Colin, thank you.

**Colin Chapman:** Thank you and thank you for this opportunity to work with teachers across the state to improve our learning and teaching practises in Systems Engineering. Here we have our statement with regard to the intellectual property of the Victorian Curriculum and Assessment Authority.

So we're concerned here with the school-based assessments, grade of assessment for the School-assessed Task. This is a production of the integrated and controlled system. So this is Unit 3, Outcome 1. In the completion of this unit the student should be able to investigate, analyse and apply concepts and principles and use components to design, plan and commence production of an integrated and controlled mechanical and electrotechnological system using the systems engineering process. We require a record of investigation, design, planning, and production, which we call the record of evidence. And also preliminarily production, we'll have to create a mechanical and electrotechnological integrated and controlled system.

Let's focus on this idea that it needs to be integrated. So we need to have mechanical and electrotechnological aspects of the system working together off each other and there must be some control. For Unit 4, we're focused on systems control itself and Outcome 1. On completion of this unit the students should be able to finalise production, test and diagnose a mechanical and electrotechnological integrated and controlled system using the systems engineering process and manage, document and evaluate the system and processes as well as their use of it.

Management means that the intention that the students developed in Unit 3 may not have gone to plan and management means responding to how things didn't go to plan, re-planning and carrying out a new plan. Documentation is vital to this study. We are expecting to gain a record of progress and modifications, which is part of the record of evidence and this can include images and texts material, including video and simulations and so on. A record of diagnostic testing and performance data and a report that evaluates and suggests improvement to the system with reference to factors that influences creation and to the student's use of the student engineering process. So this report really puts everything up for grabs, from planning right through to implementation, evaluation and testing. So the scope of the task is this, there should be a record of investigation, design, planning and production that reflects the systems engineering process.

The systems engineering process iterates from one design to the next and it follows an agile process, in that the students are encouraged to respond to the design brief with something that works in some fashion as quickly as possible and then to iterate that design over and over again, getting closer and closer to an effective response to the design brief. They need to make sure that there is clear reference to the factors that may influence the design, planning, production and use of an integrated and controlled system.

So let's look at the statement for the criteria one and the indicators. So expecting some sort of investigation and investigation is a key word here, this is an active word. So we're expecting that the students look at some problem, situation, opportunity or need, investigate that need and develop a design brief. The design brief should be sufficiently open that it allows a breadth of responses to the problem, situation, opportunity or need. That means that these students need to use language in a design brief that allows an opportunity for responses that are varied. It's important that the design brief is concerned to be able to develop an integrated controlled system, including evaluation criteria. The integrated controlled system means that the system must have some form of being able to control its response and it must make sure that the electronic and mechanical aspects work together.

There must be evaluation criteria developed and that evaluation criteria should include a mix of both quantitative and qualitative criteria. It must be an opportunity for students to go beyond it's just simply a yes-no response to an evaluation criteria, into something that allows a breadth of performance to be identified as suitable for a response to the design brief itself. In the indicators we're expecting that there is a clear and developed identification of a problem, situation, opportunity or need. There needs to be a design brief developed for an integrated, controlled system. There should be responses to this design brief and there'll be multiple responses if the design brief is developed in such a way that allows a breadth of response. There needs to be the development of evaluation criteria and they need to reference factors that influence the creation and use of the system. That means the system goes beyond the machine or device itself towards the interaction between the user and the machine. And the interaction between the user and your intended use may be such that you would have to re-design.

So here is some more detail. Students are expected to explain context, constraints and considerations, so the verb explain shows that there needs to be an argument developed about the context, constraints and considerations and why those particular things exist and why they're important. And you can see here, we've got justifies as another important verb. So evaluation criteria cannot simply be listed, they must be justified and there must be a strong link that indicates how they relate to the requirements of the design brief and the factors that influenced the creation and use of the system. So again, we're going higher on those skills, justifying the evaluation criteria while lower order skills simply listing of the evaluation criteria.

Second criteria is researching, devising, designing and modelling design options. The indicators include, conducts research and this research must be acknowledged, all sources are acknowledged and we don't specify a system for acknowledging the sources, but it must be a consistent acknowledgement system throughout their documentation. That research would include modelling of components, subsystems and systems, and that modelling can go across the gamut of activities that include calculation, virtual modelling, physical scar modelling, and physical full scar modelling of aspects. And we're looking at components, subsystems and systems. So if the student is incorporating a particular component, they can model the response from that component. It's important to do that in criteria 2, because when the student actually tests any components, subsystems or systems in criteria 6, there may well be a change in the actual performance of the components, subsystem or system, compared with the model of the system, subsystem or component. And comments should be made by the student in that regard and it may well be that there is the actual performance of those components, subsystems or systems is sufficiently different, then re-planning has to be carried out. If they do this activity it means that they have a strong justification for any changes. They need to set the generation of design ideas. This is not simply just listing designs that they found on the internet. The student needs to actually design their own responses to the design brief. We're looking for a minimum of three, three is sufficient and these designs should be annotated, labelled and so on.

The student needs to produce feasible design options. These must be design options that could be constructed using the resources and capabilities of the students. And then the student needs to select the preferred option using some system to show that it was a fair test, a grid system would be useful in this case where it's clear that the same questions are being asked of each one of the feasible design options.

So here's the detail, undertakes research including modelling of components, subsystems and processes to generate design ideas using diagrams of technical data to, and this important verb, justify feasible options and the preferred option. So there needs to be an argument as to how the options they are providing are feasible. These options need to be modelled. And then from those modelling activities, we need to develop a judgement with respect to the preferred option in a way that is fair across all of the options.

Criteria 3 is concerned with planning the creation of the system. So there's a full appreciation here that the student is planning what they may do and how they may do it, with what sorts of resources, processes and so on and that the plan may not go to plan. In order for us to reward the student for adapting, modifying and changing things regarding the plan not going to plan, we need to have a satisfactory response to criteria three. So we're expecting there to be a work plan developed, which includes a timeline, sequence of steps, Sequence of steps means that we need to see the steps in good order. And again, it may well be the case that the sequence has changed during the actual production process and that should be noted and justified. There needs to be indication of associated equipment components, materials and processes, including access and a time for supply, sourcing, plant so on and there needs to be references to materials, components and processes themselves and there needs to be a description of safety and risk assessment for materials, components, and processes. And we understand that the risk assessment and management will mature and change as the student goes through the project.

So we expect there to be a developed work plan, which identifies a sequence of steps and a timeline. So a Gantt chart is useful for this, but it's not the only method or only tool that can be used and there needs to be an analysis, not a list, an analysis of how materials, components, processes and tools will be used for the creation of the preferred option. So it's not good enough to simply say that something is going to be 3D printed. It needs to be analysis of the 3D printing process and the sorts of things that can influence the quality of such a 3D print. So we would expect there to be acknowledgement of test printing, printing the components with different density film fills, as well as different profiles for density fill, different temperature and humidity settings for the printing machine and so on. This is all part of analysis, talking about how the printing process will be an iterative process that you simply don't print out a first go component and hope for the best, but there needs to be an acknowledgement that there'll be some need to timeline an iteration process for the development of the components. They need to describe the safety and risk assessment. It is suitable for a teacher to provide a proforma for safety risk assessment, but that proforma should also make sure that it has processes in built for re-evaluating, re-assessing the ongoing safety and risk assessment that is necessary for responding to the School-assessed Task.

Criteria 4 is the first criteria beyond developing of an intention, this is the doing part. Images, video, and so on will be great evidence for use of tools, equipment and machines to make the system. Video of a student going through the process of setting up a CNC machine or a 3D printer or a laser cutter or whatever it might be, can serve as evidence towards a complex process. So it's important for students to get into the habit of making recording of their work an every day activity. Again, we need to remember with all school-based assessment that learning and teaching activities are vital to making these school-based assessment tasks work. So we're expecting here to see implementation of the work plan as developed in criteria 3 and we should start now seeing evidence of that work plan not going to plan. The student will, through use of tools, equipment, and machines, and the issues and concerns in that regard impacting the work plan and we should start now seeing the student re-developing the work plan and starting to develop new versions of it in light of evidence that is coming in with respect to equipment. An example might be that the student might have just assumed that they had unimpeded access to a 3D printer and then finds that they have to share it with other students. So they'll need to think about how they would schedule that particular work. There needs to be evidence of complying with OH&S requirements and remember, that's a matter of law and regulation. We are expecting that they will increase in their effective use and implementation of OH&S requirements. And in detail, we're expecting that they are to implement a work plan independently.

Now, remember that this is an ongoing task and it may well be that there was some support necessary early on in the piece, but then the student developed independent skills through your learning and teaching activities and if they become increasingly independent in using production, processes, tools, equipments, components and materials, then that should be serving as good evidence here. So we're not going on a one short assessment. This is an ongoing engagement with the student as they work on the School-assessed Task. We're looking at precision again, precision and technical skills will be emergent as they go through the engagement with the School-assessed Task and that we're assessing the student on the outcome. Have they got to a stage where they are being precise and developing good technical skills? And they need to show compliance with OH&S requirements to produce the preferred option.

Criteria 5 is the realisation of an integrated controlled system. Now integrated controlled systems best represented by systems of feedback mechanisms, which change their state as they measure their response to some sort of stimulus. However, there are multiple integrated controlled systems, so there's more than one response here that feedback would go some way to being able to give a good indication of success in this particular criterion. So we're looking here at production of an integrated controlled system and if the students take an agile approach, which is to make a solution that works as quickly as possible, that means you have evidence early on of integrated controlled systems. And as they iterate, that integration and control may well become better and better and reflect a stronger response to the design brief. So taking an agile approach means that we can have evidence early on in the piece, regarding this criteria 5 and then that evidence can be reinforced as we move through the project.

So we're looking again at independently produces and remember, this independently produces is an emergent skill. So it may well, the student makes the transition from supported to independent throughout their engagement with the School-assessed Task and that we should reward this development of independence. An operational integrated controlled system. Now, in the notes, we do ask the question, did it once operate? It's important that the students record all of this work and that if they're showing operation, if they're testing for operation of their integrated system, they should videotape it, so that there is some record of it at some stage working in case there some issue and it is no longer able to operate. It needs to be integrated, so the electrical and electronic aspects working together with the mechanical aspects and the mechanical aspect must be a distinct mechanical process and it must be controlled. In order for it to be controlled, there must be some sort of way that the system knows what state it's in and then respond to that state. And it must address the context, considerations and constraints of the design brief, as described in the work plan in criteria three with documented modifications. It doesn't matter how many modifications or how extensive they are, they just need to be documented and those documented modifications allow us to reward the students for this criteria, as well as the criteria 7 and 8.

Diagnostic test procedures and interpreting test data. This is an important criteria and this criteria can be engaged with from the very beginning of the project. So when the student is doing modelling and they are modelling components, then part of that modelling could be some test bed modelling and so on and testing, then they would be able to show evidence of a diagnostic test procedure. It means that there are multiple opportunities throughout the ongoing engagement with the School-assessed Task for the student to demonstrate capacities and skills in diagnostic testing and interpreting. The key thing is we need to identify the diagnostic tests, they need to provide a reason for the diagnostic test, and that should be associated in some aspect with the design brief.

Explains how to set up a diagnostic test. So that could be a procedure associated with photographs and so on. Conduct the test, again video of tests being conducted as strong evidence and generates and uses test data. And that test data can be used to improve the component, subsystem or system. It could also be used to improve the test itself. So we're looking here for the identification of reasons for the diagnostic tests, not just a list. Why is the diagnostic test useful? For a component, a student may have wanted to use an ultrasonic sensor and the ultrasonic sensor may have a data sheet with it, which makes claims towards performance. So a student may well develop a test to test whether the output from the ultrasonic sensor regarding its distance to a target. So they'll develop that test and a procedure, get the data and compare it with the data sheet to see whether the response is what a data sheet says. And if it's different, to develop either a need for a different component which is more accurate or to make compensation in their design for the different response. For a subsystem, it could be to check whether integration is working effectively. To see when the stepper motor steps through seven steps that the lever arm moves a certain displacement. And the reason I need to do that is because they're looking for a particular movement as a response to the stepper motor moving. So these would be reasons for diagnostic tests. These tests need to be carried out to generate data, analyse the data and interpret the test data. So there needs to be some qualitative data coming out of the test. So for the ultrasonic sensor, it could be distance versus output. for an Ardiuno, for example. For the stepper motor leading onto some sort of lever mechanism through linkage, it could be lever displacement versus a number of steps. Now, that sort of data could easily be graphed, which is a nice tool to help develop analysis and interpretation. And in the end, if the product system or component is not performing as we expected, it's performing differently, the students would analyse that data, interpret it and make a judgement as to where the change was necessary, modification or change of component. So this is a very important criteria and again, it can be revisited many, many times throughout the process.

There are lots of components, subsystems and the system itself to be tested and evaluated as a result of evaluations and so on. And criteria 6 can be used to collect that data. Remember, the data that comes out when it's interpreted, can inform not only compensation for components or modifications of subsystems or systems, but also a re-thinking and re-designing of the test itself.

Criteria 7 is project management to realise the preferred option. There needs to be evidence of management of the production of the system. That means we need to have a strong response to criteria 1 to 3, which was reported mid-year, so the students can show how when things didn't go according to their plan, developed any intention in criteria 1 to 3, they've managed the production. They've noticed things, they have made a new plan and carried out the plan, that's part of management. Justifying those management decisions is important to this process. They need to document decision-making modifications and they need to justify or document their justifications for such changes. So we're looking for independent demonstration of skills and time management. And remember, again, this independence may emerge with their ongoing engagement with the School-assessed Task.

In time management and organisation. So we expect that the plan they developed in criteria 3 is going to go through a number of versions and in those versions, as those plans change, we are seeing the development of skills in time management. It may well be that the student realises that we can't just say such and such a process will be finished at a particular date, that it may be more effective to give a more or a broad range of time for a task to be finished. It also means that as the student is going through the process, they may realise that while something is 3D printing, that we can timetable in other tasks to happen simultaneously. If we see evidence of that, that means we're seeing independent development of skills in time management and organisation. They need to independently describe evidence of progress and risk assessments. So remember, risk assessment is an ongoing emergent activity as the project is going along and as they develop independence in describing their changes in risk assessments and management, that's strong evidence for reward in this particular criteria. We're looking at progress and change in production work and diagnostic testing and justification of decision-making and modifications if required. Our list of decisions made is not justification. We need to have decisions indicated as the project goes along and the best time to do that is when it happens and justifying it at the time.

Criteria 8. Evaluating the use of the systems engineering process, which we remember is iterative, it moves through iterations from a response to an improved response multiple times, including the finished integrated controlled system. We need to see evidence and evaluation of design, evaluation of production, materials, tools, and processes and we need to see evidence of tests and evaluations of the systems. Remember that the evaluations were developed in criteria 1 through to 3. So we need to see here in the descriptor, use of the systems engineering process, including diagnostic testing and the predetermined criteria to evaluate the performance of the system and explain recommendations to the design and production of the system. So we still will apply the evaluation criteria as indicated at the beginning. It may well be found that that evaluation criteria wasn't as effective as it could've been and that should be commented on and then the students would then indicate how they're modified through that development of evaluation criteria process differently. We're looking for them to explain, not just list, explain their recommendations for change to the design and production of the system.

Now, if the student have gone through the iteration process for their School-assessed Task, I'll have multiple opportunities to comment on the design and production of the system. Not only that, but there'll be evidence of them making recommendations and actually carrying out those recommendations. So this is a very important criteria and it allows us to reward the students for things not going to plan, commenting and giving narrative regarding what they did, to re-plan and carry out the new plan, but not only that, to talk about how they might've done things differently from design through to production itself.

Here is the systems engineering process, which really should be in the workshop in full colour, as large as possible. Note how the arrows go backwards, forwards and round and round. This isn't a linear process and it's not a one shot process, it is a process where we can look into different cycles and repeat those cycles as often as is necessary. We have identify and document problem, need, opportunity, situation. So we're looking for ideas in design briefs and that leads into research of the feasibility, sorry, researching feasible alternatives and options and these include processes, components, subsystems and costs.

We can go directly from there to re-evaluate, modify and document and go back into the identify and document problem, need, opportunity and so on and get new ideas, refine the design brief.

Then we lead into design and model the system, drawings, flow diagrams, trials and testing simulations and modelling calculations and so on. And again, we can go into re-evaluate, modify and document, that oblong that's down below and then back into the identify, document, problem, need, opportunity, situation, research feasibility and so on. We can keep cycling through that for the first three criteria. And although we lock in our determination of satisfactory completion and level of achievement for the criteria 1 through to 3 mid-year, we do expect that the students will revisit these concerns throughout the ongoing engagement with the School-assessed Task and show how things have changed with respect to their thinking as they've had to implement the plan.

Then we lead to planning, fabricating, integrating and producing the system. And then we've got timelines and sequences which will be adjusted, changed, challenged, components and materials list will change and be challenged because of production issues and so on. And production work itself that's recorded and again, they can re-evaluate, modify and document and then go through the process again. We could even go from plan, fabricate, integrate, produce the system and so on, re-evaluate, modify and document and pop up again in design and modelling the system. And we can pop in and out of aspects of the systems engineering process as it is necessary. Then we need to see evidence of testing, diagnosing and analysing the performance, making adjustments and repairs and modifications, and that require us to re-evaluate and modify and document and then go into the research again or into design and modelling or into re-planning how we're going to do things.

Then finally, the final stop is evaluate and report on the system produced and the processes used, looking for conclusions and recommendations for improvement, not just for the system itself, but the processes that we engaged with in developing plans and intentions to have the system work. The student may also comment on how they have become more independent throughout the process. Now, this all is subject to learning and teaching activities. So you need to develop learning and teaching activities where it is demonstrated that you are engaging with all of these aspects of the systems engineering process and you would model, how you would move from one aspect to another, and how sometimes you might revisit some aspects as an agile response to a design brief.

For further information in this regard, please contact the Curriculum Manager of Design and Technologies, Dr Leanne Compton. Her contact details are below.

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