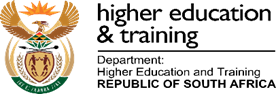
**Advanced Diploma**

**Technical and Vocational Teaching**

**Method of Teaching Automotive Repair and Maintenance**

(Engineering and Related Design Programme)

Department of Higher Education and Training

**Department of Higher Education and Training**

Advanced Diploma: Technical and Vocational Teaching

Module: How to teach in the Engineering and Related Design field

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(*SECTION BREAK*)

# Acronyms and Abbreviations

|  |  |
| --- | --- |
| Adv. Dip TVT | Advanced Diploma: Technical and Vocational Teaching |
| ARM | Automotive repair and maintenance |
| CT | Compression test |
| DHET | Department of Higher Education and Training |
| ICE | internal combustion engine |
| KWL | Know-want to know-learn |
| LTIFR | Lost time injury frequency rate |
| MCQs | Multiple choice questions |
| NCV | National Certificate Vocation |
| NOLS | National Open Learning System |
| OBD | onboard diagnostics |
| OHS | Occupational health and safety |
| OHS Act | Occupational Health and Safety Act |
| PPE | Personal protective equipment |
| TPCK | Technological pedagogical content knowledge |
| TVET | Technical and vocational education and training |
| ZPD | Zone of Proximal Development |

# Programme introduction

The Advanced Diploma in Technical and Vocational Teaching (Adv. Dip TVT) programme seeks to provide a structured professional learning pathway for current and aspirant technical and vocational lecturers/teachers. The Diploma will equip them with the knowledge and competences to implement and manage teaching and learning in their TVET colleges effectively and in alignment with national goals.

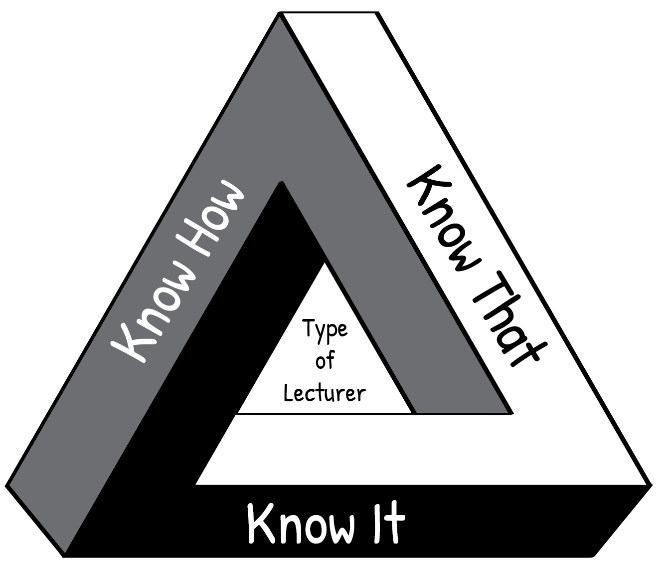
This module is one of a set of modules that contribute to the Advanced Diploma programme. The overall purpose of the Advanced Diploma is to engage lecturers working in the TVET sector in conversations about what it means to be a quality teacher in a TVET college. Each Module in the programme explores this from a different angle, but for every module the foundational concept is about the type of teacher you want to be. We all know that the relationship between teaching and learning is interrelated, so in order to understand the type of teacher you want to be you will need to engage with what learning means in a TVET context.

We often think about vocational and technical or craft knowledge as different from theoretical knowledge. However, there is increasing recognition of the power of vocational and theoretical knowledge coming together to develop the skilled craftsperson whether it is in plumbing, baking, even mathematics and physics. This integration of theory and vocational knowledge is equally important in teaching as well. Teachers are constantly needing to make informed decisions and judgements as they select what to teach and how best to teach the specific content, concept or skill.

This leads to a question about how different forms of knowledge and skill are brought together and balanced in the curriculum and in teaching and learning.

Approach to learning

To answer the question above in this diploma programme, a framework has been developed which is referred to as *know how*, *know it* and *know that*, or the HIT framework. This framework is introduced, referred to and deepened in different ways all the way through the programme.



**“Know How”** is *procedural knowledge*, “in our bodies” or *embodied knowledge*.

For example, following a bread recipe.

“**Know It**” is *recognition*, the knowledge of what counts as good; wisdom; technical and theoretical judgments.

For example, is this sourdough good quality bread?

**“Know That”** is *propositional knowledge* or

*theoretical knowledge*, the knowledge of how and why, *cognitive knowledge*.

For example, the science of bread baking.

**Figure i: The HIT framework**

Think about your own craft of teaching. The kind of teacher you want to be, is one who knows **how** (the techniques of teaching), knows **that** (the science and theory behind teaching AND learning) and knows *it* (knowing and reflecting on what makes a quality teacher). Such a teacher enables students to actively engage with their learning and to develop their full potential.

If you are interested, click on the link provided to watch a short [video](https://youtu.be/JssDzbjlYik) in which Wayne Hugo discusses the “HIT model” of TVET knowledge and learning.

Relating theory to practice

In this module new concepts are often introduced by developing them from a practical situation with which you are probably familiar. This process, which moves from your experience towards a more abstract level of theory is known as inductive learning. It makes learning easier and is very different from deductive learning, which starts by presenting abstract theories and principles, then requires you to “deduce” practical conclusions and concrete examples. You are encouraged to relate the ideas you learn from the Adv. Dip programme to your own context and to try to think theoretically about your practice. In other words, to think about the rationale for your practice.

Reflective practice and the use of a learning journal

One of the Adv. Dip TVT modules is called Reflective Practice, if you are interested, you can access it [here](https://oerafrica.org/system/files/13691/assets/13702/advdiptvtmodulereflective-practice.docx?file=1&type=node&id=13702&force=0) It covers the concept of reflection in the life of a TVET lecturer. Of particular importance is unit 2, which describes various models which facilitate reflection. The simplest reflective model that is discussed in this unit, is that of Terry Borton (1970). It consists of three steps as follows:

**Figure ii: Reflective model (after Borton, 1970)**

The three questions to prompt reflection leading to action:

1. What?

**What** happened? In this step you remember or describe the situation or event you have experienced.

1. So what?

**So,** if that happened**, what** does this show you or teach me?In this step you explore what new insights or knowledge the situation gives you.

1. Now what?

**Now** that I have learnt something new by reflecting on the situation, **what** should I do about it? In this step you think about what to do with the new awareness you have gained – i.e. how to make use of it to act more effectively in future situations.

Throughout the Adv. Dip TVT programme, you are encouraged to reflect on your practices at work in the college so that you can improve how teaching and learning takes place. We have embedded reflective practice throughout the programme, and at the end of most units in the modules you will find a reflective activity to complete. The reflective activity will enable you to make the most of what you have learnt throughout the unit, as well as assisting you to apply your learning in your workplace.

Use a learning journal

Throughout the Adv. Dip TVT modules, we encourage you to use a *learning journal*. You can download this digital template to use for your [learning journal](#_Appendix_1:_Learning). Save it where you can easily find it again. You can also use another template, or use a paper-based learning journal. You will use your learning journal to write notes and reflections and complete activities. Start your learning journal at the beginning of the programme, and keep it regularly updated throughout.

Active learning

Most learning theorists tell us that new understandings and learning depend on, and arise out of, *action*. All the modules in the Adv. Dip TVT programme include activities. Your learning will be more fruitful if you engage systematically with the activities. If you do not do the activities, you will miss out on the most important part of the programme learning pathway.

Thinking activities

At various points in the module you are asked to *stop and think* and to take some time to reflect on a particular issue. These *thought pauses* are designed to help you consolidate your understanding of a specific point *before* tackling the next section of the module. One of the habits many of us develop through a rote kind of learning is to rush through things. Work though each module slowly and thoughtfully. Read and think. This is how we develop a depth of understanding and become able to use the ideas we learn. Try to link the issues raised in each thought pause with what you have read, with what you have already learnt about learning, with your own previous experience, and so on. Think about the questions or problems raised in the module. Jot down your ideas in your learning journal so that you can be reminded of them at a later stage.

Linkages across modules

As you work through this and other modules, you will notice that topics or issues raised in one module may cross refer to the same issue or topic in another module, possibly in more detail. So for example, while there is an entire module dedicated to the investigation of *curriculum,* key issues related to curriculum will also be highlighted and discussed in a number of other modules including, modules dealing with pedagogy, psychology in TVET as well as in the method of teaching engineering and related design and electrical engineering modules.

Access to readings

There are links to readings throughout the activities. We have tried as far as possible to provide links to Open Educational Resources (OER). In cases where this was not possible you will be directed in the activity to access these through your university library. The website link is shown in the reference list.

Assessment

The activities contained in this module and the Adv. Dip TVT programme as a whole, promote a continuous and formative assessment process. This approach is intended to support your ability to relate ideas to practice and to contribute to your development as you work through the various modules of the programme.

You will also notice that each module includes a summative assessment task with the assessment criteria set out in an accompanying rubric. This summative assessment task is a model only, intended to illustrate the kind of assessment tasks that may be set by the university providing this programme.

# Module overview

## Module purpose

The purpose of this module is to equip the Technical and Vocational Education and Training (TVET) college lecturers with the knowledge, skills, and attitudes on how to effectively teach in the Engineering and Related Design field.

## Module outcomes

By the end of this module, you will have:

1. Demonstrate an understanding of concepts, methods, rules, and practices of a TVET subject or field to create appropriate learning opportunities for students.
2. Demonstrate an understanding of students, vocational education and training, learning, curriculum, and general instructional and assessment strategies.
3. Apply appropriate assessment methods for the TVET subject or field to ensure progress in learning.
4. Apply the technical and workplace knowledge and skills associated with the subject field or area to enhance teaching and learning.
5. Demonstrate an understanding of teaching practices across a variety of technical and vocational education and training contexts, including classroom and workshop/laboratory practice, and in authentic workplaces and simulated environments.

## Module structure

Figure 1: Module structure

## Module credits and learning time

This module is worth six credits, equivalent to 60 notional learning hours. It is expected that you will dedicate approximately 60 hours to successfully complete the module. This time will encompass various activities, including contact hours with your higher education institution, reading, research, and engaging in the module’s activities. Many of these activities will involve real-life application of the teaching methods you have learned.

During the module, you will be tasked with planning, preparing, and implementing activity-based automotive repair and maintenance (ARM) lessons. Afterward, you will reflect on the effectiveness of these lessons, identifying what worked well and identifying areas that may require strengthening. This reflective process will be an essential part of your learning experience.

# Unit 1: Health and Safety in Engineering Workshop Practice

## Introduction

The core business of Technical and Vocational Education and Training (TVET) colleges is to develop competent vocational and occupational professionals. In all professional practices, it is imperative that you are able to assess health and safety risks (hazards), prevent accidents, promote safety, and that you have the capacity to act appropriately in cases of accidents. It follows therefore, that it is critical for all teaching and learning processes at TVET colleges to be fully compliant with health and safety imperatives. Occupational health and safety (OHS) knowledge and skills development must be completely integrated within all aspects of the teaching and learning processes at the TVET colleges. All TVET lecturers and workshop facilitators must be competent to evaluate and mitigate potential health and safety problems that they face in learning situations and in work practices. Teaching and training OHS to TVET college students has particular requirements, stemming from the fact that young people are still developing physically, psychologically, and emotionally, and may therefore inherently pose various unique risk factors (Billorou & Sandoya, 2019). It is therefore important that as a TVET lecturer you are aware of and able to mitigate this additional challenge. For this reason, this module commences with the workshop practice and safety.

As the module unfolds, you will incrementally gain a deep understanding of the value of active learning and the need for lecturers to shift their teaching approach from transmission of content to a more active approach to teaching and learning. In the field of electrical and automotive engineering, this implies a practical, activity-based approach to teaching engineering content, including relevant OHS content and concepts. Research undertaken by various prominent learning theorists (Jean Paiget, Lev Vygotsky, and Yrjö Engeström) shows that people learn best by doing and engaging in activities that lead them to construct their own new knowledge and own understanding of the topic or subject. This approach is referred to as a *constructivist* approach to teaching and learning.

Unit 1 therefore starts with a discussion on the importance of understanding what prior knowledge and/or misconceptions students may have of any given topic; in this case, OHS content and concepts. We also stress the importance of designing lessons to support the students in constructing new knowledge by using their existing foundational understanding of a topic or subject. In this unit, we also start to explore an active approach to teaching and learning that promotes students’ understanding of OHS issues and that supports prevention practices alongside functional job-related skills. It is also important that OHS issues are not taught as separate from core engineering content, but rather that they are integrated and taught in a way that makes explicit connections with real-life (authentic) learning situations, linked to the workplace context.

## Unit 1 outcomes

By the end of this unit, you should be able to:

1. Evaluate students’ prior knowledge and misconceptions related to occupational health and safety in learning spaces and workshops.
2. Explain the purpose of the Occupational Health and Safety (OHS) Act and the consequences of non-compliance.
3. Prepare and teach the content and concepts of occupational health and safety using an activity-based approach to learning.

## The Occupational Health and Safety Act

The intent of the Occupational Health and Safety Act (OHSA) *Act No. 85 of 1993*is:

*…to provides for health and safety of persons at work and for health and safety of persons in connection with the use of plant and machinery; the protection of persons other than persons at work against hazards to health and safety arising out of or in connection with activities of persons at work; to establish an advisory council for occupational health and safety and to provide for matters connected therewith.*(Department of Labour, 1993)

In technical and vocational teaching, all stakeholders involved in teaching and related work need to understand that it is a priority to ensure that young people acquire, through appropriate training, including TVET programmes, the necessary knowledge, skills, and risk identification and prevention behaviours. Safety in the workplace is of utmost importance, and any injury incurred could bring production activities to an abrupt halt.

## The importance of appraising students’ prior knowledge and misconceptions

Before commencing any teaching and learning process, it is important that you understand what your students already know about the topic or subject area. This is true of any subject in the engineering curriculum.

Prior knowledge is the information that students already know in the subject area before new learning occurs. The role of the lecturer in teaching new knowledge in a lesson, or series of lessons, is to make sure that the student connects their existing knowledge with the new knowledge. In building a house, the new layer of bricks is placed on an existing layer. For the bricklayer to know how much mortar to apply on the existing layer, and how much pressure should be applied on the new brick, they must test and confirm the condition of the existing layer. Likewise, as a lecturer, before teaching new material you need to find out what every student already knows. Evaluating students’ prior knowledge benefits both the student and the lecturer in achieving the course outcomes.

While some prior knowledge that students bring to class will conform to current scientific ideas and theories, it is likely that students will also have misconceptions. Dealing with misconceptions will therefore also be discussed later in this section.

The specific focus of this section is on how to elicit students’ prior knowledge and misconceptions related to OHS in the engineering workshop and workplace environment.

## Evaluating prior knowledge related to occupational health and safety in learning spaces and workshops

Activity 1: Brainstorm and list techniques for eliciting students’ prior knowledge about OHS in the engineering workshop

**Suggested time:** **10 minutes**

If possible, spend ten minutes with a colleague (or on your own) brainstorming possible techniques and methods for eliciting students’ prior know about OHS in the engineering workshop.

Jot your ideas down in your [learning journal](#_Appendix_1:_Learning).

Discussion of the activity

There are several ways to elicit prior knowledge from students. How many ideas did you have? Did your list include using a quiz to find out what your students already know and understand about a particular topic?

In the next activity, we are going to explore this method in more detail.

Activity 2: Using multiple choice questions as a technique for eliciting students’ prior know about health and safety in the workplace

**Suggested time:** **60 minutes** (reading 20 minutes, quiz setting 40 minutes)

The purpose of this activity is for you to (re)familiarise yourself with OHS in the workplace, and to develop a quiz.

1. Skim through the complete document [Health and Safety in the Workplace](https://www.labour.gov.za/DocumentCenter/Publications/Occupational%20Health%20and%20Safety/What%20every%20worker%20should%20know%20about%20health%20and%20safety%20at%20work.pdf?platform=hootsuite) to remind yourself what workers should know about OHS.
2. Now refer to pages 7 to 10 of that document and create five multiple-choice questions (MCQs), each with one correct answer and three distractors (A–D) on the content from those pages. A distractor is an incorrect answer in an MCQ. Don’t use obviously wrong answers as distractors, as these won’t help you elicit prior knowledge. Indicate the correct answer for each question at the end of the quiz. The purpose of the quiz is for you to obtain a quick view of how much your students know about worker duties, worker rights, and health and safety representatives.
3. You can list the draft questions in your learning journal but try to print them out on paper too.
4. Try the quiz out on your fellow ADTVT students or your colleagues and improve the questions when you have seen their answers. This is an important step, as MCQs usually need to be refined so that they are clear and unambiguous.
5. If you are currently teaching at a TVET college, you could also try it with your students there. In your [learning journal](#learning_journal), summarise briefly what they know and don’t know about the content of the questions you asked.

Discussion of the activity

Keep the questions you have developed, as you may get a chance to use them with TVET students if you couldn’t carry out step 5. Even if you are familiar with the OHS Act, did skimming through the document remind you of aspects you might have forgotten?

You probably found that developing even a short quiz is quite demanding, as you not only have to find a useful question to ask, but you need to develop effective distractors. Good distractors include common errors people make, or misconceptions in the field, and they can help you determine aspects of the students’ prior knowledge. Here is an example of a MCQ that may be too obvious, and in that case would not elicit useful prior knowledge:

Which of the following is **not** one of the rights of a worker?

a. Access to health and safety rules and procedures of the workplace.

b. The right to participate in inspections

c. The right to comment on legislation

d. The right to remove a safety guard from a machine.

The (fairly obvious) answer is (d).

Using scenarios to evaluate prior knowledge and to teach about occupational health and safety

The rest of Unit 1 is structured as follows.

Firstly, we present two scenarios concerning *risk evaluation in the workplace*. Among the four key knowledge areas of OHS, it is expected that you will be able to extrapolate into the other three:

* *Workplace inspections and investigations*
* *Responsibilities of role players and stakeholders in OHS*
* *Enforcements and penalties*.

Activities are then formulated to explore and draw out and evaluate students’ prior knowledge, demystify misconceptions, and explain difficult concepts.

A second way of eliciting students’ prior knowledge is the use of scenarios to generate discussion and determine what students know from their answers. Complete Activity 3, which provides an example of a scenario you might use with your own students.

Activity 3: Using a scenario to evaluate prior knowledge and teach about OHS

**Suggested time:** **30 minutes**

The purpose of this activity is for you to develop a scenario for students to analyse so that you can identify their existing knowledge, as well as gaps in their understanding that may result in damage to equipment or machinery and/or put the student at risk of injury.

In this scenario, you ask your students to carry out a practical exercise, for example, how to safely jack up a car to change a tyre.

Write the scenario in your [learning journal](#learning_journal).

1. Write a paragraph or two describing the procedures that students should follow, to accomplish the task. Make some reference to possible risks and hazards related to the task, but do state what these are explicitly, as you want the students to identify the risks and hazards themselves.
2. At the end of the scenario, pose three to five questions that lead students to identify the potential OHS risks and hazards to look out for, and to suggest how to make the situation safe. Your questions should attempt to elicit students’ prior knowledge (including possible misconceptions).
3. Show the scenario and questions to your fellow ADTVT students or your colleagues and ask them for comment.
4. If you are currently teaching at a TVET college, you could set the activity for your students to answer. In your learning journal, summarise briefly what they know and don’t know about the content of the questions you asked, i.e., summarise their prior knowledge.

Discussion of the activity

As in Activity 2, keep the scenario and questions you have developed, as you may get a chance to use them with TVET students if you couldn’t carry out step 3. You might even be able to set up a practical situation in a workshop that simulates the scenario, and ask your students to answer your questions.

Were you able to write the description of the procedures to be followed, in a clear step-by-step manner, in the scenario of safely jacking up a car to change a tyre?

What sorts of key questions did you pose to check your students’ prior knowledge? Did you ask questions about:

* The nature of the surface on which the car is parked?
* The position of the gears and the handbrake?
* Reading the jack manual?
* Jack points?
* Using wheel chokes?
* Loosening the nuts?

Whether you provide your students with the written scenario to analyse or an actual physical demonstration, it is important to write down their answers. This will provide you with an impression of their prior knowledge and help you to identify possible misconceptions they may have about the content. You can then subsequently use your knowledge of your students to teach the topic more effectively.

In this short unit, we cannot describe all the ways in which a lecturer can draw out students’ prior knowledge. Many of you will already know ways of doing it, such as simple questioning, brainstorming and whole class or group discussions.

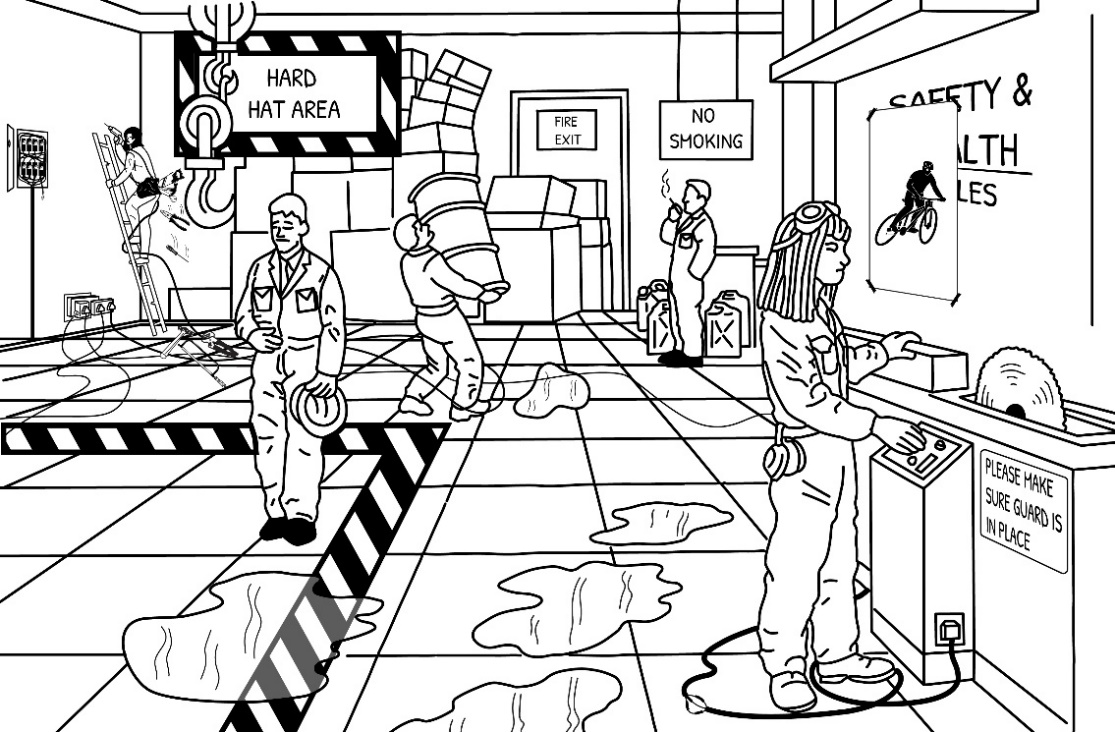
In Figure 2, an image of a scenario is provided. In Activity 4, you will think about how you can use such an image to elicit student understanding of unsafe behaviours in the workplace.

Activity 4: Using a visual image to elicit students’ understanding of unsafe behaviours in the workplace

**Suggested time:** **30 minutes**

The purpose of this activity is to select an appropriate image, and design a set of questions based on it that you can use to elicit student understanding of relate unsafe behaviours in the workplace; to relate workplace risks and hazards to the OHS Act.

Figure 2 shows various activities that may take place in a workshops or at a workplace. Analyse the image carefully, using the knowledge that you already have about safety and health requirements at workplaces.

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**Figure 2: What could possibly go wrong at a workplace? Source:** Redrawn from the internet.

After having carefully studied the image, develop a set of five to ten discussion questions that are directly related to the safety issues highlighted in Figure 2. Link each question to relevant sections/clauses in the OHS Act: <https://www.gov.za/sites/default/files/gcis_document/201409/act85of1993.pdf>

Write the questions in your learning journal together with the appropriate reference to the OHS Act. When developing each question, you should provide a clear solution to ensure that safety is adhered to. If possible, share the questions and solutions with your colleagues for their views.

Discussion of the activity

Issues of safety in the workplace are of paramount importance. You cannot start operations in any workplace before ensuring that safety is in place. What kinds of questions did you set for your students?

Figure 2 depicts various issues, for example:

* Free walking spaces should always be in place and marked as such.
* Workstations should be identified and isolated.
* Storage practices and cabling should be safe.
* Discarded material and wet floors are unsafe practices, amongst others.
* Equipment such as ladders and hoists must be used safely.
* There should be strict guidelines around handling heavy weights manually.
* Tools should be cared for.
* Surfaces should be clean.
* Appropriate Personal Protective Equipment (PPE) should be supplied and worn.

Was there anything else that you thought of? If you get a chance to discuss the questions with your own students, ask them to identify all the unsafe practices they can see in the image.

## Evaluating students’ misconceptions related to occupational health and safety

Stop and Think

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| A misconception is a view or opinion that is incorrect because it is based on [faulty](https://www.google.com/search?sxsrf=APwXEdd9kBwkf_-cRIF4bPyHB03jYZSLgQ:1685366244371&q=faulty&si=AMnBZoEP2YukYW07_nAjizsjQPEksc58cJ_QCDhb4PzI-z5qYi0xdeR0jlxqWN-zV3qXt3wy_toSE3D5isNKVMKSTqoNtQDlgA%3D%3D&expnd=1) thinking or understanding.  It is likely that, as lecturers uncover students’ prior knowledge, misconceptions will also be revealed. |

The importance of uncovering students’ prior knowledge and misconceptions is that the lecturer then knows where to start when introducing a topic or where to focus students’ efforts when teaching the content.

As lecturers, we need to be aware of common misconceptions that students may bring to engineering classes. We can then plan our lessons and workshops to ensure that students can reinforce their correct preconceptions and understand why their erroneous conceptions are incorrect. Replacing misconceptions with correct understandings is not always easy, as sometimes the errors are deeply held. We therefore need to have techniques and strategies to both appraise students’ prior knowledge and to anticipate possible misconceptions, and then to address them. Having insight into what students already know and/or have misconceptions about will assist with planning content sequence and structure, and with scaffolding (a concept that will be explored later in Unit 2).

When evaluating students’ misconceptions, several techniques can be employed. Here are some examples:

**Use an anticipation guide:** This instructional tool/technique is used to activate students’ prior knowledge and/or misconceptions, to engage them in the learning process, and to stimulate their critical thinking skills. It is typically used before reading a text, starting a new topic, or introducing a lesson. This technique will be further explored in the next activity.

**Administer a conceptual test:** This is an effective technique to identify misconceptions. These tests typically present students with MCQs that require understanding of fundamental concepts. By analysing the responses, instructors can identify common misconceptions held by students.

**Administer questionnaires and surveys:** Designing questionnaires and surveys specifically targeted at probing misconceptions can help gather valuable insights. These can be distributed to students to assess their understanding of specific topics or concepts, allowing instructors to identify any prevalent misconceptions.

**Ask students to draw a concept map:** A concept map visually represents the relationships and connections between various concepts or ideas. It is a graphical tool that helps to organise and structure knowledge in a meaningful way and can assist in identifying any gaps or misconceptions. By examining students’ concept maps, lecturers/facilitators can identify incorrect connections or conceptual gaps, which indicate misconceptions. This technique is further explored later in this unit.

**Set practical workshop tasks:** In automotive repair and maintenance (ARM), workshop practice can be used to assess students’ practical understanding and identify any misconceptions related to underlying principles. For example, observing students conducting troubleshooting, analysing data, and discussing results can help uncover misconceptions they may hold.

**Implement a diagnostic assessment:** Ask questions about key concepts and get students to work out answers in pairs and then report back to the whole class. Follow this by facilitating a whole class discussion of the explanation provided, asking the students to diagnose or analyse whether the content reported on is correct or whether there are any misconceptions.

**Implement a formative assessment:** Regular formative assessments, such as quizzes or short assignments, can help identify misconceptions as they arise during the learning process. By providing immediate feedback and addressing misconceptions early on, instructors can prevent them from persisting and becoming entrenched. For more information, see: <https://www1.curriculum.edu.au/sciencepd/teacher/assessment/resr_electricity.htm>

Remember that creating a supportive and non-judgmental learning environment is crucial when evaluating students’ misconceptions. It allows students to feel comfortable in expressing their ideas and enables instructors to effectively address and correct any misconceptions that arise.

In the following section we will explore two possible techniques for evaluating student’s misconceptions in more detail.

### Using an *anticipation guide* to evaluate students’ misconceptions

An anticipation guide consists of a list of statements or questions related to the upcoming content. These statements are designed to challenge students’ assumptions, provoke discussion, and generate interest in the topic. The statements can be either true or false, or they can require a more nuanced response.

As stated above, an *anticipation guide* is a tool to activate students’ prior knowledge and/or misconceptions and to engage them in the learning process. The lecturer provides students with the anticipation guide before they start a new topic (whether you are introducing it through discussion, a lecture or a related text from a study guide or textbook). The statements in the anticipation guide are based on key concepts, themes, or ideas that will be covered in the discussion/lecture/reading. In this instance, we would choose a text related to OHS. An example of an anticipation guide is provided in Table 1 (in Activity 5a), and a reflective approach to using it is described below.

1. *Individual response:* Students read each statement and individually indicate whether they agree or disagree, often using a simple response format such as ‘A’ for agree and ‘D’ for disagree. They are encouraged to provide brief explanations for their choices.
2. *Discussion:* Once students have completed their individual responses, the lecturer facilitates a class discussion. Students share their opinions and reasons for their choices and engage in debates about the statements. This encourages critical thinking and helps activate their prior knowledge.
3. *Text exploration:* After the discussion, students read the assigned text or engage in the lesson related to the topic. They actively seek information that confirms or challenges their initial responses in the anticipation guide.
4. *Post-reading reflection:* After completing the reading or lesson, students revisit the anticipation guide and reconsider their initial responses. They compare their initial thoughts with what they have learned, revising their positions if necessary. This reflection encourages metacognition and helps reinforce their understanding of the topic.

By using anticipation guides, lecturers can assess students’ misconceptions, foster engagement, build curiosity, and create a framework for active learning. It encourages students to take ownership of their learning, develop critical thinking skills, and make connections between their existing knowledge and new information.

The following two activities (5a and 5b) provide an opportunity for you to use an anticipation guide to identify and address students’ misconceptions related to OHS.

Activity 5a: Use an anticipation guide to evaluate students’ misconceptions on occupational health and safety

**Suggested time:** **30 minutes**

The purpose of this activity is to learn how to evaluate students’ misconceptions using an anticipation guide.

One way of approaching the preparation of an anticipation guide is to provide students with a set of statements based on common misconceptions about any topic in engineering – in this case, OHS – to discuss or critique.

If you have been lecturing in a TVET college for some time, you are likely to have a good idea about the kinds of misconceptions that students typically have about OHS in TVET workshops and workplaces. If you are new to teaching in a TVET college, you will need to give some careful thought to issues that students may have misconceptions about. You could also research the topic on the internet and see what research has been done.

Use Microsoft Word or any other computer software to draw up a table like Table 1 below. Include the three misconceptions that appear in the middle column (statement column) in your table.

Then think of four more possible misconceptions related to OHS that your students may have and add them to the middle column. Ideally, your questions should not be too generic, but should relate to an aspect of safety in the engineering workshop context. Think about safety in relation to work processes, tools, equipment, machinery, etc. that your students are required to use during ARM workshop practical sessions.

If possible, print out and make copies of your anticipation guide and test it, to see how it works. Do this *before* your planned lecture or workshop session.

After handing out copies of your anticipation guide to your students, ask them to work in pairs and to fill in the first column: they should indicate whether they agree or disagree with each statement in the middle column.

Once your students have completed this short task, ask them to write their names on the anticipation guide and to hand it back to you.

**Table 1: Anticipation guide on evaluating misconceptions in OHS**

**Student’s first name and surname:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Before class | | Statement | After class | | Reason |
| Agree | **Disagree** | **Agree** | **Disagree** | **Why?** |
|  |  | 1. A completely hazard-free workplace is impossible. |  |  |  |
|  |  | 1. OHS is just common sense. |  |  |  |
|  |  | 1. Some accidents are beyond our control and can just happen. |  |  |  |
|  |  |  |  |  |  |
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|  |  |  |  |  |  |

Take some time to carefully review and analyse your students’ responses. Make notes for yourself, in which you record which students have misconceptions and which specific misconceptions they have. Also note which students do not have any misconceptions.

Discussion of the activity

Were you able to prepare and administer an anticipation guide to one or more of your classes? If so, we hope that this activity has helped you to get a better understanding of the misconceptions that your students have about OHS matters. Having identified the misconceptions that some or all students have and the knowledge gaps that have caused the students to hold these misconceptions, you can plan how best to address these misconceptions in your next lesson or workshop session.

Activity 5b: Plan and implement an activity-based lesson to address the misconceptions related to OHS that were identified through using an anticipation guide

**Suggested time:** **60 minutes**

The purpose of this activity is to implement a lesson in which students’ misconceptions that were identified by using an anticipation guide are addressed.

The steps below are intended to guide your planning:

1. Start by dividing your class into small groups and explain what the purpose of the lesson is and how the lesson will be structured.
2. Give each group one misconception to discuss and challenge them to explain and give reasons for why their misconception is incorrect. Each group needs to elect one student to write down the group’s explanation of why the misconception is incorrect and one student to report back to the whole class.
3. Invite each group to report back to the whole class on the misconception that they discussed.
4. After each group report back, you should facilitate a whole class discussion in which you achieve consensus on why the misconception discussed is incorrect.
5. Give each student the anticipation guide that they initially filled in. Request them to now complete the information in the three last columns on the right-hand side of the guide (see Table 1, above).

Think carefully about how much time to allocate for each component of the lesson. Here is a rough guide:

* Lesson introduction: 5 minutes
* Group discussions: 10 minutes
* Group feedback: 15 minutes
* Whole class discussion on group feedback and consensus-making on each item: 20 minutes
* Students individually complete the anticipation guide: 10 minutes
* Total 60 minutes

**NOTE:** To support your planning and preparation for this lesson, we have included a list of nine commonly held misconceptions – see below. The first three echo the first three statements in Table 1. You can draw on this content when you facilitate the whole class discussion.

**Misconception #1:** *A completely hazard-free workplace is impossible.*

You may imagine that at least a few workplace injuries are inevitable, because predicting every outcome of every action taken doesn’t seem realistic (or likely). But this attitude could lead to completely preventable accidents occurring. You can achieve a hazard-free workplace, but it requires consistent discipline and dedication to recognise and mitigate every hazard.

To recognise hazards and control them, you and your workforce need to be situationally aware of both the hazards and the sources of these hazards:

• Energy

• Environment

• Equipment

• Employees (untrained people and those unwilling to behave safely).

Beyond this there must also be a universal willingness among all employees to take action to mitigate hazards.

**Misconception #2:** *OHS is just common sense.*

Actually, no. Although avoiding workplace injuries is possibly near the top of everybody’s agenda, a lack of knowledge can spoil even the best of intentions.

Employees perform tasks dangerously, either because they don’t realise their behaviour is unsafe, or because they believe they may gain a payoff beyond the results of safe practices.

If you’re an employer it is your duty to regularly address safety, and this means providing adequate safety training for all employees, as often as they require it.

**Misconception #3:** *Some accidents are beyond our control and can just happen.*

If you have a fatalistic view of the world, this will take away your personal power. Each individual worker has a great deal of power and control over the circumstances and situations around them. You and your colleagues (or employees) must understand the importance of knowing how to prevent personal injuries.

When you conduct a job briefing, you can reduce your risk by taking time to identify any hazards, then mitigating and controlling them. When you begin with the belief that you have no control, you will likely miss a hazard and, in turn, miss preparing yourself to prevent every injury. Engagement in hazard recognition and the control process for these is the key to preventing injury.

**Misconception #4:** *Workplace health and safety costs too much time and money.*

Costs are unavoidable – you will have to spend some money implementing the safety measures necessary to uphold your workplace health and safety policies, such as training, equipment, and upgrading environmental elements. Of course, no company has an unlimited supply of time or money but investing a little to prevent injuries and reduce risks will save you a lot more in the long run. The expenses you could incur to deal with a workplace injury or illness could end up being very significant and are often greater than the cost of preventative measures.

When you’re deciding on which safety expenditures are essential, stop and consider the direct and indirect costs of even a minor injury. Add it up:

• Lost time of the injured, **+**

• Lost time required by others to attend to the injured, **+**

• Medical costs that can amount to thousands for a ‘simple’ injury.

**Misconception #5:** *People are the only cause of accidents.*

This is not to say people don’t play a substantial role when accidents occur, but too often an unnecessary amount of blame is attributed to the people involved in an incident, with scant attention paid to contributing mechanical or environmental factors. Although there are situations where it is appropriate to blame an individual for an error, this is only appropriate when it leads to future change.

**Misconception #6:** *Wrongdoers must be punished.*

We’re not saying people who have behaved unsafely (leading to an accident) should not be held accountable for their actions. But workers who know that they are bound to be punished for every tiny infringement are likely to take steps to avoid punishment (such as hiding the error), making it harder to enforce safety measures. Numerous studies have shown that conventional methods of punishment applied across the board have not been effective in improving safety after an incident has occurred. Rather, consider a range of reprimands to apply to each unique situation.

**Misconception #7:** *It can’t happen to me.*

This is often merely an excuse for not acting. Ensure every person within your workplace is completely aware of the possible risks and how to manage and/or prevent them.

**Misconception #8:** *Relying solely on the ‘lost time injury frequency rate’ (LTIFR) will give you a comprehensive and reliable measure of the company’s safety performance.*

Sadly, this is not always true. For example, it’s great if you’ve driven the LTIFR down to a fraction of what it once was, but how hard should you pat yourself on the back if in just one workplace incident, 11 people were killed?

Unfortunately, the LTIFR can trivialise serious personal damage. Use it, but not in isolation from any other measuring methods at your disposal.

NB: LTIFR refers to the amount or number of lost time injuries, that is, injuries that occurred in the workplace, which resulted in an employee’s inability to work the next full workday. It is calculated according to the number that occurred relative to the total number of hours worked in the accounting period. In many countries, the figure is typically calculated per one million hours worked.

**Misconception #9:** *Safety procedures are the answer.*

A common mistake with safety management systems is they include extensive safety procedures – but workers do not know about them, care about them, or use them! The procedures sit on the supervisor’s bookcase or a computer programme, with no one referring to them (or doing so on very rare occasions).

How do you approach the teaching of OHS issues?

Discussion of the activity

Did you find the steps provided in Activity 5b helped you to plan your lesson? Did you find the suggested time for each lesson step/component useful, or will you need to adjust the timing in the future? It is important to always spend a few minutes at the end of each lesson thinking about what went well and what may need to be done differently the next time you give a similar lesson. This kind of reflection helps to strengthen and professionalise teaching practice.

In their small group discussions, were students able to construct their own understanding of why each misconception was incorrect? It is important to provide students with an opportunity to think about problems and actively build their own knowledge, through focused interaction with peers. The whole class discussion provides the opportunity for you to mediate the discussion and help your students to consolidate new content knowledge and their learning in this field.

In Activities 5a and 5b, you used an anticipation guide to address misconceptions about OHS, but remember that you can use the guide to address misconceptions related to any other aspect of TVET engineering curricula, no matter whether part of the National Accredited Technical Education Diploma (NATED) or the National Certificate Vocational (NCV) programmes.

## Concept maps: Consolidating and linking new learning in relation to occupational health and safety

For students to consolidate and apply new learning it is important that they can make connections and links between various concepts or ideas.

In the section above, concept maps are listed as a possible technique for evaluating students’ misconceptions. This technique can also be used as a method of students consolidating what they have learnt by representing it in a visual summary to reinforce learning.

**What is a concept map?** A concept map is a visual representation (drawing or diagram) of the relationships and connections between concepts or ideas. It is a graphical tool that helps to organise and structure knowledge in a meaningful way. Concept maps are a useful way of promoting active learning by encouraging students to organise and link their knowledge. They help students to identify the main concepts, their relationships, and the hierarchy of information, making it easier to grasp and remember.

Stop and Think

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| Concept maps enable individuals to see the big picture, make connections, and gain a deeper understanding of complex ideas and relationships. |

The following activity has two interrelated parts: in Activity 6a you will prepare a concept map, then, in Activity 6b, you will set the same task for your students to complete.

Activity 6a: Prepare concept maps related to OHS

**Suggested time:** **30 minutes**

In this activity you will prepare one concept map that visually depicts reasons for OHS regulations and another that depicts the consequences of not complying with OHS regulations.

1. Your concept map should answer the question: What is the overall purpose of OHS regulations? Start by identifying key reason/primary goal for these regulations. Then think of all the related reasons/goals. You may want to brainstorm these with a colleague. Jot them down in your learning journal.
2. Think about how you would like to present this information visually/graphically.

* In what order will you present the information? How will you show a sequence or hierarchy of ideas?
* How will you show the relationships/connections between ideas?

1. Use the smart art graphic function in MS Word (or any other digital application or suitable software) to generate a hierarchical block list like in the example below; or simply use a pencil to draw a diagram in your learning journal.
2. Refer to the example in Figure 3, below, to help you to design your concept map to summarise key concepts showing the purpose of OHS regulations.

**Figure 3: Example to follow to start designing a concept map showing the purpose of OHS regulations**

1. Prepare another similar concept map, this time showing the consequences of not complying with OHS regulations.
2. Refer to the example in Figure 4, below, to help you to design your second concept map.

**Figure 4: Example to follow to start designing a concept map showing the consequences of not complying with OHS regulations**

Discussion of the activity

**1. Concept map showing the purpose of OHS regulations and role players responsibilities**

When you started planning how to present the information in a concept map, did you start by jotting down what the *overall purpose* of OHS regulations is? The overall purpose or primary goal that needs to be highlighted in this concept map is *to create a safe and healthy work environment*.

Branching out from the overall purpose are two key concepts: the OHS regulations aim to protect or *safeguard employees* from workplace hazards, injuries, and illnesses; andat the same time to *promote employer responsibility* to provide a safe workplace and comply with the regulations.

Then, branching from the need to safeguard employees are the objectives to minimise and*prevent workplace accidents*;and to*ensure the physical and mental well-being of workers* by focusing on *reducing the occurrence of work-related injuries and illnesses* by providing a*dequate safety equipment and resource*s to safeguard employee health and well-being.

Under promoting employer responsibility, objectives are for employers to*implement and enforce safety policies* *and procedures*; and to *maintain compliance with safety standards* by highlighting the need *for employee training and education*regarding safe work practices, and *conducting regular inspections* to identify and address potential hazards or non-compliance.

Figure 5 provides an example of this concept map, highlighting the key objectives and how they are linked to each other.

The concept map thus demonstrates how OHS regulations encompass various objectives aimed at ensuring a safe and healthy work environment for employees, while promoting employer responsibility and maintaining compliance with the regulations.

**Figure 5: Example of a completed concept map that shows the purpose of OHS regulations**

**2. Concept map depicting the consequences of not complying with OHS regulations**

Assess your concept map thatshows the consequences of not complying with OHS regulations. As in the concept map setting out the *purpose* of OHS regulations, the *consequence of non-compliance* concept map is also structured aroundtwo main branches: *employees* and *employers.*

The two branches coming from the non-compliance concept map emphasise *legal consequences* for the organisation and the *human cost.*

The legal consequences of non-compliance for the company organisation include:

* *fines and penalties* administered by the Inspections and Enforcement Services Branch: Occupational Health and Safety of the Department of Labour
* in severe cases*, criminal charges for negligence* or wilful violations of OHS regulations
* *legal claims from affected employees*or their families, which can result in negative publicity and damage the reputation of the organisation.

The human costsresulting from non-compliance are the potential harms to and impacts on individuals. This includes the increased risk of workplace injuries and illnesses for employees, which can have a significant emotional and physical toll on affected employees and their families. In extreme cases, failure to comply with safety regulations can result in fatal accidents or incidents.

Figure 6 provides an example concept map showing the consequences of not complying with OHS regulations. It demonstrates that non-compliance has consequences that extend beyond legal penalties. Non-compliance can result in financial costs, criminal liability, lawsuits, reputational damage, harm to employees, and even loss of life. The concept map highlights the importance of adhering to these regulations to ensure the safety and well-being of employees and the sustainability of the organisation.

Compare Figure 5 with your concept map. Are there elements in this example that you not have included? Conversely, have you identified any important elements that have not been included in Figure 5?

**Figure 6: Example of a completed concept map that shows the consequences of not complying with OHS regulations**

Now that you have had practice in designing and preparing concept maps, the next step is to put into practice with your students what you have learnt. As mentioned above, preparing a concept map is a technique for supporting students to summarise their understanding of a particular topic or issue in a concise manner. It is also an opportunity for you and your students to apply what has been learnt.

For lecturers, this is an opportunity to plan and implement another activity-based lesson to support your students to consolidate their learning related to OHS. Also, as stated above, concept maps are useful teaching tools for identifying gaps or misconceptions.

For students this is an opportunity to learn a new study skill, i.e., a technique for summarising key concepts.

Activity 6b: Use concept maps as a teaching and learning tool: Support students to consolidate knowledge.

**Suggested time:** **90 minutes** (30 minutes preparation and 60 minutes lesson)

The purpose of this activity is to provide lecturers with the opportunity to implement a lesson in which their students design and use a concept map as a tool to consolidate their own learning.

1. Prepare a [lesson plan](#Lesson_Plan_Template) refer to the linked template. Ensure to include the following aspects:
   1. **Topic:** Prepare a concept map that shows the purpose of OHS regulations
   2. **Lesson purpose/objectives or outcomes:** What should your students be able to know and do at the end of the lesson?
   3. **Method:** Decide how students will prepare their concept maps. Will they use pencil and paper or will they do it on a computer in the college computer lab?
   4. **Resources:** List and prepare any resources that you may need for this lesson.
   5. **Lesson steps/processes – teaching:** What will you do first? How will you introduce the topic? Do you need to remind/recap any OHS content first? What new content – knowledge and skills – will you cover? Explain what a concept map is, what concept maps are used for, and how to go about designing or constructing a concept map.
   6. **Lesson steps/processes – learning:** **What will your students do?** Describe the learning activity that students will undertake, i.e., the steps that students need to follow to complete the concept mapping activity.
   7. **Consolidation:** Once all students have completed the task, ask them to share their work and facilitate a class discussion to confirm the key concepts.

Discussion of the activity

Did preparing your own concept map before teaching this lesson help you in your planning and teaching?

Did you discuss the *purpose* of a concept map with your students? Did your discussion include explaining that concept maps are used to visually represent the relationships and connections between various concepts or ideas? A concept map is a graphical tool that helps to organise and structure knowledge in a meaningful way.

Concept maps can be used for a variety of purposes, including understanding and learning.

* They promote active learning by encouraging students to organise and link their knowledge.
* They help students to identify the main concepts, their relationships, and the hierarchy of information.
* They are also an assessment tool to evaluate students’ understanding and knowledge. They allow for the identification of gaps or misconceptions in understanding.

In discussion at the end of the lesson with your students, did you ask your students to summarise their key learnings from the concept mapping activity? It is always a good idea to get your students to reflect on new content and skills, as this is a way of reinforcing new learning.

## Conclusion

The purpose of the OHS Act is to promote and maintain safe and healthy working conditions in the workplace. It sets out the rights and responsibilities of employers, supervisors, and workers to ensure the protection of their health and safety. The act applies to most workplaces and industries, aiming to prevent accidents, injuries, and occupational illnesses.

Complying with the OHS Act is crucial, to ensure the well-being of workers, avoid legal consequences, protect the organisation’s reputation, and maintain a productive work environment. It is essential for employers to prioritise workplace safety, implement necessary safety measures, provide adequate training, and regularly assess and address potential hazards to maintain compliance with OHS regulations.

As a TVET lecturer/facilitator, it is important to ensure that your students acquire the necessary knowledge and skills to identify risks and present behaviours required to operate safely in college workshops and eventually in the workplace. This requires that OHS concepts and content are well integrated into all engineering programmes. To do this well, lecturers need to intentionally employ teaching methodologies and techniques that are tried and tested and that are known to support learning. These include eliciting and building on student’s prior knowledge; identifying misconceptions (if any exist); and engaging students in active learning by promoting a practical approach to learning about health and safety, that allows students to develop prevention practices alongside functional job-related skills.

# Unit 2: The Pedagogy of Automotive Repair and Maintenance

## Introduction

Pedagogy refers to the theory and teaching practices or methods that are implemented to promote learning. In this module the focus is on how knowledge and skills in the field of automotive repair and maintenance (ARM) are imparted to students in the TVET college context.

Unit 2 centres on the theory of how people learn and thus delves into teaching methods that align with and support effective learning. The emphasis is on active learning and careful scaffolding of new learning content, achieved by designing lessons that systematically build upon each other, creating a coherent learning pathway. The significance of building upon students’ prior knowledge, identifying and addressing misconceptions, and breaking down complex concepts into manageable parts is also discussed.

## Unit 2 outcomes

By the end of this unit, you should be able to:

* Understand and apply approaches to teaching in automotive repair and maintenance that are underpinned by the science and theory of teaching and learning.
* Evaluate and build on students’ prior knowledge and conceptions and explain misconceptions in automotive repair and maintenance.
* Select and apply appropriate teaching methods, strategies, and multimedia to support quality teaching and learning in ARM.

## How do people learn?

While many lecturers are experts in their field, very few have been trained in education theory and design. In this section, you are invited to think about the effectiveness of the education we offer our students. Are there things we could do differently in our classroom and workshops to support our students to succeed?

The past quarter century has been a period of major advances in understanding about learning processes, learning environments, teaching, sociocultural processes, and the many other factors that contribute to learning.

Research related to how people learn points to the fact that we learn best by doing *authentic* (real, believable) tasks in a *socially interactive* (collaboratively with peers) context (Jean Piaget, Lev Vygotsky, Yrjö Engeström).

In particular, the work of Lev Vygotsky (1896–1934) has become the foundation of much research and theory in cognitive development over the past several decades. Vygotsky argued that it is important that *students construct knowledge*, rather than just passively take in information. As people experience the world and reflect upon those experiences, they build their own representations and incorporate new information into their pre-existing knowledge. This approach to learning is called **constructivism.**

Many subsequent learning theorists and educational practitioners elaborated on the theory of constructivism and on what it means in practice.

According to the cognitive research covered in How People Learn (National Research Council, 1999), environments that best promote learning have four interdependent aspects: they focus on students, well-organised knowledge, ongoing assessment for understanding, and community support and challenge.

**1. Learner-centred:** Learner-centred environments pay careful attention to the knowledge, skills, attitudes, and beliefs that students bring to the educational setting. Lecturers must realise that*new knowledge is built on existing knowledge*– students are not blank slates. Therefore, **lecturers need to uncover the incomplete understandings, false beliefs, and naïve renditions of concepts that students have when they begin a course**. If these are ignored, students may develop understandings that are very different from what the lecturer intends them to gain. This adds to what has already been stated: that every lecturer should gauge the students prior learning to know how much they know and deal with misconceptions, especially in the field of ARM.

**2. Knowledge-centred:** Knowledge-centred environments take seriously the need to help students learn the well-organised bodies of knowledge that support understanding and adaptive expertise. **Lecturers need to point their students directly towards clear learning goals by *explaining the purpose and outcomes of the topic and discussing how students can use that knowledge***. In addition, a strong foundational structure of basic concepts will give students a solid base on which to build further learning. Understanding students’ gaps in the field of ARM makes it clear what needs to be taught or demonstrated.

**3. Assessment-centred:** Assessment-centred environments provide frequent formal and informal opportunities for feedback that is focused on understanding, not memorisation. The goal is to encourage and reward meaningful learning. Feedback is fundamental to learning, but feedback opportunities are often too scarce in classrooms. Students may receive grades on tests and essays, but these are summative assessments that occur at the end of projects. **What is needed are opportunities for the students to undertake *authentic activities in which they apply their knowledge and are informally assessed*. This kind of formative assessment provides students with opportunities to revise and improve the quality of their thinking and understanding**. The goal is for students to gain meta-cognitive understanding (awareness and understanding of one’s own thought processes) – the ability to self-assess, reflect, and rethink for better understanding. This is achieved by applying a problem-based learning approach, in which students learn about a subject by working in groups to solve an open-ended problem. The problem drives the motivation and the learning. In turn, the lecturer has a good opportunity to observe and assess what the students know and understand and what they are still struggling with. The lecturer can then determine how best to mediate or intervene. In the ARM context, provide opportunities for students to actively engage in the learning experience by letting them work through difficult concepts collaboratively.

**4. Community-centred:** Community-centred environments foster norms for **people to learn from one another, and to continually attempt to improve.** In such a community, students are encouraged to be active, constructive participants, working collaboratively with peers. Further, mistakes are not judged; students are encouraged to learn from any mistakes they make. Intellectual camaraderie fosters support, challenge, and collaboration.

The development and retention of new knowledge depends in large part on the relationship between what one is learning and what one already knows. Because novices in a field typically don’t know much of the content in that field, they have little to which they can relate the things they’re attempting to learn. So, they retain less. This is why it is important the lecturer to link the new content knowledge to the student’s lived experience and context. Making knowledge relevant helps people to go beyond the information given and to think in problem representations, engage in the mental work of making inferences, and relate various kinds of information for the purpose of drawing conclusions. It is therefore important that the lecturer sequences and scaffolds teaching activities to help the students to construct their own knowledge and understanding of ARM, as well as to reconstruct their misconceptions about various concepts in ARM field.

In conclusion, constructivists are interested in the way that people engage in certain kinds of actions that lead them to construct their own new knowledge. It becomes an active rather than a passive conception of knowledge. The constructivist answer to the question, *How is it possible for somebody to come to learn something new?* is that people start engaging in action related to something new, even without understanding it. Then, if that action is facilitated or mediated, the person will begin to understand and reflect on their own actions and in that way start to internalise their learning.

Stop and Think

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| Constructivists argue that people don’t learn something by being told about it. They engage in a genuine activity, reflect on what they are doing, think back about what they have done, and learn something from it. |

In the following activity, you will have the opportunity to think more about the value of active learning and to think about the value that active learning might add to your own teaching in ARM.

Activity 7: Apply understanding of active learning in the context of ARM

**Suggested time: 45 minutes**

In this activity, you will apply your understanding of the principles and concepts of active learning to teaching new content knowledge in ARM.

In your learning journal, write a comprehensive explanation of the key benefits of active learning and hands-on experiences in relation to ARM. You should cover the following aspects:

* Practical application
* Skill development
* Problem-solving abilities
* Confidence building
* Real-world exposure
* Enhanced retention and engagement

Discussion of the activity

*Practical application:* Active learning allows the ARM student to apply their theoretical knowledge in real-world scenarios. Instead of relying solely on textbooks or lecturers, hands-on experiences enable them to gain practical skills by working with actual motorcars. This practical application helps to bridge the gap between theory and practice, enhancing their understanding of automotive systems.

*Skill development:* Working in the field of ARM requires a wide range of technical skills, such as engine repair, electrical system troubleshooting, brake maintenance, and more. Hands-on experiences provide opportunities to develop and refine these skills through actual practice. By actively working on vehicles, aspiring automotive mechanics learn how to handle tools, diagnose problems, make repairs, and perform maintenance tasks effectively.

*Problem-solving abilities:* Hands-on experiences cultivate problem-solving abilities, which are crucial for an automotive mechanic. As they encounter various issues while working on vehicles, students are compelled to think critically, analyse symptoms, and identify the root causes of problems. This process fosters their ability to troubleshoot and devise appropriate solutions, honing their problem-solving skills.

*Confidence building:* Hands-on experiences provide students with a sense of accomplishment and build confidence in their abilities. As they successfully diagnose and repair vehicles, their confidence grows, and they become more self-assured in their technical skills. This confidence is essential for an automotive mechanic to tackle challenges and approach their work with competence and professionalism.

*Real-world exposure:* Active learning in a practical setting exposes students in ARM to real-world scenarios they will encounter in their careers. They gain insights into the challenges, complexities, and demands of the automotive industry. This exposure helps them develop a realistic understanding of their future profession, preparing them for the expectations and requirements of the job.

*Enhanced retention and engagement:* Hands-on experiences promote active engagement, which enhances learning and knowledge retention. When students actively participate in tasks, manipulate components, and observe the outcomes of their actions, they are more likely to remember the concepts and retain the information for longer periods. This practical engagement makes the learning process more meaningful and memorable.

In summary, active learning and hands-on experiences are integral to learning how to be an automotive mechanic. Active learning and hands-on experiences provide practical application, skill development, problem-solving abilities, adaptability, confidence building, real-world exposure, and enhanced retention and engagement. By incorporating these approaches into their education and training, aspiring automotive mechanics can gain the practical skills and knowledge necessary to excel in their profession.

In the section that follows, we will explore how our understanding of *how people learn* translates into how we should approach *teaching*.

## Approaches to teaching that promote learning.

Good teaching – including the development of the students’ attributes – is the single most significant factor impacting students’ technical and vocational performance and personal growth in the ARM field, that a college can influence(adapted from Meyer & Land, 2003). Successful colleges, college education, and training systems, develop and nurture highly skilled lecturers, encouraging them to work professionally in a creative and collaborative culture.

While it is important to stress that there is no single recipe for excellent teaching, there is a growing, evidence-based consensus that a certain number of powerful practices and approaches help students fulfil their potential, and prepare them for modern life and the world of work. *Understanding cannot be transmitted from one person to another; rather, it needs to be* ***constructed*** *in students’ minds****.***

*The role of the ARM lecturer is to support learning to help the student develop their own understanding.* The most effective teaching practices and learning environments challenge students’ thinking beyond what they could achieve independently. The role of the ARM lecturer is to *mediate* learning of new content knowledge by supporting or ‘scaffolding’ student learning in what Lev Vygotsky (1978) described as the ‘zone of proximal development’. This is an area of challenge beyond what the student can manage on their own but is achievable with the help of a skilled person – the teacher or lecturer.

## Scaffolding learning

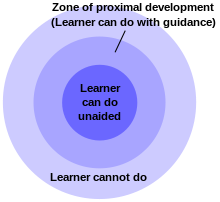
### Vygotsky’s Zone of Proximal Development and the concept of scaffolding in teaching

Vygotsky’s theory of how people learn forms the foundation of almost all other learning theories and progressive approaches to teaching and learning in the 20th and 21st centuries. We will therefore spend a little more time focusing on his ideas.

**The role of the lecturer as the ‘more knowledgeable other’**

Vygotsky conceptualised the teacher or lecturer as the *more knowledgeable other* and stated that the teacher/lecturer’s job is to support the learner/student to bridge the gap between what they already know and can do without help and what they can achieve with guidance and encouragement. This gap or space in which a lecturer operates to support the student is referred to by Vygotsky as *the zone of proximal development* (ZPD). The term ‘proximal’ refers to those skills that the student is ‘close’ to mastering and the point at which a lecturer needs to insert support.

ZPD is the zone where teaching is the most beneficial, as it is when the task is just beyond the individual student’s capabilities. Figure 7 helps to illustrate the concept of the ZPD.



**Figure 7: Vygotsky’s Zone of Proximal Development (1978)**

**Source:** <https://en.wikipedia.org/wiki/Zone_of_proximal_development>

Stop and Think

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| To learn, we must be presented with tasks just out of our ability range.  Challenging tasks ‘stretch’ the student and promote maximum cognitive growth. |

**The lecturer’s role in scaffolding learning**

Scaffolding refers to the way in which new content knowledge is built up and activities are provided by the lecturer. The students work through these activities with the support or guidance of the lecturer. As the students’ knowledge and skills develop, the lecturer’s support is slowly withdrawn, much as scaffolding is removed from a building during construction. The student will then be able to complete the task again independently. Wood et al. (1976, p. 90) define scaffolding as a process that enables a child or novice to solve a task or achieve a goal that would be beyond their unassisted efforts.

Stop and Think

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| In education, scaffolding refers to a variety of teaching techniques used to support step-by-step learning and to move students progressively towards stronger understanding. |

Activity 8: Careful scaffolding of lessons in ARM

**Suggested time: 30 minutes**

The purpose of this activityis to prepare a lesson plan for an ARM lesson in which the concept of scaffolding is designed into the lesson.

Vygotsky’s theory emphasises the role of more knowledgeable individuals in supporting students’ development through structured guidance or scaffolding. The key to this activity is to think about how you will provide the right amount of support and guidance to help students achieve the planned learning outcomes.

Use the [lesson plan](#Lesson_Plan_Template) template provided to plan and structuring your lesson.

Topic: Choose a specific topic within the subject of ARM. For example, you can focus on diagnosing electrical system issues or troubleshooting engine problems.

1. State the learning objectives or outcomes.
2. Build on existing knowledge: Think about what you would do at the beginning of the lesson to identify any potential knowledge gaps or areas where students may struggle to understand the topic.
3. List your scaffolding techniques: Write down which specific scaffolding techniques you will apply in in your planned lesson, e.g., offering simplified examples; dividing the content into smaller, more manageable components; sharing real-life scenarios or anecdotes that will help to support students in understanding and mastering the topic.
4. Describe your scaffolding techniques: Explain how you will use the support technique(s) that you have chosen to sequence the content and to break it down in such a way that it helps students to understand the topic.
5. Assess learning: Design a short informal (or formative) activity that will serve to assess your students’ learning.

Discussion of the activity

To support learning, it is important to plan lessons that are carefully scaffolded. Scaffolding refers to the teaching technique of providing support and structure to students as they develop new skills and knowledge. In the context of ARM, it involves breaking down complex concepts and skills into manageable steps, providing guidance and resources, and gradually removing support as students gain proficiency.

*Supporting students to construct their own understanding:* Scaffolding helps students make connections between different concepts and skills, promoting learning. By explicitly linking new material to prior knowledge and real-world applications, instructors facilitate the integration of knowledge into a coherent understanding of ARM. This enables students to apply what they have learned in new situations and contexts.

*Sequential learning:* ARM involves a series of interconnected skills and knowledge. By carefully planning lessons with scaffolding in mind, lecturers can ensure that students’ progress through the material in a logical sequence. This sequential learning allows students to build a strong foundation and gradually advance to more complex concepts and skills.

*Accessible content:* The technical nature of ARM can be very challenging for students to understand. Scaffolding helps make the content more accessible by breaking it down into manageable parts. By providing clear explanations, demonstrations, and hands-on activities, lecturers can help students understand and engage with the material effectively.

*Active learning:* Scaffolding promotes active learning by encouraging students to participate actively in the learning process. By incorporating hands-on activities, group discussions, and problem-solving exercises, lecturers can foster student engagement and deeper understanding. Students could apply their knowledge, practice skills, and reflect on their learning, leading to better retention and mastery.

In summary, careful scaffolding in lesson planning is invaluable when teaching ARM. It promotes sequential learning, makes the content accessible, and fosters active engagement, which helps to facilitate learning. By providing a structured and supportive learning environment, scaffolding supports student understanding, skill development, and overall success in ARM education.

## Teaching that promotes active learning

As discussed above, the approach to teaching and learning that is promoted by Vygotsky, and later by Engeström, is described as ‘active learning’. To design opportunities for active learning, lecturers need to be active leaders of learning rather than transmitters of knowledge. This involves constantly challenging student thinking; scaffolding teaching interventions in such a way that they support the student to be successful in their learning; and reflecting on the impact of their teaching approaches and adjusting what they do based on careful analysis of student performance. This can be done by designing relevant learning activities and observing how students engage with these tasks, as well as by implementing regular formative assessment tasks. Assessment will be discussed in greater detail in Unit 4 of this module.

## The value of creating collaborative learning opportunities

Collaborative learning refers to an educational approach where students actively engage in the learning process through interactions with their peers. The importance of *social interaction* in the learning processes has been highlighted by Vygotsky and has been further expanded on by Yrjö Engeström, Professor of Adult Education and Director of the Center for Research on Activity, Development and Learning at the University of Helsinki. Engeström emphasises that, for optimal learning to take place, learning activities must be undertaken in a *collaborative* manner.

The value of collaborative learning can be seen in various ways, which include enhanced critical thinking. Collaborative learning encourages students to analyse, evaluate, and solve problems collectively. By engaging in discussions and sharing perspectives, students develop critical thinking skills as they consider different viewpoints, challenge assumptions, and reach well-rounded conclusions. Collaboration also creates the opportunity for students to actively participate in discussions and teach concepts to their peers. Doing so helps students to develop a deeper understanding of the subject matter, as explaining ideas to others helps to solidify their own understanding, while they gain new insights from different perspectives.

Stop and Think

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| In addition to the points made above, think about the ways in which collaborative learning:   * supports effective communication and collaboration among students. * supports development of teamwork and problem-solving skills. * mirrors real-world work situations. |

Overall, collaborative learning promotes active engagement, critical thinking, communication, and interpersonal skills – fostering a holistic and effective learning experience. It prepares students for the challenges of the real world, while nurturing a positive and inclusive learning community.

In the following activity, you are invited to think about how to translate the benefits of collaborative learning into the design of a real-life collaborative learning activity for your students.

Activity 9: What do lecturers need to take into consideration when designing a collaborative real-life learning activity?

**Suggested time: 60 minutes**

Various learning and teaching theorists have emphasised that people learn best in a social context: that is, when tasks and problems are worked though in a collaborative manner with one or more peers.

If possible, work with a colleague, someone at your college, or someone that is on the Adv. Dip TVT programme with you.

In your [learning journal](#learning_journal), write a detailed description of the key issues to consider when designing a collaborative real-life activity in ARM to support your students’ learning.

Use the questions below as a guide to complete this learning activity.

1. How will you choose the topic for the activity that you design?
2. How will you ensure that the outcomes and purpose of the activity are clear?
3. How will you structure, sequence, and scaffold the task to support student learning?
4. How will you divide your class into groups? What is the size of groups? What is the group composition?
5. How will you structure and divide the task(s) among all members in each group?
6. What resources will you provide for your students to enable them to complete the activity?
7. How will you ensure that students consolidate their learning?
8. How will you ensure that the intended learning has happened?

Discussion of the activity

1. In thinking about the ARM topic that you would select as you designed the collaborative activity, did you think about *relevance to real-life?* The tasks should closely reflect real-life scenarios and challenges that automotive repair technicians encounter. Ensuring task relevance helps students understand the practical applications of their learning and prepares them for real-world situations.
2. Clearly define the specific outcomes and purpose of the collaborative tasks and provide clear guidelines to students. Include the steps involved in completing the task, and any specific criteria or expectations for formative assessment, if applicable. This helps students understand what is expected of them and ensures that they stay focused on the intended learning outcomes.
3. The size of groups needs to be considered; if they are too small or too big, they may not provide the desired rich and varied input. Group composition is also important to consider; think carefully about how groups are formed for collaborative tasks. Ideally, groups should consist of students with diverse skill levels and backgrounds. This allows for peer learning, where more experienced students can support and mentor their peers, fostering a collaborative and inclusive learning environment.
4. Role allocation in each group is also important to ensure that each student understands what is expected of them. There are several different ways to approach this. One way might be to assign specific roles or responsibilities within each group to ensure that all students actively contribute to the task. For example, two students could be responsible for research, another two for problem analysis, and two for documenting the process. By assigning roles, students develop a sense of ownership and accountability, and it promotes effective teamwork. Alternatively, all members of each group could take collective responsibility for each aspect of the activity. You also need to think about how the groups should present and share their completed tasks with the rest of the class.
5. Planning any activity also requires the lecturer to think about how to access the necessary resources, such as workshop manuals, diagnostic tools, and automotive parts that the students may need.
6. To consolidate your students’ learning, it is important to incorporate reflection and debriefing sessions after they complete collaborative tasks. Encourage students to reflect on their experiences, discuss challenges faced, and share their insights. These sessions also allow students to identify areas for improvement and gain a deeper understanding of the concepts and skills acquired.
7. If the activity includes an opportunity for formative or even summative assessment, did you think about what the assessment should include? For example, how would you design an assessment to reflect the real-world nature of automotive repair? Does the assessment evaluate problem-solving skills, critical thinking abilities, and effective communication within the group? You will also need to consider how to develop appropriate assessment methods to evaluate students’ individual and group performances and to think about assessment both in terms of the process and the outcome of the collaborative tasks. Also, bear in mind how to provide constructive feedback to guide students’ growth and improvement.

By considering these factors, lecturers can design collaborative, real-life learning tasks that effectively engage students, promote teamwork and problem-solving skills, and prepare them for the challenges of the automotive repair industry.

## Developing a learning pathway

In the section above, the focus has been on how people learn and what this means for pedagogy in ARM. In this section, the focus is on how to plan a learning pathway.

Stop and Think

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| What is meant by a learning pathway?  Before reading any further, jot down your own understanding of a ‘learning pathway’ in your [learning journal](#learning_journal). |

A learning pathway is also known as a learning progression or learning trajectory. It refers to a structured and sequenced journey that students follow to acquire knowledge, skills, and competencies in a specific subject or domain. It outlines the progression of learning from foundational concepts to more advanced and complex topics, guiding students through a series of interconnected steps or stages. The learning pathway provides a roadmap for students, outlining the essential concepts and skills they need to acquire, and the order in which they should be learned. It helps to ensure a logical and cohesive progression of learning by building upon prior knowledge and scaffolding new information and skills. Reflection and regular assessment and feedback need to be integrated into learning pathways, to monitor students’ progress and provide guidance for improvement. Feedback helps students and lecturers to identify strengths and areas for improvement, enabling them to adjust their learning strategies accordingly.

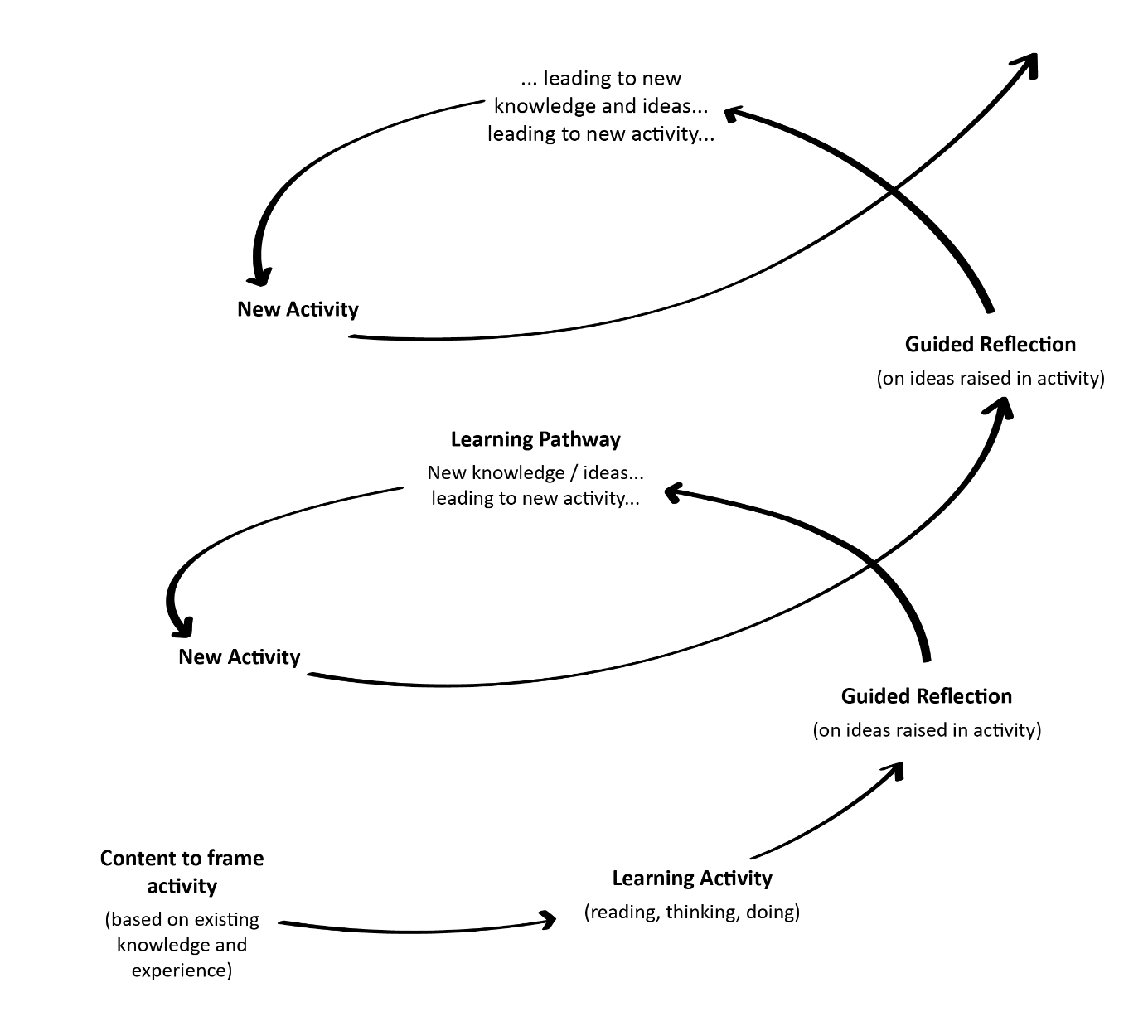
Stop and Think

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| What form do you think the learning pathway should take? A straight line or a spiral? Why? |

Constructivists think about the learning pathway as spiral. How does this idea meet the needs of teaching in the TVET context? TVET lecturers need to teach for understanding as well as for curriculum or content coverage. Lecturers should be able to engage with students’ thoughts and ideas about important concepts in the given subject area and to take them on a journey of discovery. This approach requires lecturers and students to revisit concepts over an extended period and within different contexts – creating an upward, ‘spiralling’ pathway of learning. This spiralling strategy reinforces and expands learning and leads to deeper levels of understanding.

In the spiral approach to learning, students are given access to knowledge and new ideas; an opportunity to engage, apply, and consolidate their understanding of new ideas and skills through specifically designed activities; and then, with guidance, an opportunity to reflect on what they did, thoughts they had, or answers they gave, and why and how they came to have new ideas and new knowledge. Further new ideas and knowledge is then constructed within that same framework, along a learning pathway.

Figure 8 serves to exemplify the spiralling approach to teaching and learning.



**Figure 8: Spiralling approach to teaching and learning**

**Source:** *Saide Model of Learning* (2008) Creative Commons License CCBY

Activity 10: Think about why a learning pathway is conceptualised as a spiral

**Suggested time: 15 minutes**

This activity requires you to think about why a learning pathway is conceptualised as a spiral and not in linear form.

In your learning journal, jot down the key ideas that come to mind when you answer the question: Why a learning pathway conceptualised as a spiral?

Discussion of the activity

A spiral pathway recognises that learning is not a linear progression but a cycle of revisiting and deepening understanding. It acknowledges that students often need to revisit and reinforce concepts to solidify their understanding before moving on to more complex ideas. A spiral also captures the idea that as students revisit concepts, they are, or should be, presented at increasingly higher levels of complexity. Instead of just moving forward in a straight line, students can explore and delve deeper into a subject, gaining a more comprehensive understanding with each iteration. This iterative process encourages critical thinking, reflection, and the ability to make connections across different areas of knowledge.

Importantly, learning should not be seen as a collection of isolated facts but a network of interconnected ideas. A spiral pathway emphasises the interdependence of knowledge and helps students make connections between different concepts. By revisiting previous material, students can see how new information relates to what they have already learned, enhancing comprehension and retention.

So far, we have discussed the importance of building on prior knowledge and the value of making links to the student’s context. We have discussed active learning and the importance of creating opportunities for the students to apply what they have learnt in practice; scaffolding; learning as a social activity (collaborative learning); and the importance of consolidating learning through guided reflection.

In the following section, we will spiral back to thinking about ways in which you can ascertain what prior knowledge your students have in relation to ARM, and how you can identify their misconceptions.

## Students’ prior knowledge and misconceptions in automotive repair and maintenance

ARM introduces students to the fundamentals of vehicle technology and equips them with the necessary confidence to perform tasks related to, for example, vehicle components, engines, gearboxes, fuel systems, body components, and electronics. ARM tasks focus on removing and cleaning parts, servicing (replenishing of fluid), and fitting new parts.

However, before commencing your teaching of any one of these topics, it is important that you understand what your students already know about the topic. Eliciting or obtaining an understanding of students’ prior knowledge in the field of ARM is essential for effective teaching and learning. It helps you understand the existing knowledge and experiences students bring to the topic, which in turn allows you to tailor your teaching accordingly.

Activity 11: Techniques that can be used to elicit students’ prior knowledge

**Suggested Time: 15 minutes**

If possible, work with a colleague or two to brainstorm as many techniques or methods as you can think of using to effectively gain an understanding of what your students already know (or don’t know) about a topic in ARM that you are planning to teach them.

Make a list of the suggestions in your [learning journal](#learning_journal).

Discussion of the activity

Remember to create a supportive and non-judgmental atmosphere to encourage students to share their existing knowledge openly. Building upon their prior knowledge is a vital step towards effective learning and skill development in ARM. You and your colleagues may have listed several possible methods for ascertaining what your students already know about a particular ARM topic. Some of the methods that you have listed may be included below, while some of the additional methods you thought of may also prove useful in your teaching.

* **Whole class discussion:** Perhaps the most obvious and easiest method to implement is a whole class discussion. Initiate a class discussion related to ARM topics. Ask open-ended questions and encourage students to share their thoughts, experiences, and insights. This interactive approach can bring out their prior knowledge and create a collaborative learning environment.
* **Pre-assessment surveys:** Develop and distribute a pre-assessment survey or questionnaire that asks students about their previous experiences with ARM. Include questions about any formal training, practical experience, or personal interests they have in the field. This will provide a general understanding of their background knowledge.
* **Concept mapping:** Ask students to create concept maps or mind maps related to ARM. Provide them with a central topic or concept, such as ‘Vehicle maintenance’, and ask them to brainstorm and connect subtopics, procedures, tools, or components they are familiar with. This visual representation can reveal their prior knowledge structure.
* **Know-want to know-learn (KWL):** Use KWL charts to engage students in reflecting on their existing knowledge and identifying what they want to learn. This can be done as a whole class activity in which you prepare a KWL chart, put it up on the wall and fill it in with your students – or it can be done as an individual activity. Ask students to draw a table with four columns as in this example:

|  |  |  |  |
| --- | --- | --- | --- |
| **Topic** | **Know** | **Want/need to know** | **Have learned** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Then ask your students to list what they already know about the specific automotive repair and maintenance topic that you have chosen, under the ‘Know’ column. This allows them to recognise their prior knowledge and sets the stage for new learning. Once you have established what your students know, you can tell them what you will focus on in the topic that you are about to teach them, and they can write it down in the ‘Need to know’ column. Finally, after you have completed the topic, the students can fill in the last column, ‘Have learned’. The table thus becomes a summary or record, to track their learning.

* **Hands-on activities:** Incorporate hands-on activities or demonstrations related to ARM. Students can work individually or in small groups to perform simple tasks like changing or checking fluid levels or filters, changing brake pads, or identifying different engine parts. The tasks set will depend on the topic being covered at the time. This hands-on experience can reveal their practical knowledge and skills.

Each time you embark on teaching a new topic, use these and other techniques that you know of to establish your students’ prior knowledge. In this way you will ensure a firm base for building new content knowledge and skills and for making your teaching relevant to your students’ learning needs.

Understanding misconceptions that your students may have, goes hand in hand with understanding the student’s prior knowledge. It is therefore also necessary for you to develop good techniques and methods for identifying and working through misconceptions.

Activity 12: Why is identifying students’ misconceptions in ARM important?

**Suggested time: 15 minutes**

Think about why it is important for automotive repair lecturers and facilitators to identify misconceptions held by their students before commencing teaching on a new topic.

If possible, get together with a small group of colleagues and brainstorm answers to this question.

Jot down the points from the brainstorm in your learning journal.

Discussion of the activity

After brainstorming your ideas with colleagues, read through the points listed below. Do they align with the points that you brainstormed? Are there any new ideas here that are useful for strengthening your own understanding of pedagogic practices in ARM?

Identifying misconceptions will enable you to tailor your teaching to address the specific needs of your students. By understanding the existing misconceptions, you can modify your teaching strategies, examples, and explanations to directly target and correct those misconceptions which will help to ensure that students receive accurate information.

As highlighted above, identifying possible misconceptions that students have, goes hand in hand with an understanding of the pedagogic importance of building on prior knowledge: Students bring their pre-existing knowledge and beliefs to the learning environment. If these prior understandings contain misconceptions, they can hinder the acquisition of new knowledge. By identifying and addressing misconceptions early on, you can help students unlearn incorrect information and build a solid foundation of accurate knowledge. This foundation can then serve as a basis for further learning and skill development. Conversely, if misconceptions are left unaddressed, they can become deeply entrenched in students’ thinking. As a result, when new information is presented, students may interpret it in a way that aligns with their misconceptions. By identifying and addressing misconceptions beforehand, lecturers can prevent the reinforcement of incorrect beliefs and ensure that students interpret and integrate new information accurately.

Importantly, the process of identifying misconceptions held by students supports and promotes a constructivist learning environment as it the process of identifying misconceptions enables students to actively construct knowledge based on their existing beliefs and experiences. By identifying misconceptions, lectures can create a learning environment that encourages students to critically reflect on their own understanding, engage in active learning, and reconstruct their knowledge based on accurate information. This approach can therefor support a deeper and more meaningful understanding of automotive repair concepts.

### Gaining an understanding of student misconceptions in ARM

If you have been an ARM lecturer for some while, you may already understand some of the typical misconceptions that students. However, it remains important to confirm your thinking and ensure that you identify all misconceptions related to a particular topic. The section below provides some suggested techniques for eliciting or obtaining a good understanding of your student’s misconceptions. You can try out these techniques, in addition to the strategies that you already use.

**Diagnostic questions:** Pose thought-provoking questions to students during class discussions, workshop sessions, or assessments. These questions should target common misconceptions and challenge students to think critically. Analysing their responses can help you to uncover any incorrect beliefs.

**Pre-assessment surveys:** Begin your new topic or section of the curriculum with a pre-assessment survey that includes questions related to key concepts and skills. This can help you gauge your students’ existing knowledge and identify any prevalent misconceptions before you begin teaching a particular topic.

**Peer discussion and collaboration**: Encourage students to engage in group discussions, peer teaching, or collaborative problem-solving activities. By interacting with their peers, students may uncover and address each other’s misconceptions, fostering a deeper understanding of the subject matter.

**Error analysis:** Review students’ assignments, reports, or completed repairs to identify recurring mistakes or incorrect approaches. This analysis can shed light on common misconceptions and allow instructors to provide targeted feedback and corrective guidance.

**Formative assessment strategies:** Employ frequent formative assessments such as quizzes, short written responses, or hands-on demonstrations. Analysing the results can help instructors pinpoint areas of misconception and adjust instructional strategies accordingly.

**Reflection activities:** Incorporate reflection activities where students can critically analyse their own thinking, identify any misconceptions they may have, and propose corrections or alternative solutions. This process promotes metacognition – the process of thinking about one’s own thinking and learning –and can stimulate self-correction.

By using a combination of these strategies, you can effectively identify and address misconceptions held by your students, leading to improved learning outcomes and a more accurate understanding of ARM concepts.

### Some possible resources to support your teaching

The following videos all deal with various misconceptions related to ARM. They are presented from the perspective of both a motor vehicle owner and a person engaging with automotive repairs. While they may not all be relevant, the issues discussed in each video might assist you in thinking about a range of misconceptions that your students may have. After watching the videos, you might also find that there is some content that you could share with your students to support their learning in ARM.

|  |
| --- |
| Automotive myth busters, tune ups, part 1 <https://www.youtube.com/watch?v=pTP1WnpVDcc>  Automotive myth busters, tune ups, part 2 <https://www.youtube.com/watch?v=S_VEpiBo5xk>  Automotive myth busters, cooling systems <https://www.youtube.com/watch?v=Atq8cHEisV0>  Automotive myth busters, tires, suspension, brakes, steering <https://www.youtube.com/watch?v=_eKlfPJVk6w>  Automotive myth busters, batteries <https://www.youtube.com/watch?v=ebLNy7MdPOc> |

## Selecting and applying appropriate teaching methods and multimedia to support quality teaching and learning in ARM

The ARM industry has changed drastically in recent years and continues to change because of the significant technological advancements in this field. For many, it has become a challenge to keep up with these technological changes, which have implications for both content knowledge and the methods that are used to teach ARM in TVET colleges.

As teachers and lecturers, regardless of the subject, level, or sector that you teach in, keeping up with technological and other changes in your field is part of being a lifelong learner and a professional educator. You can engage in discussions with industry professionals, attend workshops, seminars, or conferences, and network with experts in the field. This continuous learning will not only benefit you but will also enrich your teaching methods and allow you to share real-world examples and experiences with your students.

Keeping up to date with technological advancements in the automotive industry is important as it has a direct impact on the repair and maintenance processes. By staying up to date, you ensure that the information you provide to your students is accurate, relevant, and aligned with the current industry standards. It allows you to teach them the most efficient and effective repair techniques, using the latest tools and equipment. Technological advancements in ARM often focus on improving vehicle safety and reducing environmental impact. By keeping up with these changes, you can educate your students on the latest safety features, repair procedures, and regulations. This knowledge is vital to ensure their own safety and the safety of the drivers and passengers of the vehicles they will be working on.

By keeping up with technological advancements and adapting your teaching approaches accordingly, you can ensure that your students receive the best education possible.

### Effective teaching with technology: Teaching ARM

To develop a more comprehensive understanding of how best to teach in the field of ARM, we will briefly examine the approach to teaching that was developed by Lee Shulman, an American educational psychologist and reformer. He has made notable contributions to the study and assessment of teaching, and the fields of medicine, science, and mathematics.

Shulman introduced the concept of pedagogical content knowledge (PCK) in the mid-1980s. PCK is defined as the integration of pedagogy (teaching method) and content: the ‘what’ and ‘how’ of teaching. Shulman argued that as well as subject knowledge and general pedagogical skills, teachers/lecturers must know how to teach topics in ways that students can understand. To do this, and to support students in their learning, Shulman advocated that teachers should:

* reflect on what students find difficult
* select teaching strategies that will help students address difficulties
* select assessment strategies that will identify problem areas (so that teachers can know how best to adjust their teaching and what aspects to focus on).

Stop and Think

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| Moving on from the mid-1980s to the 2000’s and the present, what element do you think might be missing or could be added to the teaching method developed by Shulman? Think about 21st century teaching requirements in ARM. |

In 2006, Mishra and Koehler developed the technological pedagogical (and) content knowledge (TPCK) framework. This expanded Shulman’s pedagogical content knowledge (PCK) approach to include the technological dimension necessary for 21st century teaching and learning.

The formulation of the TPCK framework considers the role that technological knowledge can play in effective teaching. TPCK suggests that effective teaching with technology requires an understanding of three essential components:

1. *Technological knowledge* (TK): Refers to an understanding of the tools, systems, and technologies that can be used in teaching and learning. It involves knowledge of how to use and integrate technology effectively in educational settings.
2. *Pedagogical knowledge* (PK): Relates to the understanding of teaching methods, approaches, and strategies that are effective in facilitating student learning. It encompasses knowledge of instructional techniques, classroom management, assessment, and student engagement.
3. *Content knowledge* (CK): Represents subject matter expertise, which includes a deep understanding of the concepts, principles, and key ideas within a specific academic discipline.

According to the TPCK framework, effective teaching with technology requires the integration of these three types of knowledge. However, it also recognises that the integration is not simply the sum of the individual components. Instead, it highlights the importance of the intersection or overlap of these knowledge domains. TPCK represents the understanding of how technology, pedagogy, and content knowledge interact and inform each other to support meaningful and effective teaching and learning experiences. An important aspect of the TPCK approach is that it does not exist in a vacuum but rather is grounded and situated in specific contexts as represented by the outer dotted circle in the TPCK diagram (see Figure 9).



**Figure 9: The technological pedagogical and content knowledge framework**

**Source:** Mishra & Koehler (2006)

In summary, the TPCK framework proposes that effective technology integration in education goes beyond mere technical skills. It emphasises the integration of technological knowledge, pedagogical knowledge, and content knowledge to enhance teaching and learning experiences.

When teaching ARM in TVET colleges, several contextual factors should be taken into consideration to ensure effective and comprehensive learning experiences for students.

Stop and Think

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| Consider the difference between these two statements:   1. Learning from technology – using technology for content distribution or transmission   Versus   1. Learning with technology – using technology to support learning |

Activity 13: What contextual factors should be taken into consideration when teaching ARM?

**Suggested time: 15 minutes**

If possible, get together with a small group of colleagues and brainstorm answers to the following two questions:

1. Why it is important for ARM lecturers and facilitators to think about the context in which they are teaching before commencing teaching on a new topic?
2. What kind of contextual issues do you think are important to consider when you are planning and preparing your ARM lessons?

Jot down the points in your [learning journal](#learning_journal).

Discussion of the activity

Considering the learning context before commencing teaching on a new topic in ARM helps lecturers/facilitators create a more learner-centred, relevant, and engaging learning experience. It enhances the practical application of knowledge, addresses safety considerations, incorporates industry advancements, acknowledges cultural and regional differences, and facilitates the use of appropriate pedagogical strategies.

During your brainstorming process, how widely did you think about the learning context? Did you consider the learning environment as the space and resources that you have available at your college? Did you also consider your students’ background as part of the context? Or did you think of context more broadly and include curriculum and industry contexts as well?

If you thought about the learning environment, what factors did you take into consideration? Apart from equipment and resources available for teaching automotive repair, did you also think about safety issues and class size? Safety considerations in automotive repair include potential hazards, such as working with electrical systems, lifting heavy objects, and handling chemicals. What do these potential hazards mean for you and your students?

Bearing in mind the TPCK framework, did you think about which technological applications you could use to support your teaching of a particular topic? For example, can you identify some suitable videos or simulations that would support teaching and learning in ARM?

When you thought about your students, did you remember to consider the students’ prior knowledge and experiences?

How does your ARM teaching and learning context align with industry standards and workplace requirements? This is critical consideration to ensure the relevance of your students’ skills and qualifications. Have you considered how best to foster partnerships with local automotive businesses, repair shops, or dealerships to provide students with opportunities for cooperative education, or work-integrated learning. Collaborating with industry professionals can enhance the learning experience by offering real-world insights, hands-on practice, and potential employment opportunities.

By considering these contextual factors, you can create a more relevant and engaging learning environment for students pursuing automotive repair in TVET colleges.

In the following activity you have the opportunity to apply the TPCK framework to design an activity based ARM Lesson.

Activity 14: Use the TPCK framework to design an activity-based ARM lesson

**Suggested time: 60 minutes (to design)**

**Your lesson plan should indicate how much time you will need to implementation**

**Design**

Use the [lesson plan](#Lesson_Plan_Template) template to design and implement an ARM lesson in which you apply the elements of the TPCK framework.

As you will have seen from your engagement with the TPCK framework, it is a conceptual framework that integrates technology, pedagogy, and content knowledge in education. When designing a lesson for ARM students using the TPCK framework, you need to consider the intersection of these three knowledge domains. Here’s an example of how you can apply TPCK to design your lesson:

*1. Content knowledge (CK):* Identify the key concepts and skills related to ARM that you want students to learn. This may include topics such as engine diagnostics, electrical systems, brake repair, or troubleshooting techniques.

*2. Pedagogical knowledge (PK):*Determine the most effective teaching strategies and approaches for conveying the content knowledge to your students.

* Remember context, including students’ prior knowledge.
* Consider using a combination of lectures, demonstrations, hands-on activities, and collaborative learning experiences to engage students and enhance their understanding of the subject matter.

1. *Technological Knowledge (TK):* Identify the appropriate technologies that can support and enhance the teaching and learning of ARM. This may include software applications, diagnostic tools, virtual simulations, online resources, or multimedia presentations.

**Implementation**

Once you are satisfied with your lesson plan, you are strongly encouraged to implement your lesson. It’s a great opportunity for you to strengthen your own experience of teaching ARM using the pedagogic approaches promoted in this module.

Discussion of the activity

**Design**

The TPCK framework encourages a balanced integration of pedagogy, content knowledge, and use of technology to create meaningful and engaging learning experiences for ARM students.

When you applied the TPCK approach to your lesson design and planning, did you start by thinking about your teaching and learning context? What strategies did you select to establish your students’ prior knowledge and misconceptions about the topic?

Remember, people learn best though active learning. Below are some strategies that you may have already thought about, or if you have not, you could revise your lesson plan to include one. Consider these methods for future lessons.

*Activity-based learning:* Provide opportunities for students to engage in hands-on activities and practical experiences. Allow them to work with actual engines, electrical systems, or brake components, giving them a chance to apply theoretical knowledge in a real-world context. This can include activities such as disassembling and reassembling engine parts, conducting electrical circuit tests, or inspecting brake systems.

*Problem-based learning:* Present students with authentic problems related to engine diagnostics, electrical systems, brake repair, or troubleshooting techniques. Encourage them to analyse the problems, identify potential causes, and devise appropriate solutions. This approach promotes critical thinking, problem-solving skills, and the application of theoretical knowledge to practical situations.

*Case studies:* Use case studies that highlight real-world scenarios encountered in ARM. Provide students with detailed descriptions of specific engine malfunctions, electrical system failures, or brake issues. Ask them to analyse the cases, diagnose the problems, and propose effective repair strategies. Case studies allow students to develop their analytical skills and decision-making abilities in a context relevant to their future career.

*Collaborative learning:*Encourage students to work together in small groups or pairs to solve problems and complete hands-on tasks. This collaborative approach promotes peer-to-peer learning, fosters teamwork skills, and allows students to share their knowledge and experiences with one another. It also reflects the collaborative nature of ARM work in real-world settings.

*Demonstration and visual aids:* Use demonstrations and visual aids such as diagrams, charts, or multimedia presentations to explain complex concepts, procedures, and systems. Visual representations can help students visualise the inner workings of engines, electrical circuits, or brake systems, making it easier for them to understand and retain information.

*Technology integration:* As per the TPCK framework, integrate technology tools and resources to support your teaching and to enhance the learning experience. This could include using computer-based diagnostic software, virtual simulations, online resources, or educational videos. Technology can provide interactive and immersive learning experiences, allowing students to practice diagnostics, repair techniques, and system analysis in a controlled environment.

**Implementation**

Did your implementation of the lesson go well?

Reflection on what worked well and what you might want to do differently the next time you implement this lesson or a similar one. As a reminder for the future of what worked well and what did not, remember to make some notes on the lesson plan or in your [learning journal](#learning_journal).

## Conclusion

Unit 2 focused on the pedagogy of ARM, exploring how people learn and the implications of learning theory for how we teach. A constructivist approach to teaching and learning is promoted in this unit. It includes the fostering of active teaching strategies, careful scaffolding of learning, the value of collaboration among peers, techniques for eliciting prior learning and misconceptions, and the use of technology to support learning.

Unit 3 will focus on applying an active approach to teaching the heat engine (e.g. internal combustion engines) as well as on methods and strategies for teaching troubleshooting, maintenance, and testing.

# Unit 3: Teaching about Internal Combustion Engines and Motor Vehicle Troubleshooting, Maintenance, and Testing

Introduction

In this unit, the focus is on methods and strategies for teaching selected topics in automotive repair and maintenance (ARM). While there are, of course, a range of other important topics in ARM, these cannot all be covered in the scope of this module. It is, however, hoped that you will be able to apply the methods and strategies exemplified and modelled in this unit to other ARM topics that you teach.

Unit 3 comprises two sections: Section 1 focuses on the methods and strategies for teaching about the components and functions of the internal combustion engine (ICE); and Section 2 discusses methods and strategies for teaching about motor vehicle troubleshooting, maintenance, and testing.

We have chosen to focus on how to teach about ICEs for several reasons. Since the ICE serves as the *primary power source* for most vehicles on the road, it is of paramount importance in the context of ARM. (While electric cars have electric engines, these are globally still in the minority.) The ICE converts energy from burning fuel into mechanical power, which propels the vehicle forward. Thus, any problems with the engine’s performance can significantly impact the vehicle’s overall functionality.

It is therefore important that ARM students have a good understanding of the purpose and function of ICEs. By studying them, students gain a fundamental understanding of how engines work, their components, and their operation. This knowledge forms the basis for diagnosing and repairing engine-related issues effectively.

Because ICEs are complex machines, with numerous moving parts and intricate systems, they require *specialised knowledge and expertise* to diagnose accurately and repair properly. ARM students must learn to analyse symptoms, understand the interplay between different components, and identify potential causes of malfunction. This knowledge will help them troubleshoot and resolve issues efficiently, saving time and resources.

Studying these engines also provides opportunities for students to learn about maintenance schedules, fluid changes, spark plug replacements, belt adjustments, and other essential tasks. This knowledge is crucial for keeping engines running smoothly and ensuring their longevity.

Overall, studying ICEs is essential for automotive repair students as it provides them with a solid foundation of knowledge and skills needed to diagnose, repair, and maintain vehicles effectively.

Equally, learning about testing and maintenance is crucial for automotive repair students for several reasons:

*Diagnostic skills:* Testing is an essential aspect of automotive repair. By learning different testing techniques and equipment, students can accurately diagnose issues and identify faulty components. They gain the ability to use tools like diagnostic scanners, multimeters, and pressure gauges, to measure various parameters and pinpoint the root causes of problems.

*Preventive maintenance:* Regular maintenance is vital for the longevity and optimal performance of vehicles. By understanding maintenance procedures, students can develop preventive maintenance schedules and perform tasks such as oil changes, filter replacements, fluid checks, and tyre rotations. These activities help prevent major breakdowns, enhance safety, and save costs in the long run.

*Safety:* Proper testing and maintenance contribute to vehicle safety. Students learn how to inspect critical components like brakes, suspension systems, steering mechanisms, and electrical systems to ensure they are in good working order. Identifying and addressing potential safety hazards is essential to protect the driver, passengers, and other road users.

*Compliance and regulations:* Automotive repair professionals must comply with safety and environmental regulations. Learning about testing and maintenance helps students understand these regulations and perform repairs and maintenance in accordance with legal requirements. This knowledge ensures that repaired vehicles meet safety standards and emissions regulations.

Learning about testing and maintenance is essential for ARM students as it enables them to diagnose problems accurately, maintain vehicles effectively, ensure safety and compliance, enhance customer satisfaction, keep up with technological advancements, and broaden their career prospects.

ARM lecturers in the TVET college sector not only need to master the *content* of the ARM curriculum, but also need to have the knowledge and skills to *teach* the content to the students in ways that are safe (in the workshop), specific, and understandable. They must empower students to perform practical motor repair and maintenance tasks in a workshop and eventually in the workplace.

Unit 3 outcomes

By the end of this unit, you should be able to:

1. Engage students to determine their prior knowledge, conceptions, and misconceptions related to the purpose and function of internal combustion engines.
2. Learn about and apply appropriate methods to teach the content and concepts related to the internal combustion engine.
3. Engage students to determine their prior knowledge, conceptions, and misconceptions related to motor vehicle testing and maintenance.
4. Learn about and apply appropriate methods to teach the content and concepts related to the motor vehicle testing and maintenance.

## Section 1: Teaching about internal combustion engines

### The *what* and the *how*

The assumption in this module is that the ARM TVET lecturers are subject matter experts and have excellent knowledge of the content to be covered. Before engaging with the ‘how’ (or method) of teaching, it is important to be clear about ‘what’ (the content that is to be taught). As a lecturer teaching ARM,it is therefore always important to clarify for yourself the key content knowledge, concepts, and/or skills related to the particular topic that you plan to teach your students. Once you have defined for yourself *what* the focus of the lesson or set of lessons is, you then need to decide *how* best to go about teaching the content.

Stop and Think

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| Remember the five ‘Ps’ of effective lecturing: **P**roper **p**lanning **p**revents **p**oor **p**erformance! |

Start by answering the question: Why is it important for ARM students to learn about ICEs? The ICE is a vital component of automotive education and engineering programmes. Students need to have a comprehensive understanding of the principles, operation, and maintenance of these engines, as they power a wide range of vehicles, including cars, motorcycles, and small aircraft.

Then define for yourself the key concepts and content related to the ICE so that you have them ‘top of mind’ as you plan how you will teach this topic to your students. The key concepts should include:

*Basic principles:* Students should understand the following points on the concept of combustion, the role of fuel and air mixture, and the importance of compression and ignition in generating power within the engine.

* An internal combustion engine is a type of heat engine that converts the chemical energy stored in fossil fuels into mechanical energy. It is the most common type of engine used in automobiles, motorcycles, small aircraft, and various other applications.
* The basic principle behind an ICE involves the controlled combustion of a fuel-air mixture within a confined space called a combustion chamber. The resulting rapid expansion of hot gases generates a high-pressure force that moves pistons or a turbine, producing mechanical work.
* There are two primary types of ICEs: spark-ignition engines (also known as petrol engines) and compression-ignition engines (also known as diesel engines).
* In a spark-ignition engine, a spark plug ignites a fuel-air mixture, usually petrol, at the top of the piston’s stroke. The resulting combustion drives the piston downward, turning the crankshaft and ultimately powering the vehicle or machinery.
* In a compression-ignition engine, air is compressed inside the cylinder to a high pressure and temperature, and then fuel (usually diesel) is injected. The heat generated by the compressed air causes the fuel to ignite spontaneously, without the need for a spark plug.
* Both types of engines involve a series of complex processes, including intake, compression, combustion, and exhaust, which occur in a repeating cycle known as the four-stroke cycle (in most automotive engines) or the two-stroke cycle (in some smaller engines).

Are there any other points you would like to add?

Students need to have a good understanding of various aspects of an ICE:

*Engine components:* These include the cylinder block, cylinder head, pistons, connecting rods, crankshaft, camshaft, valves, and intake/exhaust systems. However, most important is that lecturers explain the function of each component and how they work together to convert fuel energy into mechanical work.

*Engine cycles:* These are primarily the Otto (four-stroke) cycle and the diesel cycle. Explain the processes involved in each cycle, including intake, compression, combustion, and exhaust, and discuss the differences between petrol and diesel engines.

*Emissions and environmental considerations:* Address the impact of ICEs on the environment and the regulations in place to control emissions. Teach students about emission control systems, such as catalytic converters and exhaust gas recirculation, and discuss advancements in engine technologies aimed at reducing environmental impact.

*Diagnostics and troubleshooting:* Introduce students to diagnostic techniques used to identify and troubleshoot engine issues. Teach them how to use diagnostic tools, interpret error codes, and perform tests to diagnose problems effectively.

*Emerging technologies:* Briefly touch upon emerging technologies related to ICEs, such as hybrid powertrains, alternative fuels, and electrically assisted systems. Highlight the importance of staying updated with advancements in engine technology and the need for continuous learning in the field.

*Practical applications:* How will you provide opportunities for your students to have hands-on experience and to apply the concepts they have learned? Think about how you will incorporate workshop exercises, engine disassembly and reassembly activities, and real-world projects to reinforce theoretical knowledge and develop practical skills.

**Note:** The NCV ARM Level 3 Subject Guidelines require students to be able to disassemble, reassemble, install, and then remove the main components of an automotive vehicle.

Based on what you plan to cover (content knowledge) in your lesson(s) about ICEs, you can design a set of questions to help you to understand what your students already know and any misconceptions they may have.

For example, you could check your students’ familiarity with mechanical systems, including knowledge of components like pistons, crankshafts, camshafts, valves, connecting rods, and bearings. It is important that students grasp how these parts interact and contribute to the engine’s operation.

Check whether your students have a basic understanding of fluid mechanics, including the behaviour of gases and fluids in motion. Again, this is essential for comprehending the air and fuel flow within the engine, as well as the principles of combustion and exhaust gas dynamics.

Activity 15: Think of other key concepts that are important for students’ understanding of internal combustion engines

**Suggested time: 15 minutes**

In the section above, we highlight the importance of a basic understanding of thermodynamics and mechanical and fluid systems. What other key concepts would you add to this list? Write a list of foundational concepts related to ICEs and how they function.

If possible, do this activity with one or more colleagues and record your ideas in your [learning journal](#learning_journal).

Once you have a comprehensive list, you will be able to check what your students already know and understand against what they need to know and understand, in terms of the ARM curriculum or subject guideline requirements.

Discussion of the activity

The ARM course should provide comprehensive training that covers all the topics that will help students to develop a solid understanding of ICEs and their functioning. For this reason, lecturers should build a clear understanding of what their students do and do not know, and to plan lessons systematically to cover knowledge gaps.

When you were writing down foundational concepts related to ICEs, did you come up with any or all of the following?

*Electrical systems:* Since modern engines incorporate various electrical components like ignition systems, fuel injection systems, sensors, and control modules, students should have a foundational knowledge of electrical circuits, voltage, current, and electrical components.

*Fuel systems:* Understanding the principles of fuel delivery, fuel-air mixtures, carburetion, and fuel injection systems will help students comprehend how the engine receives and utilises fuel for combustion.

*Lubrication systems:* Knowledge of lubrication systems, including oil pumps, filters, and the importance of proper lubrication, is crucial for maintaining engine performance and longevity.

*Emissions and environmental regulations:* Awareness of emission control systems, such as catalytic converters and oxygen sensors, as well as environmental regulations related to emissions, will provide insight into the need for cleaner and more efficient engines.

*Diagnostic tools and techniques:* Familiarity with diagnostic equipment, such as scanners, multimeters, and pressure gauges, along with troubleshooting techniques, will enable students to identify and address engine-related issues effectively.

Now that you have thought about the key foundational concepts that your students should know and understand, you can think of ways of eliciting this information from them, to determine their current levels of prior knowledge and to check whether they have any misconceptions.

Establishing students’ prior knowledge of internal combustion engines

Students vary differently in the places where they come. Along their journey to your classroom, they are likely to have absorbed a broad range of pre-existing knowledge, beliefs, skills, and attitudes that could affect how they receive, understand, and organise new knowledge. This prior knowledge may help or hinder the student in learning (Diaz, 2017).

Stop and Think

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| In Units 1 and 2, techniques for eliciting prior knowledge were discussed, including:   * Using a pre-assessment survey * Concept mapping * Knowing what to know and learn * Observing your students in a hands-on activity.   Reread the section in Unit 1, *Evaluating prior knowledge related to occupational health and safety in learning spaces and workshops,* and in Unit 2, *Students’ prior knowledge and misconceptions in automotive repair and maintenance,* to refresh your memory on how to use various techniques to establish what your students already know. |

Once you have established what your students do and don’t know, you need to delve a little deeper and uncover whether they have any misconceptions about the components and functioning of ICEs.

### Identifying student misconceptions related to internal combustion engines

Student misconceptions can be identified through a process of diagnostic questioning and listening or with well-structured MCQs. You can refresh your memory on how MCQs were used to determine your students’ conceptualisation of OHS matters in Unit 1, while in Unit 2, additional techniques such as a survey, peer discussion, and error analysis for determining misconceptions were also discussed.

### Components and functions of internal combustion engines

ICEs consist of various components, each serving a specific function to ensure the smooth operation of the engine. The key components and their functions in an ICE are listed below. The list will help you to prepare a survey to assess whether your students hold any misconceptions.

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| **Cylinder:** The cylinder is a cylindrical chamber where the combustion process takes place. It houses the piston and the combustion chamber.  **Piston:** The piston is a cylindrical component that moves up and down within the cylinder. It is connected to the crankshaft through a connecting rod. The piston’s primary function is to transfer the force generated by the combustion process to the crankshaft.  **Combustion chamber:** The combustion chamber is the space in the cylinder where the fuel-air mixture is ignited and burned. It is typically formed by the cylinder head and the top surface of the piston.  **Cylinder head:** The cylinder head is a crucial component mounted on top of the cylinder. It contains the intake and exhaust valves, spark plug (in petrol engines), and fuel injectors (in some engines). The cylinder head provides passages for the intake and exhaust gases and houses the valve train.  **Valves:** ICEs have two types of valves – intake valves and exhaust valves. The intake valves allow the fuel-air mixture to enter the combustion chamber during the intake stroke, while the exhaust valves allow the burnt gases to exit during the exhaust stroke. Valves are operated by the camshaft through a series of components like lifters, pushrods, and rocker arms.  **Camshaft:** The camshaft is a rotating shaft driven by the crankshaft. It controls the opening and closing of the valves at precise timings. The shape of the cam lobes determines the valve timing and lift.  **Crankshaft:** The crankshaft is a central shaft that converts the linear motion of the piston into rotational motion. It is connected to the piston through a connecting rod. The crankshaft’s rotation transfers the engine’s power to the transmission and eventually to the wheels or the driven mechanism.  **Connecting rod:** The connecting rod connects the piston to the crankshaft. It transfers the linear motion of the piston to the rotational motion of the crankshaft.  **Fuel system:** The fuel system delivers fuel to the engine. In petrol engines, it includes components such as a fuel tank, fuel pump, fuel injectors (or carburettor), and a fuel rail. In diesel engines, it involves a high-pressure fuel pump and fuel injectors.  **Ignition system:** The ignition system is responsible for igniting the fuel-air mixture in petrol engines. It includes components like the spark plug, ignition coil, distributor (in older systems), and electronic control module (ECM) or ignition control unit (ICU) for timing and control.  **Cooling system:** ICEs generate heat during operation, and a cooling system is required to maintain optimal temperatures. It includes components such as a radiator, coolant fluid, water pump, thermostat, and cooling fan.  **Lubrication system:** The lubrication system ensures proper lubrication of moving parts to minimise friction and wear. It includes an oil pump, oil filter, and oil passages that distribute engine oil to various components, such as bearings, pistons, and camshaft.  **Exhaust system:** The exhaust system collects and directs the burned gases from the combustion process out of the engine. It includes components like the exhaust manifold, catalytic converter (in some engines), muffler, and tailpipe.  **Timing belt or chain:** Many ICEs use a timing belt or timing chain to synchronise the rotation of the camshaft and crankshaft. It ensures precise valve timing and coordination between various engine components. |

These components work together to facilitate the intake, compression, combustion, and exhaust processes, enabling the ICE to convert chemical energy into mechanical work.

If your students have any misconceptions or do not understand what the key components and functions of ICEs are, they are bound to have difficulty in understanding how these engines work and how to identify and repair them. It is therefore important that you find relevant methods to demonstrate the relationship between the key concepts and the functions of the ICE components.

Activity 16: Design a survey to test students’ misconceptions of the components and functions of internal combustion engines

**Suggested time: 60 minutes**

Design a survey to check ARM students’ misconceptions related to components and functions of an ICE.

Start by thinking about what content knowledge your students need, to understand the parts and functions of an ICE. Develop a set of questions to assess their knowledge.

Read the example provided below and develop a similar survey, with your own set of questions.

Administer the survey to your students and review their responses.

**Exemplar survey**

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| 1. True or False: The function of the carburettor in an internal combustion engine is to mix air and fuel for combustion. 2. Which component of an internal combustion engine is responsible for igniting the air-fuel mixture? 3. Spark plug 4. Piston 5. Crankshaft 6. Timing belt 7. Select the correct statement regarding the function of engine valves: 8. Engine valves regulate the flow of exhaust gases out of the engine. 9. Engine valves control the flow of air into the engine. 10. Engine valves are responsible for cooling the engine. 11. Engine valves have no specific function in the combustion process. 12. What is the primary purpose of the oil pump in an internal combustion engine?     1. To lubricate the engine components     2. To cool the engine     3. To generate electrical power     4. To control the air-fuel mixture 13. True or False: The camshaft is responsible for operating the valves in an internal combustion engine. 14. Which component of the engine is connected to the crankshaft and converts reciprocating motion into rotational motion? 15. Piston 16. Connecting rod 17. Flywheel 18. Timing chain 19. What is the function of the radiator in an internal combustion engine? 20. To provide air conditioning to the cabin 21. To regulate the engine’s oil temperature 22. To cool the engine by dissipating heat 23. To filter impurities from the engine oil 24. True or False: The function of the catalytic converter is to reduce harmful emissions in the exhaust gases. 25. Which component is responsible for controlling the timing of the air-fuel mixture and exhaust valve openings? 26. Timing belt 27. Timing chain 28. Camshaft 29. Crankshaft 30. Select the correct statement regarding the function of the piston in an internal combustion engine: 31. The piston generates electrical power for the engine. 32. The piston controls the flow of coolant in the engine. 33. The piston compresses the air-fuel mixture before ignition. 34. The piston eliminates exhaust gases from the engine.Top of Form |

Discussion of the activity

In the survey that you developed, did you include questions about the following key aspects of functions of an ICE?

* The component that is responsible for intake and compression strokes
* The function of the fuel injector
* The function of the alternator
* The primary function of the exhaust system
* The function of the crankshaft
* The component responsible for synchronising the rotation of the camshaft and the crankshaft
* The function of the air filter
* The function of the exhaust gas recirculation system?
* The component responsible for opening and closing the intake and exhaust valves
* The function of the oil filter

What did your review of your students’ responses show? Did you record their misconceptions so that you could specifically address these?

### Methods for addressing students’ misconceptions related to learning about internal combustion engines

Addressing misconceptions related to teaching about the ICE to ARM students requires a targeted approach. Here are some strategies to address misconceptions effectively. Several lines of evidence suggest that recognising and revising student misconceptions requires active involvement with the material.

To start with, *conceptual clarification* is important. Provide clear and accurate explanations of key concepts related to the ICE. Use visual aids, diagrams, animations, or hands-on demonstrations to enhance understanding. Break down complex concepts into smaller, more manageable parts and relate them to real-life examples or familiar scenarios.

*Active learning strategies:* Engage students in hands-on activities, experiments, or simulations that allow them to explore the ICE first hand. Encourage them to take apart engine components, assemble them, and observe their functions. This practical approach can help dispel misconceptions and solidify conceptual understanding.

*Peer collaboration:* Encourage students to engage in peer discussions, group work, or collaborative projects. This allows them to share their understandings, challenge misconceptions, and learn from each other. Monitor and guide these interactions to ensure accurate information is being shared.

Provide*scaffolding* and support as students develop their understanding. Start with simpler concepts and gradually increase the complexity of the content. Use guided practice, step-by-step instructions, or worked examples to help students build their knowledge and correct misconceptions along the way.

*Formative assessment and feedback:* Implement regular formative assessments, such as quizzes, concept checks, or short assignments, to monitor student progress and identify persistent misconceptions. Provide timely and constructive feedback to guide students towards accurate understanding.

*Reflection:* Encourage students to reflect on their learning process, identify their misconceptions, and actively work towards correcting them. Ask students to explain their thinking, self-assess their understanding, and identify areas of improvement.

Remember, addressing misconceptions takes time and patience. It is crucial to create a supportive and safe learning environment, where students feel comfortable asking questions, challenging their own understanding, and actively participating in the learning process.

Activity 17: Design and implement a lesson to address misconceptions on the components and function of an internal combustion engine

**Suggested time:****3.5 hours** (2 hours to plan the lesson and prepare all learning and teaching support materials and 1.5 hours for implementation)

**Objective:** By the end of this lesson, your TVET students will be able to correctly explain common misconceptions associated with the components of an ICE and their functions

**Prepare learning and teaching support materials required for this lesson:**

* Multimedia: diagrams, videos, etc.
* Links to two possible videos are provided here, however, you can search YouTube for more options.

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| * + **Title: *How car engines work || Working of car engines || Working of four-stroke petrol engines***      - URL: <https://www.youtube.com/watch?v=wSdIbjCiE8g&t=41s>     - Duration: 4 minutes     - License: Creative Commons * **Title: *How an engine works (Toyota)*** * Url: <https://www.youtube.com/watch?v=G4hC5Uc9aZY> * Duration: 8 minutes * License: Creative Commons |

* Handouts with guided practice exercises, which you need to design
* Try and ensure availability of engine components for hands-on exploration

Use the [lesson plan](#Lesson_Plan_Template) template and follow the steps to plan and prepare your lesson.

**Note:** Adjust the times on the lesson plan template to suit your needs.

**Lesson plan steps**

**Step 1:** **Spur motivation**, **link to experience, prior knowledge**/previous learning, and work context.

* Plan the start of your lesson. (10 minutes)

**Step 2: Identify misconceptions** **and address them** and any relevant new content that may be necessary. (20 minutes)

* In your plan, think about how you will highlight and address the misconceptions identified in Activity 16 (or any other common misconceptions about the ICE, which you know from experience).
* This might be a good time to also introduce the suggested video(s) to explain how car engines work.

**Step 3:** **Activity – Hands-on exploration** – what will students do? (30 minutes)

* Collect and provide engine components for students to examine and explore.
* How will you encourage collaboration among students? Do you want the students to work individually or in pairs or small groups?
* Prepare handouts with guided practice exercises. These exercises should involve identifying components, labelling diagrams, and explaining their functions. Provide step-by-step guidelines, so that students know what is expected of them.

**Step 4: Discussion** **of the activity** (20 minutes)

* In your planning process, think about how you want your students to report back on this activity. Will it be a whole-class discussion? Or will groups/pairs share their results?

**Step 5: Review and reflect** (10 minutes)

* Prepare to recap the key concepts covered in the lesson. Ask students to reflect on their initial misconceptions and discuss how their understanding has changed. Address any remaining questions or concerns and think about how you will consolidate learning about new concepts that you introduced.

**Lesson implementation**

Having planned and prepared the lesson, now implement it.

1. Begin the lesson by asking students to share what they already know about ICEs. Encourage them to mention key components, processes, and their functions. Note down their responses on the board.
2. Discuss misconceptions about ICEs, based on students’ responses in Activity 16 and any other common misconceptions related to this topic that you are aware of.

* Address each misconception and explain why it is incorrect. Emphasise the importance of accurate understanding for automotive repair.
* Present simplified explanations of key concepts related to the ICE, such as intake, compression, combustion, and exhaust strokes. Use visual multimedia, diagrams, or animations to support understanding.

1. For the hands-on activity, provide engine components for students to examine and explore. Ask them to identify different parts and their functions. Make sure you have provided sufficient verbal or written guidance for your students to complete the task. Remember to break up the task into steps. Pose questions in the task that help your students to make the connections between the physical components and their function.
2. To help your students to reflect on and consolidate their learning, ensure that you leave them sufficient time to present and discuss their results. Facilitate the discussion, using this opportunity to address any remaining misconceptions and to reinforce key concepts.
3. The final step in the lesson is for you to summarise and consolidate the key learning points of the lesson.

Discussion of the activity

**Planning and preparing the lesson**

Did the structured lesson plan template assist you in the planning process? Planning and preparation contribute greatly to lesson outcome. There is much truth in the saying, proper planning prevents poor performance.

**Implementing the lesson**

Reflect on the implementation of the five steps or components of the lesson. What worked well and what could be improved? Write your reflections in your learning journal so that the next time that you teach this lesson, you will be prompted to make the necessary adjustments.

### Scaffolding learning and constructing a learning pathway: Designing a sequenced set of lessons in ARM

In Unit 2 we discussed the importance of developing a set of lessons that build one on the other, to create a structured and sequenced learning pathway for your students to follow, to acquire knowledge, skills, and competencies in ARM. The learning pathway outlines the foundational concepts, identifies prior learning, addresses misconceptions, and then moves the student onto more advanced and complex topics. It guides them through a series of interconnected lessons and workshop sessions.

In Activity 18 the task is to plan the next lesson, to consolidate and advance your students’ skills and knowledge on the topic of the ICE. The purpose is to ensure a logical and cohesive progression of learning, building upon prior knowledge and scaffolding new information and skills.

Activity 18: Plan and implement a lesson to consolidate and advance learning about the internal combustion engine

**Suggested time: 3.5 hours** (2 hours to plan the lesson and prepare all learning and teaching support materials and 1.5 hours for implementation)

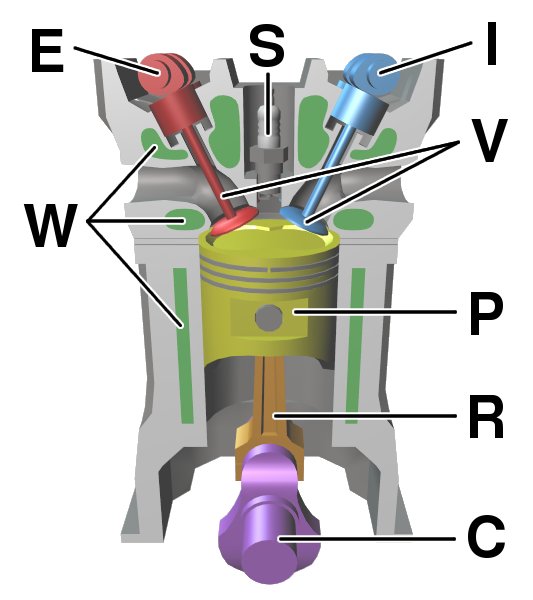
**Objectives:**

* Build on the knowledge that students have mastered and expand their understanding of an ICE.
* By the end of this lesson, students should be able to accurately explain the functioning of an ICE.

**Guidelines for planning and preparing this follow up lesson:**

Use the [lesson plan](#Lesson_Plan_Template) template and follow the steps to plan and prepare your lesson in the same way as you did in Activity 17.

Remember to prepare the learning and teaching support materials required for this lesson, including worksheets, handouts, and diagrams and to identify any relevant videos on YouTube or animations available on the Wikimedia site that support teaching and learning in this topic. For example, you could use the diagram, of a four-stroke engine (below) and/or get your students to access the animated version of the four-stroke engine by exploring the links (urls) provided in the*key to diagram of four-stroke engine*, also below. Use these multimedia resources to design a learning activity.



**Figure 10: Diagram of four stroke engine**

**Source:** <https://upload.wikimedia.org/wikipedia/commons/4/47/Four_stroke_engine_diagram.jpg>

**Key to diagram of four stoke engine:**

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| **C** –crankshaft. <https://en.wikipedia.org/wiki/Crankshaft>  **E** – exhaust camshaft. <https://en.wikipedia.org/wiki/Camshaft>  **I** – inlet camshaft. <https://en.wikipedia.org/wiki/Camshaft>  **P** – piston. <https://en.wikipedia.org/wiki/Piston>  **R –** connecting rod. <https://en.wikipedia.org/wiki/Connecting_rod>  **S –** spark plug. <https://en.wikipedia.org/wiki/Piston>  **V –** valves. red: exhaust, blue: intake. <https://en.wikipedia.org/wiki/Poppet_valve>  **W –** cooling water jacket. <https://en.wikipedia.org/wiki/Camshaft>  **Gray structure** – engine block**.** <https://en.wikipedia.org/wiki/Engine_block> |

**Step 1: Recap the key learning points from the previous lesson** (5 minutes)

* Begin the second lesson by briefly reviewing the key concepts from the previous lesson. Address any lingering questions or misconceptions from the previous day.

**Step 2: Advancing the understanding** (20 minutes)

* Introduce more complex concepts related to the ICE, such as the role of the fuel injection system, ignition timing, and the impact of engine design on performance. Provide clear explanations and examples.
* Think about how you will introduce these more complex concepts. What multi-media diagrams or videos will you use to support teaching and your student’s learning? See links to videos provided in Activity 17.

**Step 3: Guided practice and application** (30 minutes)

* Distribute handouts with guided practice exercises that involve analysing real-world engine diagrams, troubleshooting scenarios, or engine performance data. Encourage students to apply their knowledge and correct any misconceptions they encounter.

**Step 4: Collaborative learning activity** (25 minutes)

* Divide students into small groups and assign each group a specific topic or aspect of the ICE. Ask them to research and prepare a short presentation to explain their assigned topic, addressing misconceptions and providing accurate information. Each group will present their findings to the class.
* Decide what type of multi-media you will use to support your students to undertake this activity.

**Step 5: Assessment and reflection** (10 minutes)

* Design a short, written assessment or reflection task to gauge students’ understanding of the ICE and their ability to correct misconceptions. This can be done as homework or in class.

**Lesson implementation**

Having planned and prepared the lesson, now implement it with your students.

Discussion of the activity

The focus of this activity is to plan a follow-on lesson intended to consolidate students’ learning from the previous lesson and to build and advance their understanding of the ICEs.

The activity exemplifies how ARM lecturers can carefully scaffold the teaching and learning of complex content over two or more lessons. It serves as an example of how to start mapping out lessons comprising activities, assessment tasks, and reflections that build towards the creation of a complete learning pathway through the ARM curriculum content.

If you used the diagram provided in Figure 10, above, did you get your students to explain and present on the different components and functions of the combustion engine?

Did you remember to conclude the lesson by asking students to reflect on how their understanding has evolved and improved? It is also important to encourage your students to continue seeking accurate information and dispelling misconceptions in their automotive repair studies.

You could provide your students with the URL links to each of the nine components and get them to do some further investigation on the functioning of these various components as a homework task, or as part of your next follow-on lesson.

As part of your own ongoing professional development and commitment to quality teaching and learning in ARM, did you remember to reflect on and record what worked well and what could be improved in this lesson?

Consolidating learning before moving on

The focus of Section 1 of this unit has been on teaching about ICEs. Section 1 models the TPCK approach to teaching and learning that was first discussed in Unit 2. In this module and section, the assumption is that as a TVET lecturer in the field of ARM you are a subject matter expert, therefore the focus is not on ARM content but rather on pedagogical content knowledge (PCK). In other words, the focus is on *how* to teach in the field of ARM, what teaching techniques and strategies to use. The ‘T’ in TPCK stands for technology and requires lecturers to think about how technology can best be used to support learning a specific topic.

Stop and Think

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| Reread activities 17 and 18 and see how technology was used in these two activities.  What other types of technology do you think could be used to support learning about the ICE? |

The *activities* in this section are intended to both create an opportunity for you to apply your own learning about teaching methods in ARM, as well as to model the way you need to teach and engage with your students as active learners in your classrooms and workshops.

Stop and Think

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| Active learning is about creating many opportunities for students to put into practice what they have been taught. In your class, encourage peer learning in groups or set up small teams of students and ask them to prepare and teach a section of content to the class. This is one way of assessing whether students have understood what they have learnt. |

Additionally, the *structure* of this section has modelled a learning pathway as discussed and depicted in Unit 2 (see Figure 8). It starts with new content; then provides an activity in which you get a chance to apply the new knowledge and skills; and moves on to discussion and reflection on the activity, which supports consolidation of the component of learning. It then adds a new component of learning, building the learning pathway, while steadily increasing the complexity of the content.

In Section 2, the focus is on applying appropriate methods to teach the content and concepts related to motor vehicle testing and maintenance.

## Section 2: Teaching about motor vehicle troubleshooting, maintenance, and testing

### The *what* and *how*

Section 2 follows the same format as Section 1. As an ARM subject matter expert, start by defining the key content knowledge, concepts, and skills that your students need to master in relation to motor vehicle testing and maintenance.

The DHET NCV Level 4 Subject Guidelines focus on testing, diagnosing, and repairing faults in various automotive systems, including the exhaust, cooling, and hydraulic braking systems, among others.

Once you have defined for yourself *what* the focus of the lesson or set of lessons is, you then need to decide *how* best to go about teaching the content. In this section we will focus on activities related to the method (the how) of teaching motor vehicle testing and maintenance.

Start by thinking about the purpose of teaching about motor vehicle troubleshooting, maintenance and testing? Here are some key reasons why it is important for ARM students to have this knowledge:

* *Ensuring vehicle safety:* Proper testing and maintenance practices help identify and address potential safety issues in vehicles. Mechanics need to know how to inspect critical components and systems to ensure they are in good working condition, reducing the risk of accidents caused by mechanical failures.
* *Extending vehicle lifespan:* Regular maintenance helps prolong the lifespan of vehicles. By learning about maintenance schedules, fluid changes, and part replacements, automotive mechanic students can assist in keeping vehicles running smoothly for longer periods.
* *Diagnosing and troubleshooting:* Testing is a crucial skill for mechanics, to identify the root cause of vehicle issues accurately. Through diagnostic procedures, students can pinpoint problems and make appropriate repairs, saving time and resources.
* *Being adaptive to technological advancements:* As automotive technology evolves mechanics need to keep up with the changes. Learning about testing and maintenance equips students with the ability to work on newer vehicle models and advanced systems.

If the key purpose of TVET is to provide individuals with practical skills, knowledge, and competencies necessary to enter the workforce or advance in their chosen career paths, then it follows that TVET programmes should develop skills that prepare students for real-world work environments. Factors such ascustomer satisfaction thusalso need to be considered when discussing the purpose of vehicle testing and maintenance with your students. A well-maintained vehicle performs better and provides a more comfortable driving experience for customers. Satisfied customers are more likely to return for future services and recommend the mechanic to others, benefiting their reputation and business.

Stop and Think

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| Vehicle testing and maintenance are vital components of an automotive mechanic’s skill set. These skills not only ensure the safety and reliability of vehicles but also contribute to customer satisfaction, environmental responsibility, and professional growth. By mastering these aspects, ARM students set themselves up for successful and fulfilling careers in the industry.  Proper vehicle maintenance can contribute to reduced emissions and better fuel efficiency, which positively impacts the environment. ARM students learn about tuning vehicles for optimal performance, minimising their carbon footprint. |

### Establishing students’ prior knowledge of motor vehicle testing and maintenance

As discussed in Unit 2, as well as in Section 1, above, the teaching of every new topic should commence with an understanding of your student’s prior knowledge and possible misconceptions of the ARM topic being taught.

Stop and Think

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| “Learners actively construct their understanding by trying to connect new information with their prior knowledge.” (National Academies of Science, 2001) |

Before commencing motor vehicle testing ARM students should have a solid foundation of theoretical knowledge and practical skills related to *automotive systems* and *repair procedures.*

Think about and select an appropriate technique for establishing your students’ prior knowledge of the fundamental systems found in vehicles, such as the engine, transmission, suspension, brakes, electrical system, and exhaust system. They should also know how these systems function and interact with each other.

Establishing your students’ prior knowledge could be facilitated in whole class group discussion or you could divide your class into groups and get each group to discuss their prior knowledge of one system or aspect, for example:

* *Electrical systems:* Circuits, wiring diagrams, and how to troubleshoot electrical problems.
* *Engine performance:* Testing and diagnosing engine-related issues like spark plugs, fuel injectors, and sensors.
* *Emissions control systems:* Understanding and testing emissions control systems and their role in compliance with environmental regulations.
* *Troubleshooting skills:* Knowledge of how to interpret diagnostic trouble codes and follow systematic diagnostic procedures.
* *Maintenance procedures:* Routine maintenance procedures, such as oil changes, fluid checks, and filter replacements.

Once all groups have finished discussing, each group should present their understanding of the topic they were allocated to the whole class.

It’s important to note that the level of prior knowledge required may vary depending on the specific motor vehicle testing being undertaken. For example, emission testing might require a deeper understanding of exhaust systems and emissions control, while safety inspections may focus more on general vehicle condition and safety-related components.

Overall, a strong theoretical foundation and practical experience in ARM are essential for students to effectively commence motor vehicle testing. This ensures that they can perform accurate and thorough tests while maintaining safety standards and delivering reliable results.

### Identifying student misconceptions related to troubleshooting, maintenance, and motor vehicle testing

Like the issue of prior knowledge, possible misconceptions also must be addressed in every lesson or set of lessons on a given topic. It is the starting point each time as you build systematically on what the student knows, be it from their life experience, from the previous year’s ARM study, or from the previous ARM lesson. You play a vital role in dispelling misconceptions and providing students with accurate knowledge and best practices in vehicle testing and maintenance.

Identifying and addressing possible misconceptions does not need to take up a whole lesson – it could be a quick five-to-ten-minute exercise. However, like all lesson steps or components, it is crucial to meticulously plan and prepare the activity. By doing so, you can ensure that you progress smoothly with your planned lesson, and that there is a shared understanding of the concepts being investigated and learned.

Activity 19: Addressing misconceptions related to motor vehicle testing and maintenance

**Suggested time: 15 minutes**

Decide what techniques you will use to identify the misconceptions your students may have in relation to the aspects of motor vehicle testing and maintenance that you plan to cover. Think back to some of the suggested approaches discussed in Unit 2.

Based on your own experience of teaching in ARM, you might also make a list of the typical misconceptions that you have observed ARM students to have in relation to motor vehicle testing and maintenance.

As you plan the next steps in your lesson, think about how you will address the possible misconceptions that you have already identified as well as those that may be brought up by your students.

Discussion of the activity

Here are some typical misconceptions that students may have about motor vehicle testing and maintenance. Do they align with the misconceptions that you have already listed for yourself? As you read through the list, consider how you might address these in your lesson(s):

* *Skipping regular maintenance is okay:* Some students may believe that skipping or delaying regular maintenance tasks, such as oil changes or tyre rotations, won’t have a significant impact on a vehicle’s performance. In reality, neglecting maintenance can lead to major issues and reduce the vehicle’s lifespan.
* *Assuming all cars with the same symptoms have the same problem:* The assumption that every vehicle with similar symptoms has the same underlying issue is a common misconception. The same symptoms can have various causes, depending on the vehicle’s make, model, and year, as well as its maintenance history and driving conditions. Proper diagnostics are essential to identifying the specific problem accurately.
* *Overlooking preventive measures:* Some students might prioritise fixing existing issues but overlook preventive measures to avoid potential problems. For instance, neglecting to check and replace a worn timing belt could lead to severe engine damage later.
* *Ignoring warning lights:* Students may think that if the vehicle appears to run fine, they can ignore warning lights on the dashboard. However, warning lights often indicate underlying issues that need immediate attention.
* *Using the same maintenance approach for all vehicles:* The belief that the same maintenance procedures and repair techniques apply to all vehicles is a misconception. Different car models and brands have unique designs and requirements, necessitating specific approaches for maintenance and repair.
* *Ignoring basic checks:* Sometimes, technicians may overlook simple or obvious issues, assuming the problem must be more complex. Simple problems like loose connections, blown fuses, or low fluid levels can often be the cause of the issue.
* *Not testing after a repair:* Students might assume that once a repair is complete, there’s no need to test the vehicle thoroughly. However, testing after repairs is crucial to ensure that the issue has been resolved and that no new problems have emerged.
* *Not inspecting fluids:* Some students may overlook the importance of checking and changing fluids regularly, such as engine oil, transmission fluid, coolant, etc. Neglecting fluid maintenance can lead to costly repairs or engine damage.
* *Believing it’s okay to miss a regular service sometimes:* In some cases, underlying problems may arise due to poor maintenance practices or ignoring regular service intervals. Neglecting maintenance can create cascading issues that may seem unrelated initially.
* *Underestimating the importance of possible electrical problems:* Troubleshooting electrical issues can be challenging, and some automotive technicians may avoid it due to perceived complexity. However, modern vehicles rely heavily on electronic systems, making it crucial to address electrical problems properly.

Experienced lecturers and automotive workshop facilitators play a vital role in dispelling these misconceptions and providing students with accurate knowledge and best practices in troubleshooting, vehicle testing, and maintenance.

In the following section, our focus shifts to *planning and teaching* troubleshooting, maintenance, and testing, specifically concerning the ICE. As emphasised at the beginning of Unit 3, the engine is the heart of automotive vehicles, making it a crucial aspect in the context of repair and maintenance.

For automotive professionals to excel in their field, they must possess a profound comprehension of engine mechanics and diagnostics. This knowledge is essential for ensuring vehicles run smoothly, guaranteeing safety, optimising performance, and ultimately enhancing the overall longevity and value of the vehicles they service.

### Troubleshooting, maintenance, and testing

In automotive repair, troubleshooting, maintenance, and testing are interconnected processes that work together to identify and resolve issues with vehicles. Each of these activities plays a critical role in keeping vehicles in good working condition and ensuring their optimal performance. Let’s explore the relationship between these three aspects.

**Troubleshooting**

Troubleshooting involves the systematic investigation of vehicle problems or malfunctions. When a vehicle owner or mechanic observes unusual behaviour, warning lights, or performance issues in the vehicle, troubleshooting is used to pinpoint the specific cause of the problem. This process can include visual inspections, listening for unusual sounds, gathering information from the vehicle owner about the issue, and using diagnostic tools to retrieve error codes and data from the vehicles on board systems.

**Maintenance**

Maintenance refers to the regular upkeep and servicing of a vehicle to prevent potential issues and keep it running smoothly. It involves a series of routine tasks and checks that are performed on a scheduled basis or as recommended by the vehicle’s manufacturer. The purpose of maintenance is to prevent problems from occurring, prolong the life of the vehicle, and maintain its optimal performance. Maintenance tasks can include oil changes, filter replacements, fluid checks and replacements, tyre rotations, brake inspections, and more.

**Testing**

Testing in automotive repair involves the use of specialised diagnostic tools and techniques to assess the vehicle’s various systems and components. These tests can be conducted during troubleshooting to identify specific issues, as well as during maintenance to ensure that the vehicle’s systems are functioning correctly. Testing may involve using on board diagnostics (OBD), computerised scanning tools, manual inspections, and functional tests to assess different aspects of the vehicle’s performance.

### The relationship between these three functions

***Troubleshooting and maintenance:*** Troubleshooting and maintenance are closely related as they both aim to ensure the proper functioning of the vehicle. When a problem is identified during troubleshooting, maintenance tasks may be required to address the issue and prevent similar problems from occurring in the future. For example, if troubleshooting reveals, a leaking coolant hose, maintenance involves replacing the hose to prevent engine overheating and potential damage.

***Troubleshooting and testing:*** Troubleshooting often involves conducting various tests to diagnose the specific problem accurately. Testing provides valuable data and feedback about the vehicle’s systems, which guides the troubleshooting process. For instance, if a check engine light is on, testing the vehicle’s computer systems with a diagnostic scanner can provide trouble codes that indicate the nature of the problem, aiding in the troubleshooting process.

***Testing and maintenance:*** Testing is instrumental in verifying the effectiveness of maintenance tasks. After performing maintenance, such as replacing a faulty sensor or changing the oil, testing is often done to ensure that the issue has been resolved, and the vehicle is functioning correctly. For example, after replacing brake pads during maintenance, a road test may be conducted to verify that the brakes are working as expected.

In summary, troubleshooting, maintenance, and testing are interlinked in automotive repair. Troubleshooting is used to identify specific problems, maintenance addresses those problems and aims to prevent future issues, while testing verifies the success of maintenance and ensures that the vehicle is in optimal working condition. By combining these three elements, automotive repair professionals can diagnose and fix problems, maintain vehicle health, and provide reliable, safe, and efficient vehicles for their owners.

#### Troubleshooting

Automotive troubleshooting is a critical skill that requires a methodical approach and a sound understanding of vehicle systems.

Stop and Think

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| Guessing and parts swapping: Some inexperienced individuals may resort to guessing the problem or replacing parts randomly without a proper diagnosis. This can lead to wasted time, money, and may not even fix the actual issue. |

It is important that your TVET students understand that effective troubleshooting requires a systematic approach, thorough checks, diagnostic tools, and technical resources. Good communication with the vehicle owner and being open to learning and seeking help when necessary are also crucial aspects of successful troubleshooting.

In Section 1, we examined ways of teaching about the components and functions of the ICE. The next important step on the learning pathway is for students to have a thorough understanding of how all the parts of an ICE work together in a four-stroke engine, which is an[internal combustion](https://en.wikipedia.org/wiki/Internal_combustion) engine in which the [piston](https://en.wikipedia.org/wiki/Piston) completes four separate strokes while turning the crankshaft.

Understanding the components of the ICE, their functions and how they all combine and work together in a four-stroke engine is the base from which students can move on to learning about trouble shooting.

The following activity is intended to provide you with an approach to consolidating your students’ holistic conceptualisation of how the components of an ICE work together to facilitate the intake, compression, combustion, and exhaust processes that enable the ICE to convert chemical energy into mechanical work.

Activity 20: How does a four-stroke engine work?

**Suggested Time: 2 hours**

Design a lesson in which you recapitulate and consolidate how a four-stroke ICE works.

The purpose is for students to integrate their knowledge of how all the components of the ICE work together.

**Use the** [**lesson plan**](#Lesson_Plan_Template)[**template**](file:///C:/Users/a0010633/AppData/Local/Microsoft/Windows/INetCache/Content.Outlook/MJ4PILFA/Lesson%20Plan%20Template%20(1).docx) **provided to prepare your lesson**.

**Prepare learning and teaching support materials required for this lesson:**

The two videos listed below are useful resources. Plan and prepare an activity to engage your students actively with the video content of one or both videos. Think about an activity that you could design to provide your students with the opportunity to apply and demonstrate their conceptual understanding of how a four-stroke engine works.

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| **Title: How does a four-stroke engine work?**   * **Url:** <https://www.youtube.com/watch?v=gK22p1LOB8k> * **Duration:** 2.35 minutes * **License:** Creative Common CCBY   **Title: How a 4-stroke engine works**   * **Url:** <https://www.youtube.com/watch?v=dtnzvWdTHaE> * **Duration**: 3.07 minutes * **License:** Creative Common CCBY |

Below is a summary in point form of how a four-stroke engine works.

**How a Four-Stroke Engine Works**

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| 1. **Intake stroke:** The process begins with the intake stroke. The engine’s intake valve opens, and the piston moves down the cylinder. As it does, a mixture of air and fuel (petrol or diesel) is drawn into the cylinder from the intake manifold. 2. **Compression stroke:** After the intake stroke, the intake valve closes, and the piston moves back up the cylinder, compressing the air-fuel mixture. This compression raises the temperature and pressure of the mixture, making it more volatile and ready for combustion. 3. **Combustion (power) stroke:** Once the air-fuel mixture is compressed, a spark plug (in petrol engines) ignites the mixture; or in diesel engines, the high pressure and temperature of the compressed mixture cause spontaneous ignition. The mixture rapidly burns, creating a high-pressure gas that pushes the piston down with force. This downward movement of the piston is what generates the power. 4. **Exhaust stroke:** After the power stroke, the exhaust valve opens, and the piston moves back up again, but this time to expel the burned gases from the cylinder into the exhaust manifold and eventually out of the engine through the exhaust pipe. |

The engine keeps repeating these four strokes—intake, compression, power, and exhaust—in a continuous cycle, as long as it is running.

The energy generated by the power stroke is transmitted to the crankshaft through a connecting rod, and this rotational motion is what ultimately drives the vehicle’s wheels in a car or performs other work in machinery.

Modern engines are usually equipped with various systems to improve efficiency, such as variable valve timing, turbochargers, and direct injection, among others. These technologies help optimise the engine’s performance, fuel economy, and emissions.

Discussion of the activity

In keeping with the TPCK approach, how could you use the video(s) (i.e., the technological component of teaching) to support your students learning and ensure they engage actively with the content? One way could be to watch the video carefully first and to develop a worksheet for students to respond to, either individually or in pairs. This would help to focus the students’ attention on the video(s) and require them to engage with the content more actively.

What kind of activity could you design for students to do to demonstrate their conceptual understanding of the function of a four-stroke engine? You could ask students to use the description of how a four-stroke engine works*,* above, to draw a concept diagram/map. A concept map is a diagram to visually represents relationships between concepts and ideas. To remind yourself of how concept maps work, take a look again at Unit 1, where a number of concept maps are exemplified, see in particular, Figure 6.

The content of the textbox below provides a narrative, or written description of what students would need to depict graphically in their concept diagrams. If you require your student to draw a concept, be sure to provide the appropriate guidelines so that your students can successfully complete the task. Explain that the diagram should comprise a schematic representation of all the components of a four-stroke engine with each component linked sequentially with arrows to depict what happens, first, second, third, etc. to create the overall engine functionality. Remind students to:

* Arrange the elements in a clear and organised manner to depict the relationships and flow of the four-stroke engine’s operation effectively.
* Use arrows to show the flow of air, fuel, and exhaust gases.
* Label each stroke (intake, compression, power, exhaust).
* Label the key components (piston, connecting rod, crankshaft, valves, spark plug).

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| **How a four-stroke engine works**  **Four strokes:**   1. intake stroke 2. compression stroke 3. power stroke 4. exhaust stroke   **Intake stroke:**   * + Air and fuel intake: arrows pointing towards the cylinder, representing the flow of air and fuel.   + Intake valve: A labelled circle or rectangle representing the intake valve (open position).   + Piston movement: An arrow indicating the downward movement of the piston.   **Compression stroke:**   * Intake and exhaust valves: Both valves labelled, but intake and exhaust valve closed (sealing the cylinder). * Piston movement: An arrow indicating the upward movement of the piston, compressing the air-fuel mixture.   **Power stroke:**   * Spark plug: A labelled circle or symbol representing the spark plug, producing a spark. * Combustion: An explosion represented by lines or waves inside the cylinder. * Piston movement: An arrow indicating the downward movement of the piston, generating power.   **Exhaust stroke:**   * Exhaust valve: A labelled circle or rectangle representing the exhaust valve (open position). * Piston movement: An arrow indicating the upward movement of the piston. * Exhaust gases: Arrows pointing away from the cylinder, representing the expulsion of burned gases.   **Key components (connected to appropriate strokes):**   * Piston: A labelled shape representing the piston, connected to the intake, compression, power, and exhaust strokes. * Connecting rod: A line connecting the piston to the crankshaft, indicating power transfer. * Crankshaft: A labelled circular shape representing the crankshaft, connected to the connecting rod. * Valves: Labelled circles or rectangles representing intake and exhaust valves. * Spark plug: A labelled circle or symbol connected to the power stroke. |

Stop and Think

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| It is important to identify and implement methods of teaching that demonstrate the relationship between the purpose and functions of the components of the ICEs so that students have a comprehensive understanding of how the ICE converts chemical energy into mechanical work. This understanding frames all troubleshooting that pertains to ICEs. |

##### Troubleshooting internal combustion engines

Troubleshooting ICEs involves identifying and resolving issues that may affect their performance or functionality. The following are some common problems encountered in ICEs and potential troubleshooting steps that all TVET lecturers and students need to be familiar with:

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| 1. **Engine fails to start:**    * Check fuel supply: Ensure there is sufficient fuel in the tank and that the fuel pump is operating correctly.    * Verify spark: Inspect the spark plugs for wear or damage and ensure they are producing a spark.    * Check ignition system: Ensure the ignition system components, such as the ignition coil or control module, are functioning properly.    * Check air intake: Verify that the air filter is clean and not clogged. 2. **Engine misfires or runs roughly:**    * Inspect spark plugs: Fouled or worn-out spark plugs can cause misfires. Replace or clean them if necessary.    * Check ignition system: Ensure proper functioning of the ignition system components, such as the ignition coil, distributor, or spark plug wires.    * Check fuel delivery: Check the fuel injectors or carburettor for clogs or blockages. Clean or replace them as needed.    * Check air intake: Check for any restrictions or blockages in the air intake system. Clean or replace the air filter if necessary. 3. **Engine overheating:**    * Inspect cooling system: Check for coolant leaks, radiator blockages, or malfunctioning water pump. Repair or replace components as needed.    * Check coolant levels: Ensure the coolant levels are sufficient and that it contains the correct mixture of coolant and water.    * Check thermostat: Check the thermostat for proper operation. A faulty thermostat can cause overheating.    * Inspect fan and fan belt: Ensure that the cooling fan is functioning correctly and that the fan belt is properly tensioned. 4. **Excessive fuel consumption:**    * Check for fuel leaks: Inspect the fuel system for leaks, including the fuel lines, fuel injectors, or carburettor. Repair or replace components as necessary.    * Check oxygen sensor: A faulty oxygen sensor can lead to incorrect fuel-air mixture, resulting in increased fuel consumption. Consider replacing the sensor.    * Inspect air filter: A clogged, or dirty air filter can restrict airflow, leading to inefficient combustion. Clean or replace the air filter as required.    * Check tyre pressure: Check tyre pressure regularly, as underinflated tyres can increase fuel consumption. 5. **Engine performance loss:**    * Check for air intake restrictions: Inspect the air filter and intake system for blockages or restrictions. Clean or replace components as needed.    * Check fuel delivery: Verify fuel pressure and check for clogged fuel filters. Clean or replace filters if necessary.    * Check ignition system: Inspect ignition components such as spark plugs, ignition coil, and spark plug wires for wear or damage. Replace as needed.    * Perform a compression test (CT): Perform a CT to assess the condition of the cylinders and piston rings. Low compression may indicate internal engine problems. 6. **Engine fails to start:**    * Check fuel supply: Ensure there is sufficient fuel in the tank and that the fuel pump is operating correctly.    * Verify spark: Inspect the spark plugs for wear or damage and ensure they are producing a spark.    * Check ignition system: Ensure the ignition system components, such as the ignition coil or control module, are functioning properly.    * Check air intake: Verify that the air filter is clean and not clogged. 7. **Engine misfires or runs roughly:**    * Inspect spark plugs: Fouled or worn-out spark plugs can cause misfires. Replace or clean them if necessary.    * Check ignition system: Ensure proper functioning of the ignition system components, such as the ignition coil, distributor, or spark plug wires.    * Check fuel delivery: Check the fuel injectors or carburettor for clogs or blockages. Clean or replace them as needed.    * Check air intake: Check for any restrictions or blockages in the air intake system. Clean or replace the air filter if necessary. 8. **Engine overheating:**    * Inspect cooling system: Check for coolant leaks, radiator blockages, or malfunctioning water pump. Repair or replace components as needed.    * Check coolant levels: Ensure the coolant levels are sufficient and that it contains the correct mixture of coolant and water.    * Check thermostat: Check the thermostat for proper operation. A faulty thermostat can cause overheating.    * Inspect fan and fan belt: Ensure that the cooling fan is functioning correctly and that the fan belt is properly tensioned. 9. **Excessive fuel consumption:**    * Check for fuel leaks: Inspect the fuel system for leaks, including the fuel lines, fuel injectors, or carburettor. Repair or replace components as necessary.    * Check oxygen sensor: A faulty oxygen sensor can lead to incorrect fuel-air mixture, resulting in increased fuel consumption. Consider replacing the sensor.    * Inspect air filter: A clogged, or dirty air filter can restrict airflow, leading to inefficient combustion. Clean or replace the air filter as required.    * Check tyre pressure: Check tyre pressure regularly, as underinflated tyres can increase fuel consumption. 10. **Engine performance loss:**     * Check for air intake restrictions: Inspect the air filter and intake system for blockages or restrictions. Clean or replace components as needed.     * Check fuel delivery: Verify fuel pressure and check for clogged fuel filters. Clean or replace filters if necessary.     * Check ignition system: Inspect ignition components such as spark plugs, ignition coil, and spark plug wires for wear or damage. Replace as needed.     * Perform a compression test (CT): Perform a CT to assess the condition of the cylinders and piston rings. Low compression may indicate internal engine problems. |

It’s important to note that troubleshooting steps may vary depending on the specific type and model of the ICE. Additionally, it may be helpful to consult the engine manufacturer’s manual or seek professional assistance if the troubleshooting steps do not resolve the issue. When correct troubleshooting is performed, engine maintenance is easier.

In the following activity, one common problem has been selected from the list of common problems encountered in ICEs, above, and an exemplar activity developed. This models how TVET lecturers can design and implement an activity-based approach to teaching and learning about troubleshooting in ARM.

Activity 20: Troubleshooting: Automotive engine overheating

**Suggested time: 2 hours: Implementation**

**Objective:** The objective of this activity is to provide ARM students with hands-on experience in diagnosing and troubleshooting an overheating motor car engine. In this activity, TVET students will learn to identify and address common causes of engine overheating, enhancing their practical skills and problem-solving abilities.

**Prepare learning and teaching support materials required for this lesson:**

* A motor car with an overheating engine
* Basic automotive repair tools (socket set, wrenches, screwdrivers, pliers, etc.).
* Coolant and water for refilling the cooling system.
* Safety equipment (safety glasses, gloves, etc.).
* Flip chart for discussion.

Read through the steps of this activity carefully. Make the necessary preparations and implement this activity with your ARM students. If you cannot implement it exactly as it has been set out here, then adapt it to suit your context.

**Activity steps:**

1. **Pre-activity discussion: Assess students’ prior knowledge**
2. Ask students about the importance of engine cooling systems and the consequences of engine overheating.
3. Check student’s understanding of the components of the cooling system, such as the radiator, water pump, thermostat, cooling fan, hoses, and coolant reservoir.
4. Clarify and add information, building on what students’ have discussed.
5. **Scenario setup:**
6. Introduce the problem (motor car with an overheating engine). Explain that it has been deliberately prepared, and that the cause of overheating is known.
7. Highlight the importance of systematic troubleshooting and logical thinking when diagnosing problems.
8. **Group formation:**
9. Divide students into small groups of 3–4 members.
10. Assign each group to a specific aspect of the cooling system they need to inspect and troubleshoot (e.g., radiator, water pump, cooling fan, thermostat, hoses).
11. **Hands-on troubleshooting:**
12. Ask each group to start their inspection and troubleshooting process on their assigned components.
13. Encourage them to check for common issues, such as leaks, blockages, malfunctioning fans, or stuck thermostats.
14. Remind students to document their observations and possible causes during the process.
15. **Guided discussion:**
16. Gather all groups together for a guided discussion on their findings and potential causes of overheating.
17. Facilitate a brainstorming session, encouraging students to share their insights and collectively analyse the problem.
18. **Diagnosis and solutions:**
19. Request each group to finalise their diagnosis of the specific problem causing the engine overheating.
20. Ask them to propose possible solutions.
21. **Hands-on repair (optional):**
22. Depending on available time and resources, allow the students to attempt the repair or replacement of the faulty component under supervision.
23. If it’s not feasible to perform the repair on the spot, discuss the correct repair procedures and emphasise safety precautions.
24. **Recap and takeaways:**
25. Summarise the workshop by highlighting the importance of systematic troubleshooting and the significance of each cooling system component.
26. Discuss the students’ experiences and lessons learned during the activity.
27. Address any questions or uncertainties that arose during the workshop.
28. **Post-activity reflection with students:**

Encourage students to write a brief reflection on the workshop, what they learned, and how they can apply the knowledge in their future careers as automotive repair technicians.

Discussion of the activity

Troubleshooting is simply a process of diagnosis to determine the exact cause of a particular problem. It is very difficult to properly repair a vehicle without a proper diagnosis.

By conducting this hands-on workshop, automotive repair students will gain valuable experience in diagnosing and addressing engine overheating issues, preparing them for real-world challenges in their profession.

This activity modelled an approach to active learning in which students are required to undertake an authentic, real-life activity, in which they worked together in small teams to solve a problem applying a troubleshooting approach.

Were you able to implement the activity exactly in the way it was set out here, or did you need to adapt it to your own context?

Remember to reflect on the activity implementation in your [learning journal](#learning_journal). Record what went well and what may need to be approached differently next time. If you adapted the activity, you should also record the changes you made.

To consolidate your own professional development and expertise in implementing active learning, it is suggested that you choose another common problem encountered in ICEs from the list above, and use the exemplar activity as a model to develop another practical activity to support your student’s learning about troubleshooting in ARM in relation to the ICE.

#### Testing

Like the relationship between troubleshooting and maintenance, in automotive repair the relationship between testing and maintenance is also crucial for ensuring the proper functioning and longevity of vehicles. Both testing and maintenance play complementary roles in keeping vehicles in good condition and identifying and addressing potential issues.

Testing in automotive repair involves using diagnostic tools and techniques to identify problems or faults in the vehicle’s systems. This could be done through various methods, such as:

* On board diagnostics: Modern vehicles are equipped with OBD systems that can detect and report malfunctions related to the engine, transmission, emissions, and other critical systems. Mechanics use specialised scanners to access the vehicle’s OBD system and retrieve trouble codes that point to specific issues.
* Computerised systems: Vehicles are becoming increasingly complex, with many electronic components and sensors controlling various functions. Specialised testing equipment allows mechanics to evaluate these systems and identify any discrepancies or malfunctions.
* Manual testing: Mechanics may also perform manual tests, such as checking fluid levels, conducting visual inspections, and performing functional tests to diagnose problems that might not be immediately apparent through electronic systems.

Maintenance, as already discussed, refers to the regular upkeep and servicing of a vehicle to ensure it operates optimally and reliably over its lifespan. Maintenance typically includes regularly changing the engine oil and oil filter to maintain engine performance and prolong engine life; checking and replacing various fluids – essential for proper system operation; replacement of various filters; tyre maintenance; and brake inspection. In general, following the manufacturer’s recommended service schedule helps prevent potential issues and catch problems early.

Stop and Think

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| Testing and maintenance are interconnected in automotive repair. Here’s how they relate to each other:  ***Diagnosis and repair:*** When a vehicle exhibits symptoms of a problem (e.g., unusual noises, warning lights), testing is used to diagnose the specific issue. Once the problem is identified, maintenance tasks are often required to fix it. For instance, a diagnostic test might reveal a faulty oxygen sensor, and the maintenance procedure would involve replacing the sensor.  ***Preventive maintenance:*** Testing is not only used for troubleshooting existing issues but also for preventive purposes. Regular diagnostic testing can help identify potential problems before they escalate, allowing mechanics to perform maintenance tasks to prevent more extensive damage.  ***Maintenance confirmation:*** After performing maintenance, testing is often conducted again to ensure that the problem has been resolved and that the vehicle is functioning as intended. |

In summary, testing is essential for identifying problems in vehicles, while maintenance tasks are necessary for fixing those issues and keeping the vehicle in top condition. By combining both testing and maintenance, automotive repair professionals can ensure the safety, reliability, and longevity of vehicles for their owners.

##### Testing of internal combustion engines

Testing and quality checks play a crucial role in ensuring the performance, reliability, and compliance of ICEs.

The following two activities focus on teachingabout common testing and quality checks and designing authentic learning activities for TVET students to apply their skills and knowledge related to testing.

Activity 21a: Teaching testing and quality checks for internal combustion engines

**Suggested time: 1–2 hours - Implementation**

**Objective:** The objective of this lesson is to familiarise ARM students with common testing and quality checks conducted during the maintenance of ICEs. By the end of this lesson, students should be able to understand the importance of these tests and how they contribute to the overall performance and longevity of the engines.

**Prepare learning and teaching support materials required for this lesson:**

* Relevant handouts on engine maintenance and testing procedures
* Sample engine components for demonstration (if available)

Read through the lesson steps and activities carefully. Make the necessary preparations and implement this lesson with your ARM students. If you cannot implement it exactly as it has been set out here, then adapt it to suit your context.

**Lesson steps**

1. **Motivation and link to prior knowledge** (10 minutes)

* Begin the lesson by asking students to briefly explain the significance of ICEs in automotive vehicles.
* Ask students why they think that maintenance and testing to ensure engine performance and reliability is important?

1. **Understanding ICEs – addressing misconceptions** (optional, 10 minutes)

Depending on how the discussion in Step 1 goes, you may need to spend a little time recapping the basic components and working principle of ICEs, or possibly addressing some misconceptions that may have arisen in the initial class discussion.

It is also important to highlight the key areas susceptible to wear and tear that affect engine performance and to discuss the benefits of routine maintenance and testing in preventing major issues.

**Explain and demonstrate common testing procedures** (45 minutes)

**Note:** During the lesson, encourage active participation from the students by asking questions, providing real-world examples, and conducting practical demonstrations when possible. Provide handouts summarising the testing procedures for students to refer to later.

***Compression test***

CTs measure the compression pressure within the cylinders. This helps assess the condition of the engine’s piston rings, valves, and cylinder head gasket. Low compression can indicate internal engine problems, such as worn-out piston rings or valve leaks.

* Explain the purpose of a CT.
* Demonstrate the process of conducting a CT on an engine.
* Discuss how CT results indicate engine health.
* Conduct a question-and answer session (Q&A) with students.

***Leak test***

Leak testing involves checking for any leaks in the engine’s fuel system, cooling system, or oil system. Techniques such as pressure testing or dye penetration testing may be used to identify leaks and ensure proper sealing of components.

* Introduce the concept of a leak-down test.
* Show how to perform a leak-down test on an engine.
* Interpret the results to identify potential issues.
* Conduct a Q&A with students.

***Ignition system test***

An ignition system test is a diagnostic procedure that evaluates the health and functionality of the vehicle’s ignition system. The ignition system is responsible for generating and delivering the high voltage needed to create a spark at the spark plugs, which ignites the air-fuel mixture in the engine’s cylinders during the combustion process. It includes checking battery voltage, spark plugs, ignition coils, and ignition timing.

* Discuss the importance of a properly functioning ignition system.
* Explain the steps involved in conducting an ignition system test.
* Describe how to interpret the test results and diagnose ignition-related problems.
* Conduct a Q&A with students.

1. **Quality checks during maintenance** (30 minutes)

***Oil quality check***

* Explain the significance of regular oil checks and changes.
* Demonstrate how to inspect and assess the quality of engine oil.
* Discuss the consequences of neglecting oil maintenance.
* Conduct a Q&A with students.

***Cooling system inspection***

* Highlight the role of the cooling system in engine operation.
* Show how to inspect coolant levels and assess the cooling system’s condition.
* Explain the potential risks of a malfunctioning cooling system.
* Conduct a Q&A with students.

1. **Conclusion** (10 minutes)

* Recap the main points covered in the lesson.
* Emphasise the importance of regular maintenance and testing for ICEs.
* Encourage students to apply the knowledge gained in real-world automotive repair scenarios.
* Conduct a Q&A with students.

Discussion of the activity

Students require knowledge and skills in key testing procedures to be able to perform tasks and meet requirements set by the industries. It is therefore critical that TVET students are afforded the opportunity to apply their knowledge and put what they have learnt into practice by undertaking authentic, real-life tasks in workshop settings. Providing the students with such opportunities to is a basic responsibility of all TVET lecturers.

This activity has highlighted only selected testing procedures; there are other common testing and quality checks that ARM students should be familiar with. These include:

* **Performance testing:** Performance tests evaluate the engine’s power output, fuel efficiency, emissions, and overall operational performance. These tests may involve measuring parameters under controlled conditions, such as torque, horsepower, fuel consumption, and exhaust emissions.
* **Emissions testing:** Emissions testing is performed to ensure compliance with environmental regulations and standards. It measures the engine’s emissions of pollutants, such as carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC), and particulate matter (PM). Emissions testing is often mandatory for certification and regulatory compliance.
* **Dynamometer testing:** Dynamometer testing involves placing the engine on a dynamometer, which applies a load to simulate real-world operating conditions. This allows for the measurement of various performance parameters, including power, torque, fuel consumption, and emissions, while the engine operates under controlled conditions.

Use your [learning journal](#learning_journal) to reflect on this activity and to record what went well and what may need to be approached differently next time. If you adapted the activity, you should also record the changes you made.

While this activity focused on how to teach various aspects of testing, and encouraged students’ engagement in discussion, it did not provide an opportunity for students to apply their learning. This is addressed in the following activity.

Activity 21b: Performing a compression test on an internal combustion engine

**Suggested time: 60–90 minutes** **(to implement, depending on the number of students and available resources)**

**Objective:** The objective of this learning activity is to enable automotive repair students to demonstrate competence in conducting a CT on an ICE. Through hands-on practice, students will learn the importance of this diagnostic procedure and how to interpret the results to identify potential engine issues.

Read through the steps of this lesson and the learning activity carefully. Make the necessary preparations and implement this activity with your ARM students. If you cannot implement it exactly as it has been set out here, then adapt it to suit your context.

**Prepare learning and teaching support materials required for this lesson:**

* Engine with accessible spark plug holes (can be a standalone engine or a demonstration engine setup)
* Compression tester kit with the appropriate adapters for the engine’s spark plug holes
* Short guide on the CT procedure steps
* Safety goggles and gloves for each student

**Activity steps:**

1. **Prior knowledge and safety precautions**

(10 minutes)

* Start the activity with a brief discussion with students, ask them about the purpose and significance of a CT in automotive diagnostics.
* Emphasise safety precautions, including wearing safety goggles and gloves, and the importance of following instructions carefully.

1. **Support learning**(15 minutes)

* Having demonstrated the step-by-step process of conducting a CT on the engine in the previous lesson, spend a few minutes posing questions to your students to check that they remember the key CT procedure steps.
* Explain how to set up the compression tester and how to connect it to the spark plug holes.
* Discuss the correct cranking procedure and how to read and interpret the compression gauge.

1. **Hands-on practice** (30–45 minutes)

* Divide the students into small groups, each with an assigned engine and compression tester.
* Provide the necessary materials and equipment for each group.
* Remind the students to follow the guide provided to perform the CT on their assigned engine.
* Circulate among the groups to offer guidance, answer questions, and ensure safety protocols are being followed.

1. **Test and analysis** (10 minutes)

* After the students have completed the CT, gather the results from each group.
* Facilitate a discussion to analyse the test results and interpret the findings.
* Encourage students to identify any potential issues based on the compression readings and discuss possible causes.

1. **Conclusion** (5 minutes)

* Discuss and summarise with students the key takeaways from the activity and the importance of CTs in ARM.
* Encourage students to continue practicing the CT and apply this diagnostic tool in real-world scenarios.
* Address any additional questions or concerns from the students.

**Note:** This learning activity should be conducted in a well-ventilated area with appropriate safety measures in place. The instructor’s guidance and feedback during the hands-on practice are essential to ensure students grasp the concepts and techniques involved in the CT. By engaging in this practical learning activity, students will develop the necessary skills to confidently perform CTs and utilise this valuable diagnostic tool in their future automotive repair careers.

Discussion of the activity

Unlike theoretical education (reading and trying to memorise the content of textbooks and study guides) quality teaching and learning in TVET emphasises hands-on learning and practical experience. This approach ensures that graduates possess the skills and confidence to perform specific tasks effectively. This activity is intended to exemplify the breadth and depth of learning that is possible for students to achieve when they are provided with the opportunity of engaging with authentic tasks and real-world application of knowledge. The compression testing activity supports students to be able to:

* Understand the significance of compression testing as a vital diagnostic procedure to assess the health of an engine’s cylinders and internal components. They will learn why compression testing is an essential part of engine troubleshooting and maintenance.
* Become familiar with the tools used in compression testing, such as the compression tester, adapters, and pressure gauge. They will learn how to properly set up and use these tools for accurate testing.
* Perform a CT step-by-step on an actual engine. They will gain confidence in attaching the compression tester to the spark plug holes and cranking the engine to obtain compression readings.
* Interpret the compression readings obtained during the test. They will learn what different compression values indicate about the condition of the engine’s cylinders and components.
* Analyse the CT results and identify potential engine issues, such as worn piston rings, cylinder wall damage, valve problems, or a blown head gasket. They will learn how to pinpoint the source of engine performance problems through compression testing.
* Practice critical thinking and develop problem-solving skills related to engine compression issues. They will learn to make informed decisions on the appropriate course of action based on the CT results.
* Understand the role of compression testing in preventative maintenance. They will recognise how regular CTs can help detect problems early, leading to timely repairs and preventing more severe engine damage.
* Appreciate that safety is vitally important in automotive repair activities. Students will learn and adhere to safety precautions, such as wearing appropriate protective gear and ensuring the engine is in a safe state during testing.
* See the direct application of their knowledge and skills in real-world automotive repair scenarios. They will understand the practical significance of compression testing in their future careers.

Overall, the hands-on activity on compression testing provides a valuable learning experience for automotive repair students, allowing them to build essential skills, confidence, and a deeper understanding of the importance of compression testing in engine diagnostics and maintenance.

#### Maintenance

Maintenance and troubleshooting in automotive repair are closely related and often go hand in hand. Let’s explore how the skill of automotive maintenance follows on from and relates to troubleshooting in ARM.

**Preventative maintenance**

Automotive maintenance involves performing routine inspections, servicing, and repairs to keep a vehicle in good working condition. By conducting regular maintenance checks, such as oil changes, filter replacements, and fluid top-ups, technicians can identify potential issues early on. This proactive approach helps prevent major problems and reduces the likelihood of unexpected breakdowns, which in turn minimises the need for extensive troubleshooting.

**Early detection of problems**

During routine maintenance tasks, ARM students have an opportunity to inspect various components of a vehicle. With training and experience, they can recognise signs of wear, damage, or malfunctioning parts. Early detection means the issues can be addressed before they escalate into more significant problems. This makes subsequent troubleshooting process more manageable and cost effective and less time-consuming.

**Familiarity with vehicle systems**

Through regular practice maintenance work, ARM students become familiar with the specific models of vehicles that they work on. They better understand the intricacies of the motor vehicle’s systems, including the engine, transmission, suspension, and electrical components. When troubleshooting an issue, they have sufficient in-depth knowledge to pinpoint potential problem areas more accurately.

**Knowledge of common problems**

Automotive maintenance exposes ARM students to problems that are common to vehicles of a particular make or model. This accumulated experience helps students develop a mental database of likely issues and potential causes. When faced with a troubleshooting scenario, this knowledge base enables them to make educated guesses and efficiently narrow down the root cause of the problem.

**Diagnostic skills**

Both maintenance and troubleshooting require strong diagnostic skills. In automotive maintenance, students must diagnose routine issues and assess the overall health of a vehicle. In troubleshooting, they apply the same diagnostic skills to identify and fix more complex problems. The ability to diagnose problems accurately and methodically is therefore a fundamental skill that spans both maintenance and repair of motor vehicles.

**Problem-solving approach**

Automotive maintenance and troubleshooting share a problem-solving approach. In motor vehicle repair and maintenance, students are required to engage proactively to solve potential issues to keep the vehicle in good condition. In troubleshooting, they reactively address existing problems to restore the vehicle to proper working order, thus extending the life span of the vehicle. Both scenarios require critical thinking, logical reasoning, and a systematic approach to problem-solving.

In conclusion, the skill of automotive maintenance is closely related to troubleshooting in automotive repair. Maintenance provides ARM students with valuable insights into vehicle systems, common problems, and diagnostic approaches, all of which contribute to their ability to troubleshoot effectively. The combination of maintenance and troubleshooting expertise makes ARM students well-rounded and capable of handling a wide range of automotive issues.

The maintenance of internal combustion engines

Having explored and confirmed the close relationship between trouble shooting and maintenance, we focus specifically on maintenance of ICEs.

Maintenance is crucial to keep an ICE running efficiently and reliably. Proper maintenance helps prolong the engine’s lifespan, improves fuel efficiency, reduces emissions, and prevents costly breakdowns.

Importantly, familiarise yourself with the specific maintenance requirements and intervals outlined in the engine’s owner’s manual. Adhere to the recommended maintenance schedules to ensure optimal performance and longevity of the engine.

Here are some key routine maintenance tasks for ICEs:

* **Regular oil changes:** Engine oil lubricates the moving parts and helps prevent wear and friction. Follow the manufacturer’s recommendations for oil change intervals and use the recommended oil type and viscosity.
* **Air filter maintenance:** Clean or replace the air filter regularly to ensure proper airflow to the engine. A clogged air filter can reduce performance and fuel efficiency.
* **Spark plug inspection and replacement:** Check the spark plugs periodically for wear, deposits, or damage. Replace them according to the manufacturer’s recommendations. Properly functioning spark plugs are essential for efficient combustion.
* **Fuel system maintenance:** Clean or replace fuel filters and inspect the fuel lines regularly. Fuel additives can be used periodically to clean the fuel system and prevent deposits.
* **Cooling system maintenance:** Check the coolant levels regularly and inspect for leaks. Flush and replace the coolant as recommended by the manufacturer. Ensure that the radiator fins are clean and not obstructed.
* **Timing belt/chain replacement:** If the engine has a timing belt or chain, follow the manufacturer’s recommended replacement interval. A broken or worn timing belt/chain can cause severe engine damage.
* **Regular inspection of belts and hoses:** Check the condition and tension of belts and hoses, such as the fan belt, coolant hoses, and vacuum hoses. Replace any worn or damaged components to prevent overheating of the engine causing breakdowns.
* **Battery maintenance:** Check the battery terminals for corrosion and clean them if necessary. Ensure the battery is securely mounted and has sufficient charge. Replace the battery as needed, following the manufacturer’s recommendations.
* **Lubrication of moving parts:** Lubricate all moving parts, such as hinges, linkages, and pivot points, as recommended by the manufacturer. Use the appropriate lubricants for each component.
* **Exhaust system inspection:** Regularly inspect the exhaust system for leaks, damage, or rust. Ensure that the exhaust system is functioning properly, and that the catalytic converter is not clogged.
* **Regular tune-ups:** Periodically perform tune-ups, which may include checking and adjusting ignition timing, idle speed, and valve clearance. Consult the manufacturer’s recommendations or seek professional assistance for a complete tune-up.

Maintenance tasks may vary depending on the specific type of ICE (e.g., petrol, diesel) and the manufacturer’s recommendations. Always consult the engine’s manual for detailed maintenance instructions and guidelines.

Stop and Think

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| The maintenance activity that follows next models how demonstrations by TVET lecturers/workshop facilitators, coupled with the opportunity for students to engage in real-life application of learning, is a powerful teaching and learning method that supports students to construct their own understanding of the content being taught. |

Activity 22: Air filter inspection and maintenance

**Suggested time: 60 minutes (implementation)**

**Objective:** The objective of this activity is to familiarise ARM students with the importance of air filters in ICEs and teach them how to properly inspect and maintain air filters. By the end of the lesson, students should understand the role of air filters in engine performance and how regular maintenance can optimise engine efficiency.

**Learning and teaching support materials required for this lesson:**

* Internal combustion engine (could be a real vehicle or a demonstration engine)
* New air filter for demonstration purposes
* Used air filter to show typical wear and dirt accumulation
* Handout or visual aid detailing the steps for air filter maintenance
* Basic automotive repair tools (socket set, screwdrivers, etc.)
* Safety equipment (safety glasses, gloves, etc.)

As in Activity 17, read through the steps of this activity carefully. Make the necessary preparations and implement this activity with your ARM students. If you cannot implement it exactly as it has been set out here, then adapt it to suit your context.

**Activity steps:**

1. **Pre-activity discussion: Assess students’ prior knowledge**
2. Begin by asking students to explaining what they understand the significance of air filters to be in ICEs.
3. Ask students to what they think the impact of a clogged or dirty air filter on engine performance might be.
4. Consolidate the students’ discussion by emphasising that air filters protect the engine by preventing dirt, debris, and contaminants from entering the combustion chamber. Discuss how a clogged or dirty air filter will result in reduced fuel efficiency and power output, as well as potential damage to engine components.
5. **Air filter overview:**
6. Present a new and clean air filter to the students, explaining its construction and materials.
7. Show a used and dirty air filter, pointing out the accumulated dirt and debris that would otherwise enter the engine.
8. **Demonstrate air filter inspection:**

Demonstrate the step-by-step process of inspecting an air filter:

* Open the vehicle’s hood and locate the air filter housing.
* Remove the air filter cover or housing using appropriate tools.
* Take out the air filter and examine it for dirt, debris, and signs of damage.
* Discuss what constitutes a clean filter and what would be considered a filter needing replacement.

1. **Maintenance procedure:**
2. Provide students with a handout or visual aid detailing the steps for air filter maintenance, including cleaning and replacement.
3. In a controlled environment, have the students practice the maintenance procedures on a demonstration engine or a removed air filter.
4. **Troubleshooting exercise:**
5. Present students with scenarios where the engine’s performance is affected due to a dirty or clogged air filter.
6. In groups, have students diagnose the potential issue based on the symptoms and discuss how they would verify the problem by inspecting the air filter.
7. **Discussion:**
8. Encourage students to ask questions related to air filters, maintenance, and their impact on engine performance.
9. Facilitate a discussion on the importance of regular air filter inspection and maintenance in ensuring the longevity and efficiency of ICEs.
10. **Consolidation:**
11. Ask the students to summarise the key points covered in the lesson, reinforcing the importance of air filter maintenance in engine performance and longevity.
12. Provide students with additional resources or reading materials for further self-study.

Discussion of the activity

By engaging in this hands-on lesson activity, ARM students will gain the practical knowledge and skills required to check and maintain air filters effectively. This knowledge will prepare them for real-world challenges as they embark on their careers as automotive technicians.

The pedagogic value of a TVET ARM lecturer or workshop facilitator demonstrating an air filter inspection is multi-faceted and can be highly beneficial for the students. Seeing the instructor perform the air filter inspection in real-time allows students to observe the correct techniques and procedures. Visual learning is an effective way to grasp concepts, and students can better understand the steps involved in the inspection process. The demonstration also provides an opportunity for the lecturer/facilitator to demonstrate the correct procedure for accessing the air filter, removing it, and inspecting it thoroughly. This ensures that students learn the proper way to handle different types of air filter housings and avoid potential damage during the inspection. Troubleshooting insights into how a clogged air filter can affect engine performance can be shared by the lecturer/facilitator. By understanding the impact of a neglected air filter, students gain a deeper appreciation for the significance of this maintenance task.

Other benefits of using a demonstration include the opportunity for the lecturer/facilitator to share professional tips and tricks for efficient air filter inspection, such as using a flashlight to check for debris or understanding when to clean a filter versus replacing it. These insights come from real-world experience and can save time and effort during inspections. It is also a chance to integrate safety practices, modelled by the lecturer/facilitator wearing appropriate PPE and handling the air filter and housing with care.

Importantly, the demonstration places the air filter inspection in the context of working on a real vehicle, making it more relatable and practical for students. This context helps them connect theoretical knowledge to actual automotive repair scenarios. Following the demonstration with a hands-on maintenance experience enhances students’ learning by reinforcing theoretical knowledge with practical application. It also builds confidence in their ability to perform the inspection correctly.

Were you able to implement the activity exactly in the way it was set out here, or did you need to adapt it to your own context?

Use your [learning journal](#learning_journal) to reflect on this activity and to record what went well and what may need to be approached differently next time. If you adapted the activity, you should also record the changes you made.

You are encouraged to use or adapt the approach and methods followed in this activity to the teaching of other maintenance tasks such as oil checks or spark plug inspection and replacement.

## Conclusion

The key purpose of TVET is to provide individuals with practical skills, knowledge, and competencies necessary to enter the workforce or advance in their chosen career paths. To achieve this, TVET programmes should focus on bridging the gap between education and the labour market by developing relevant job-specific skills and preparing students for real-world work environments.

Technical and vocational education and training programmes must provide hands-on training, aligning with the needs of various industries. This emphasis on practical expertise is essential for meeting employers’ demands. Therefore, teaching and learning in TVET should be based on an approach that engages students in authentic tasks and real-world applications.

Successful hands-on learning and practical experience instils the necessary skills and confidence in graduates so they perform tasks effectively. Ultimately, a relevant, high-quality TVET qualification can empower individuals from diverse socio-economic backgrounds by providing them with valuable skills and access to better-paying jobs. This, in turn, fosters economic growth while promoting social and individual development.

Unit 4 will focus on authentic assessment in ARM.

# Unit 4: Authentic Assessment in Automotive Repair and Maintenance

## Assessment and its role in teaching and learning

This module focuses on methods of teaching ARM, emphasising the constructivist approach discussed in Unit 2, which promotes active learning and links learning to the students’ own experience and context. Emphasis has also been placed on the lecturer’s role in breaking down complex concepts to more manageable components or ‘chunks’ of learning, scaffolding and sequencing content to carefully build a learning pathway (see Figure 8). This approach marks a big shift away from information transmission and procedural teaching, in which the student is largely a passive recipient of content, to an approach in which lecturers enable students to engage actively with new knowledge and skills.

This shift in approach to teaching and learning requires a new way of thinking about how lecturers design the learning process. It also implies a shift in assessment design and practice away from testing what students know, mainly by requiring them to recall content learnt, to assessing their ability to apply knowledge and skills in a real-life context.

Stop and Think

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| **Three key learning design questions:**   1. **What do we want students to learn?** (the curriculum – content knowledge, skills, attitudes, and values) 2. **How can we help them to learn?** (lecturers make decisions about what approach and method to use to support and enable learning) 3. **How will we know if they have learned it?** (lecturers make decisions about how students will be assessed). |

As can be seen from these three key questions, assessment plays an integral role in teaching and learning. It provides the opportunity for valuable feedback on students’ progress, helping lecturers to evaluate the effectiveness of their teaching methods. Equally, assessment feedback is a vital part of students’ learning.

In this unit we discuss the role of assessment in general and authentic assessment in particular, as an integrated component of teaching and learning. We consider assessment **of** learning; assessment **for** learning; and assessment **as** learning.

In the field of ARM, authentic assessment is particularly important, due to the practical nature of the learning and skills involved. Authentic assessment aims to measure students’ abilities in real-world contexts that reflect the demands and challenges they will face in their future careers. Traditional forms of assessment, such as multiple-choice tests or written examinations, have their limitations regarding evaluating practical skills in ARM. While they may assess theoretical knowledge to some extent, they often fail to capture the full range of competencies required for success in the field.

Authentic assessment, on the other hand, offers a more comprehensive and meaningful approach to evaluating students’ abilities. Authentic assessment in ARM involves designing assessment tasks and activities that closely resemble the tasks that automotive mechanics are likely to encounter in the workplace. This may include diagnosing and troubleshooting mechanical problems (as discussed in Unit 3), conducting repairs, performing maintenance procedures, or interacting with customers. By simulating real-world situations, authentic assessments provide students with opportunities to demonstrate their skills, knowledge, and problem-solving abilities in a relevant context.

## Unit 4 outcomes

By the end of this unit, you should be able to:

1. Value the role of assessment in teaching and learning.
2. Explain and present the value of applying authentic assessment versus the application of traditional assessment in automotive repair and maintenance.
3. Design, develop, and administer authentic assessment tasks for assessing TVET students’ skills and knowledge related to all aspects of the ARM curriculum requirements.
4. Design and mark assessment rubrics and provide constructive written feedback to students.

## Assessment in education and training

In education and training, assessment is the process of gathering and discussing information from multiple and diverse sources to develop a deep understanding of what students know, understand, and can do with their knowledge because of their educational experiences. The process culminates when assessment results are used to improve subsequent learning (Huba & Freed 2000).

Assessment is the systematic basis for making inferences about the learning and development of students. It is the process of defining, selecting, designing, collecting, analysing (making data-driven decisions to improve teaching and curriculum design), interpreting, and using information to increase students’ learning and development (Erwin 1991).

## Thinking about assessment holistically

Assessment in education serves multiple purposes and can be categorised into three main types: assessment of learning, assessment for learning, and assessment as learning. Each type has its own distinct purpose and value in supporting student development and academic or vocational success.

The following activity provides an opportunity for you think about your own current understanding of the three main types of assessment.

Activity 23: Reflect on your current understanding of the three main types of assessment

**Suggested time: 30 minutes**

In your [learning journal](#learning_journal), briefly explain the purpose and value of the following assessment types in your own words:

1. Assessment **of** learning
2. Assessment **for** learning
3. Assessment **as** learning

Discussion of the activity

***Assessment of learning*** is most probably the most common form of assessment and possibly the type of assessment that you might be most familiar with. Compare what you have written about the purpose and values of this assessment type with the input provided here.

***Purpose****:* The primary purpose of assessment of learning is to evaluate and measure students’ achievement and performance after a period of learning. It is often used to determine the level of knowledge and skills students have acquired at the end of a unit, course, or academic year. This type of assessment is typically summative and results in grades or marks that are recorded in the students’ academic records.

***Value:*** Assessment of learning provides valuable information to educators, parents, and students themselves about the students’ overall academic progress. It helps identify areas of strength and weakness, informs decision-making about promotion or graduation, and allows for comparisons between students and across schools or educational systems. Additionally, it provides accountability for colleges and helps ensure that educational standards are met.

***Assessment for learning:***The DHET Assessment Guidelines place considerable emphasis on formative assessment of TVET students. Read the text below and evaluate your own understanding of the purpose and value of assessment for learningagainst what is written here.

***Purpose:*** Assessment for learning, also known as formative assessment, aims to provide ongoing feedback to students and lecturers during the learning process. The goal is to monitor students’ progress, identify learning gaps, and adjust instruction accordingly, to enhance learning outcomes. This type of assessment is embedded in the teaching and learning process and involves continuous and timely feedback.

***Value:*** The value of assessment for learning lies in its ability to support and enhance students’ learning experiences. By providing feedback and opportunities for improvement, it empowers students to take ownership of their learning and make necessary adjustments to succeed. For lecturers, formative assessment helps them understand students’ needs better and tailor their teaching strategies to meet them. It also enables early intervention to address challenges before they become significant barriers to learning.

***Assessment as learning****:* Finally, reflect on the idea of assessment as learning*.* Are you familiar with this type of assessment? Can you think how you may incorporate it in your own teaching in ARM?

***Purpose:*** Assessment as learning focuses on the process of self-regulation and metacognition in students. It encourages students to be actively involved in their own learning and development by monitoring their own progress, reflecting on their learning strategies, and setting themselves goals *for improvement. In this type of assessment, students engage in self-assessment and self-reflection.*

***Value:*** The value of assessment as learning lies in its capacity to foster metacognitive skills such as self-awareness and self-directed learning. When students become more aware of their learning strengths and weaknesses, they can develop effective study habits and strategies to become better learners. Assessment as learning promotes lifelong learning skills, critical thinking, and self-efficacy, which are essential for success in both academic and real-world contexts.

In summary, assessment of learning provides a snapshot of students’ achievement at a specific point in time; assessment for learning offers ongoing feedback to support current learning efforts; and assessment as learning empowers students to take charge of their own learning and develop essential metacognitive skills. When used in combination, these three types of assessment contribute to a holistic and effective educational experience.

Embedded within these three types of assessment are two main approaches to assessment, traditional and authentic.

## Traditional assessment

Even though approaches to teaching have started to change, and despite assessment’s integral relevance to education, many assessment techniques used today still resemble the ones used by previous generations. Looking at this reality we can say that assessment practices have tended to evolve more slowly than other pedagogical innovations, such as changes in methods, approaches, techniques, and use of resources, including the use of information and communication technology (ICT). One of the main reasons for that seems to be the difficulty in changing consolidated beliefs about assessment. However, these beliefs need to be rethought if we want to see real transformation in the way we teach for effective learning. In other words, we really need to change the paradigm of assessment, for it to better respond to the needs of new teaching and learning contexts and practices. This change is not necessarily an easy process.

Traditional assessment generally refers to formal tests that check students’ ability to recollect and reproduce the content studied during a course (Coombe et al., 2012). These are usually standardised timed tests that are applied to all students in the same conditions. However, these are not the only characteristics of traditional assessment. Other typical features underpin our practices, that we might have consolidated as the ‘right’ way to assess students. Brown (2004), for example, has systematised what traditional assessment entails. One feature he mentions is the use of assessment as a tool to merely check learning at the end of a term, in other words, its use in a summative way.

Final exams are a good example of summative assessment as they address the content studied during the whole course and determine if students can move on to the next grade or level. Another of these features is the attention given to establishing one single right answer. Traditional tests are usually focused on students giving the expected, correct answer so that there is little room for doubt or discussion. In this sense, they are easy to mark, and their results are highly reliable. Multiple-choice tests illustrate well this feature, because there is no room for subjectivity or flexibility in doing a test in this format – there can only be one accepted answer.

Considering these characteristics, we can clearly see that scores are of great importance in traditional assessment. In fact, they are so significant that the feedback students receive is often just the score or marks of the test. In this construct, it is the result of an end-of-term multiple-choice test, for example, that will tell students how well they did in the course. The focus of traditional assessment is therefore directed to the product of the assessment rather than the learning process.

Being summative, focusing on the final product, expecting standardised answers, and having feedback based on the score achieved, are not the only characteristics of this traditional assessment paradigm. Often assessment comprises a sequence of test items that may not have a clear context. For example, consider the MCQ:

*What is the Otto cycle?*

1. *The process of air-fuel mixture compression in the engine cylinder.*
2. *The sequence of events in a four-stroke ICE.*
3. *The method of cooling the engine using a water-based system.*
4. *The process of exhaust gas recirculation in modern engines.*

*Correct answer: b) The sequence of events in a four-stroke ICE.*

In this example, the question is decontextualised because it does not provide any specific context or real-world scenario related to ICEs. The question focuses solely on knowledge of the Otto cycle and tests students’ understanding of engine processes in an abstract manner. Besides often being decontextualised, traditional tests also tend to overlook the assessment of authentic interaction and application of skills and knowledge.

Assessment not only has the potential to influence teaching practices and curriculum, but also plays a significant role in shaping students’ perceptions of learning. Additionally, the emotional aspect of assessment cannot be overlooked, as it has a direct impact on students’ feelings about their cognitive progress (Nobre & Villas-Boas, 2020). It is crucial to emphasise that the type of motivation generated by assessment is often closely tied to how the results are utilised (Harris & McCann, 1994). Traditional assessment methods, which heavily rely on closed or fixed-choice test items and final scores, tend to foster extrinsic motivation (motivation that come from outside oneself, e.g. doing something for financial gain, promotion, praise or approval) rather than intrinsic motivation (the doing of an activity for its inherent satisfaction rather than for some external ‘reward’). In such cases, both students and lecturers are more concerned about the result of passing or failing than about the processes of understanding what has been learned, evaluating the effectiveness of teaching methods, identifying areas for improvement, developing essential skills or competencies, and measuring individual growth.

In the following activity you will begin to explore what authentic assessment might entail.

Activity 24: Brainstorm what you understand authentic assessment to be

**Suggested Time: 15 minutes**

With a colleague or two, brainstorm responses to the following questions and jot down your points in your [learning journal](#learning_journal).

1. What you think authentic assessment is?
2. What do you think are the advantages of authentic assessment?

Discussion of the activity

In your brainstorming exercise, did the points that you jotted down cover the key points made here?

* Authentic assessment tasks ask students to perform real-world tasks that demonstrate meaningful application of essential knowledge and skills. They are contextualised tasks, enabling students to demonstrate their competency in a more authentic setting.
* A well-designed authentic assessment should include a task for students to perform *and* a rubric by which their performance on the task will be evaluated. The criteria are given to the students up front, so that the student knows exactly what is expected of them.
* Because authentic assessment is based on *doing,* rather than remembering and recall, it promotes deeper learning.

Further features of authentic assessment are discussed below.

## Authentic assessment

Authentic assessment in education is an approach to evaluating a student’s learning progress and achievements that goes beyond traditional standardised testing. It focuses on measuring a student’s ability to apply knowledge and skills to real-world situations, tasks, and problems that are relevant to their academic and practical experiences.

The key features of authentic assessment include:

*Real-world relevance:* Assessments are designed to simulate or reflect the kind of tasks or challenges students might encounter in their future careers or daily lives, making the learning experience more meaningful and applicable.

*Contextualised learning:* Students are assessed in the context of a real-life environment, allowing lecturers to understand how well they can transfer knowledge and skills from the classroom to real-life situations.

*Active student involvement:* Authentic assessment requires active engagement from students, encouraging deeper understanding and critical thinking. Examples of tasks are hands-on projects, problem-solving exercises, or open-ended tasks.

*Performance-based tasks:* Instead of MCQs or memorisation tests, authentic assessment typically involves practical demonstrations, presentations, portfolios, or other forms of student performance.

*Multidimensional evaluation:* Authentic assessment evaluates various aspects of a student’s learning, including subject-specific knowledge, problem-solving abilities, creativity, communication skills, collaboration, and self-assessment.

*Formative and summative aspects*: Authentic assessment can be used for both formative purposes (ongoing evaluation during the learning process to provide feedback and improve learning) and summative purposes (final evaluation to determine the level of achievement at the end of a course or unit).

Authentic assessment not only helps lecturers better understand their students’ capabilities but also provides students with a more engaging and relevant learning experience. By focusing on practical application and critical thinking, authentic assessment promotes deeper learning and prepares students for success beyond the classroom.

Stop and Think

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| Traditional assessment (tests) is designed to take a snapshot of what the student knows/remembers at a particular point in time.  Authentic assessment tasks involve the student in work that makes learning more meaningful and builds on the students’ present knowledge and skills. |

**Table 2: Summary of key characteristics of traditional and authentic assessment**

|  |  |
| --- | --- |
| Traditional | Authentic |
| Selecting a response | Performing a task |
| Contrived | Real life |
| Recall/memorisation (remember/know) | Construct/apply (do, synthesise, create) |
| Lecturer structured | Student structured |
| Indirect evidence | Direct evidence |
| Normative-referenced | Criterion-referenced |

## Criterion-referenced versus normative-referenced assessment

Criterion referencing in authentic assessment refers to an approach to evaluation where students’ performance is measured against predefined criteria or specific learning standards, rather than being compared to the performance of other students. In this context, the focus is on assessing how well students have mastered specific knowledge, skills, or competencies based on established benchmarks or standards.

In a criterion-referenced assessment, the score shows whether test takers performed well or poorly on a given task. The emphasis is on measuring the individual student’s ability to complete the task and being able to pinpoint which part of the tasks are done well, and which may still need more work, based on which criteria have been met.

By employing criterion referencing in authentic assessment, lecturers can gain valuable insights into each student’s individual progress and proficiency levels, fostering a deeper understanding of their strengths and areas for growth. This approach also encourages a learner-centred approach, as students are encouraged to focus on their own development and learning, rather than competing with others.

In traditional assessment, normative-referenced tests provide information on how an individual student’s performance on the test compares to others in the class or group, i.e. the reference group.If 50% is a pass rate, all students who achieve less than 50% fail, and all students who achieve above 50% pass. Students are ranked: the student with the highest score or percentage comes first, the second highest comes second, and so on. In such a system of normative referencing, the emphasis is on a comparison of student’s achievements, rather than on an assessment of the individual student’s mastery of the task.

The following activity will help you to consolidate your understanding of the features and the advantages and disadvantages of both traditional and authentic assessment methods.

Activity 25: Prepare and make a presentation comparing traditional and authentic assessment in ARM

**Suggested time: 2 hours** (90 minutes to prepare the two assessment method examples and to put the PowerPoint Presentation together and 30 minutes to present)

Prepare a PowerPoint presentation in which you analyse and compare traditional assessment methods with authentic assessment methods in the context of ARM.

Design two assessment task on the topic *fuel system maintenance* to exemplify both types of assessments and explain their strengths and limitations.

Consider the relevance, validity, and practicality of each assessment approach.

Once you have prepared your PowerPoint, present it to your colleagues at your TVET college or to fellow students.

**Guidelines**

1. Identify and describe a traditional assessment method commonly used in ARM education and training.
2. Refer to the *DHET NCV Assessment Guidelines (AG) for Automotive Repair and Maintenance (ARM*), select the appropriate level and ascertain the assessment criteria related to fuel system maintenance in an ICE.
3. Select a ***traditional*** assessment method and prepare an assessment (a test) for your students on *fuel system maintenance*.
4. Select and describe an ***authentic*** assessment method suitable for evaluating ARM education and training.
5. Using the authentic assessment method that you have selected, prepare an assessment task for your students on *fuel system maintenance.* Apply the same assessment criteria that you used in your preparation of the traditional assessment task.
6. Discuss the strengths and limitations of both the traditional and the authentic assessment methods.
7. Compare and contrast the traditional and authentic assessment methods, highlighting their differences in terms of relevance, validity, and practicality in evaluating students’ abilities in ARM.

Discussion of the activity

1. When you identified a ***traditional*** *assessment method* what options did you consider? What types of questions or tasks did you formulate?

* *Multiple-choice questions:* These questions can assess students’ understanding of fuel system components, functions, and troubleshooting techniques.
* *True/False questions:* This format can test students’ knowledge of fuel system maintenance principles and safety practices.
* *Fill-in-the-blank or short answer questions:* This method is useful when asking students to provide specific names or descriptions of fuel system components and their functions.
* *Diagram labelling:* This method tests *s*tudents’ ability to read and understand a diagram of a fuel system. They must correctly label each component and state their roles in the system.

2. What *benefits* of applying traditional assessment methodsto assessfuel system maintenance did you identify?

Two that you may have thought about are:

* Written tests allow instructors to gauge students’ theoretical understanding of fuel system maintenance concepts.
* Traditional methods help maintain consistency in evaluation, making it easier to compare students’ performance.

Did you think of any others?

3. What *disadvantages* of applying traditional assessment methodsto assessfuel system maintenance did you identify**?** Did you include any of the following in your presentation?

* Written tests primarily measure theoretical knowledge and the ability to write it down, which may not fully reflect students’ ability to apply that knowledge practically in real-world scenarios. Fuel system maintenance involves hands-on skills and problem-solving, which are not effectively assessed through written tests alone.
* Written tests often encourage rote memorisation, rather than fostering a deeper understanding of concepts. Students may memorise facts temporarily without truly grasping the underlying principles of fuel system maintenance.
* Written tests lack authenticity because they do not replicate real-world situations students will encounter as automotive technicians. Authenticity is crucial for ensuring that students are adequately prepared for their future careers.
* Written tests are performed within time limitations. Time-limited tests may not give students sufficient opportunity to demonstrate their full understanding and abilities, particularly in complex subjects like fuel system maintenance.

Can you think of any others?

4. When you identified an *authentic assessment method* what options did you consider? What types of questions or tasks did you formulate? Did you think of using any of the methods listed below?

* Hands-on repair and maintenance: Students are presented with a real or simulated vehicle with a fuel system issue, and they must diagnose the problem and perform the necessary repairs. This could include tasks like fuel filter replacement, fuel injector cleaning, or fuel pump testing.
* Performance-based tasks: Give students a checklist of fuel system maintenance tasks. They must demonstrate their ability to carry the tasks out in a timely and accurate manner. Tasks could include inspecting fuel lines, testing fuel pressure, checking fuel injectors, and calibrating fuel system components.
* Diagnostic troubleshooting: When presented with a malfunctioning vehicle, students must identify the cause of the fuel system problem, using diagnostic equipment and procedures. They should explain their diagnostic process and provide a logical justification for their findings.
* Oral presentations and demonstrations: Students can prepare and deliver oral presentations or demonstrations explaining the workings of a fuel system, common maintenance tasks, and their practical application. This assessment method evaluates students’ communication skills and their ability to convey technical information effectively.

Can you think about how you might use a simulation, case studies, or practical collaborative projects to design and prepare an authentic assessment?

5. What *benefits* did you identify?

* Have you noticed that setting authentic assessment tasks for students provides a more comprehensive and practical evaluation of students’ competence in fuel system maintenance? By engaging students in real-world tasks and scenarios, these assessments better prepare them for actual automotive repair challenges and encourage deeper learning and skill development.
* Authentic assessment is also a learning activity: it is designed to improve the student’s skills. While a traditional test is designed to take a snapshot of what the student knows, the authentic assessment task involves the student in work that makes learning more meaningful and builds on the student’s knowledge and skills. As a student is engaged in an assessment task with assessment criteria, both learning and assessment are occurring.

6. What *disadvantages* of applying authentic assessment methodsto assessfuel system maintenance did you identify? Did you include any of these in your presentation?

While authentic assessments offer valuable insights into students’ practical application of knowledge and skills, they also come with some disadvantages and limitations:

* Authentic assessments can be more time-consuming and require additional resources to set up and evaluate, making them potentially challenging for large class sizes or institutions with limited facilities.
* Some aspects of fuel system maintenance (and other skills/knowledge) may be challenging to assess through authentic tasks alone. Essential theoretical concepts or less common scenarios might receive less emphasis.
* It may not always be feasible to replicate certain real-world scenarios in a controlled classroom environment, which can limit the authenticity of the assessment.
* Conducting authentic assessments for large groups of students is challenging. Educators may need to rotate groups of students, which requires careful planning in advance.
* Assessing authentic tasks may potentially involve subjective judgment from lecturers or workshop facilitators. However, this can be addressed by designing assessment rubrics that help to ensure consistency in grading and evaluation.

To address these limitations, a balanced approach that incorporates both authentic and traditional assessments (like written tests) can be beneficial. Using multiple assessment methods helps ensure a more comprehensive evaluation of students’ knowledge and skills in combustion engine fuel system maintenance, covering both theoretical understanding and practical application. It also allows educators to leverage the strengths of each assessment type while compensating for their respective limitations.

In the following section we will focus on how to design and develop authentic assessment tasks and activities.

Stop and Think

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| The authentic assessment task attempts to put the student in a ‘real-world’ context so that classroom learning can be put to authentic uses. |

## How to design authentic assessment tasks

Authentic assessments are often described as reverse planning models of teaching. Differently put, the content and learning activities need to be designed down from the stated assessment standards or outcomes. The authentic assessment tasks are designed to enable the student to apply or demonstrate their skills and knowledge. A rubric provides the criteria against which students are evaluated and finally the assessor (lecturer) applies the criteria to determine whether the desired performance has been met and to allocate the score achieved.

Carefully study the four questions in Figure 11, which provide a useful guide to designing authentic assessment tasks. **Note** how each question equates with a step in the design process.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Four questions to guide the design of authentic assessments**  1. What should students know and be able to do? This list of knowledge and skills becomes your:  **STANDARDS OR OUTCOMES**    2. What indicates that the students have met these standards? To determine if students have met these standards, you will design or select relevant . . .  **AUTHENTIC TASKS**    3. What does good performance on this task look like? To determine if students have performed well on the task, you will identify and look for characteristics of good the performance called . . .  **CRITERIA**    4. How well did the students perform? To differentiate student performance across criteria, you will create a . . .  **RUBRIC**   |  | | --- | |  |  |  |  | | --- | --- | | 5) How well didstudents perform? | 6) What do students need to improve upon? Information from the rubric will give students and lecturers feedback | | **CRITERIA FOR GRADING ASSESSMENTS** | **ADJUST TEACHING** | |

**Figure 11: Four questions to guide the design of authentic assessments**

**Source:** Adapted from Mueller, J. *Authentic assessment toolbox*<http://jfmueller.faculty.noctrl.edu/toolbox/howdoyoudoit.htm>

**Summary of steps**

1. Identify your standards/outcomes for your students.
2. For a particular standard or set of standards, develop a task your students could perform that would indicate that they have met these standards or outcomes.
3. Identify the characteristics of good performance on that task (criteria) that will indicate that your students have performed well, i.e., they have met the standards.
4. For each criterion, identify two or more levels of performance at which students can perform. The combination of the criteria and the levels of performance for each criterion will be your rubric for that task (assessment).

Fortunately, you do not have to develop an authentic assessment from scratch. You may already be using authentic assessment tasks in your classroom. Or, you may already have the standards written (don’t forget to refer to the NCV Assessment Guidelines for ARM) – which is the first and most important step in the process.

Perhaps you have a task but need to articulate the criteria for evaluating student performance on the task. Or, you may just want to develop a rubric for the task. Wherever you are in the process, you can use the information in the *Authentic Assessment Toolbox* to help you through the steps of creating authentic assessments.

Useful resource

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| --- |
| *Authentic Assessment Toolbox,* created by Jon Mueller – is a how-to text on creating authentic tasks, rubrics, and standards for measuring and improving student learning.  <https://jonfmueller.com/toolbox/> |

As stressed in the discussion of Activity 23, a well-designed authentic assessment task needs to include a rubric by which the student’s performance on the assessment task will be evaluated. Therefore, it is important to discuss rubrics and to expand on why they are important and what to consider when designing a rubric for an authentic ARM assessment.

## What is a rubric and what is it used for?

A rubric is typically an assessment or evaluation tool, usually in the form of a matrix or grid, used to interpret and mark students’ work against criteria and standards.

A rubric makes explicit a range of assessment criteria and expected performance standards. Assessors evaluate a student’s performance against all of these, rather than assigning a single subjective score.

A rubric:

* Makes students aware of all expectations related to the assessment task and helps them evaluate their own work as it progresses.
* Promotes the consistent application of learning expectations, learning objectives, or learning standards in the classroom, or works to measure their attainment against a consistent set of criteria.

You can use rubrics to structure discussions with students about different levels of performance on an assessment task (i.e., for giving students feedback). Rubrics are also a very useful tool that can be employed during peer-assessment and self-assessment.

In education and training settings, rubrics clearly define academic expectations for students and help to ensure consistency in the evaluation of academic work from student to student, assignment to assignment, or course to course. Rubrics are also used as scoring instruments to determine grades or the degree to which learning standards have been demonstrated or attained by students.

In courses, rubrics may be provided and explained to students before they begin an assignment to ensure that they understand learning expectations. Since the ARM field is practical in nature, it is especially important to explain the rubric you will use, before the students embark on the task.

Rubrics may take many forms, so acquaint yourself with a variety, to understand which rubric is suitable for which kind of tasks.

Rubrics include the following information:

* The educational purpose of an assignment, the rationale behind it, or how it connects to larger concepts or themes in a course.
* The specific criteria or learning objectives that students must show proficiency in to successfully complete an assignment or meet expected standards. An oral presentation rubric, for example, will establish criteria (such as speak clearly, make eye contact) on which students will be graded.
* The specific quality standards the lecturer will use when evaluating, scoring, or grading an assignment. For example, if the lecturer is grading an assignment on a scale of 1 to 4, the rubric may detail what students need to do or demonstrate to earn a 1, 2, 3, or 4. Other rubrics will use descriptive language (*does not meet*, *partially meets*, *meets*, or *exceeds* the standard, for example) instead of a numerical score.

Rubrics are generally designed to be simple, explicit, and easily understood. Rubrics may help students see connections between learning (what is taught) and assessment (what is evaluated) by making the feedback they receive from educators clearer and more detailed and useful. Educators as well as students understand from feedback what they may still need to teach/learn. Educators may use rubrics midway through an assignment to help students assess what they still need to do or demonstrate before submitting a final product. Rubrics may also encourage students to reflect on their own learning progress and help educators to tailor instruction, academicsupport, or future assignments to address distinct learning needs or learninggaps. In some cases, students are involved in the co-creation of rubrics for a class project or for the purposes of evaluating their own work or that of their peers.

When designing rubrics to assess performance in the ARM field, it’s essential to consider the specific skills, knowledge, and behaviours that are important for success in this industry. Read the general framework for developing assessment rubrics.

|  |
| --- |
| **General framework for developing assessment rubrics in ARM context**  1. **Identify key skill areas relevant to ARM**. These may include:   1. *Technical competence:* Assess the technician’s ability to diagnose and repair various automotive systems, such as engine, transmission, brakes, electrical, heating, ventilation, and air conditioning systems. 2. *Safety and compliance:* Evaluate adherence to safety protocols, including proper handling of hazardous materials, following safety guidelines, and complying with regulations and standards. 3. *Problem-solving and troubleshooting:* Assess the ability to identify and resolve complex automotive issues efficiently and effectively. 4. *Communication:* Evaluate communication skills, both written and verbal, and the ability to explain repairs and interact with customers. 5. *Time management:* Assess the ability to prioritise tasks, manage time effectively, and complete repairs within given timeframes. 6. *Tools and equipment:* Evaluate the proper use of tools, equipment, and technology relevant to the automotive repair field.   2. **Define the different levels of performance for each skill area**. This can be done using a rating scale, such as:   1. Advanced: Demonstrates exceptional proficiency and consistently exceeds expectations. 2. Proficient: Consistently performs at a high level of competence. 3. Competent: Meets the expected standards and requirements consistently. 4. Developing: Shows potential but requires further improvement and guidance. 5. Below expectations: Falls significantly below the expected standards and requires substantial improvement.   3. **Break down each skill area into specific criteria** or behaviours that demonstrate proficiency. For example:  a. Technical competence:   * + Accurate diagnosis of automotive issues   + Successful completion of repairs   + Proper use of diagnostic equipment and tools   + Knowledge of industry best practices and repair procedures   b. Safety and compliance:   * + Adherence to safety protocols   + Proper handling and disposal of hazardous materials   + Knowledge of relevant regulations and standards   c. Problem-solving and troubleshooting:   * + Systematic approach to problem-solving   + Efficient troubleshooting methods   + Ability to find and address root causes.   d. Communication and customer service:   * + Clear and concise communication with customers and team members   + Active listening skills   + Ability to explain repairs and maintenance procedures in layman’s terms.   e. Time management:   * + Effective prioritisation of tasks   + Timely completion of repairs   + Efficient use of available time   f. Tools and equipment:   * + Proper handling and use of tools   + Knowledge of specialised equipment and technology   + Ability to troubleshoot and resolve equipment issues.   g. Continuous learning:   * + Participation in training programs and workshops   + Pursuit of professional certifications   + Active engagement in industry-related forums or communities   4. **Create a rubric** for each criterion within the skill areas. Define performance expectations for each level (e.g., specific behaviours or outcomes) and assign appropriate point values or ratings.  Ensure that the rubric is clear, concise, and easy to understand. Use descriptive language to clearly articulate the different performance levels and criteria.  5. **Evaluate performance**, use the rubrics as a guide. |

**Key features of a rubric include:**

**Criteria:** Rubrics define the essential elements or aspects of the task or performance that will be evaluated. These criteria are usually broken down into specific components to provide a comprehensive assessment.

**Levels of performance:** Each criterion in a rubric is accompanied by multiple levels of performance that reflect varying degrees of achievement or proficiency. These levels often range from excellent to unsatisfactory or from high to low, depending on the context.

**Descriptors:** Each level of performance is described using clear and concrete language, providing evaluators with a detailed understanding of what to look for in the individual’s work or performance.

**Scoring:** Rubrics typically include a scoring scale that aligns with the levels of performance. This scale allows evaluators to assign a numerical score or rating to each criterion and overall performance.

In this section you will use the guide to designing authentic assessments and the framework for designing rubrics, above, to develop authentic assessment tasks with rubrics covering selected ARM topics examined in Units 1–3 of this module.

### Putting theory into practice: Designing authentic assessments and rubrics

Designing authentic assessments and rubrics requires careful consideration of the various factors discussed in the section above.

Activity 26: Design an authentic assessment task and prepare a rubric for assessing students’ understanding of health and safety requirements in ARM workspaces

**Suggested time: 60 minutes**

**1. State the outcomes that must be achieved in this assessment task.** It is essential to align the assessments with the learning objectives or outcomes of the ARM topic. The assessments should reflect the skills and knowledge that students are expected to acquire and demonstrate by the end of their training. (**Hint**: Start with the end in mind – reverse design – i.e. begin with assessment criteria and work towards learning content and activities.)

**2. State the purpose of the activity explicitly**. It is important for students to understand the aim of the task.

**3. Design and develop one or more authentic task(s) that your students need to perform**

Ensure that the task requires the students to apply knowledge and skills. It may include both theoretical and practical real-life components. The task must provide students with the opportunity to demonstrate that they have met the required standards or outcomes.

**4. Design an assessment rubric for the authentic assessment task that you have developed:**

1. *Identify the characteristics of good performance on that task, the criteria,* that, if present in your students’ work, will indicate that they have met the standards.
2. *Identify two or more levels of performance for each criterion* at which students can perform that will sufficiently differentiate between student performance for that criterion. The combination of the criteria and the levels of performance for each criterion will be your rubric for that task (assessment).
3. *Describe each level of performance*using clear and concrete language, providing evaluators with a detailed understanding of what to look for in the individual’s work or performance.
4. *Include a scoring scale that aligns with the levels of performance*. This scale allows evaluators to assign a numerical score or rating to each criterion and overall performance.
5. *Make the assessment rubric available upfront***.** Students need to understand how their work will be assessed. They need to have a clear idea about the criteria used to assess their tasks.

**5. Be explicit about expected time on task and resources to be used and/or consulted.** Time-management is crucial. If the assessment activities need be completed over a longer time, give milestones/sub-tasks that lead to the creation of products. Value and assess both process and product.

**6. Provide clear, unambiguous guidelines.**

* Delineate the steps needed to complete the activity. Students cannot complete the task/answer the question if they do not understand the instructions/questions.
* Direct the students to key resources/tools.

Discussion of the activity

Below are an exemplar of the kind of authentic activity and rubric that could be designed for it. Go through them carefully and use them as a guide to evaluate your own authentic assessment design and rubric.

**Activity**

Did you start your design by formulating one or more outcomes? For example:

***Outcome:*** *Students are able to demonstrate their understanding of the requirements of health and safety in the ARM workshop.*

Did you provide a clear description of the task(s)? 63

***Task description:*** *The task will involve both written analysis and practical application to ensure a comprehensive assessment of your knowledge and skills in maintaining a safe working environment* *in an automotive repair workshop.*

*Your task is to conduct a health and safety assessment of the college ARM workshop. Identify potential hazards and risks in the workshop and propose appropriate safety measures to prevent accidents and ensure a safe working environment for everyone.*

Did you prepare clear guidelines setting out the steps that the students need to take to complete the task?

***Guidelines for completing the task:*** *Prepare a written report:*

1. *Identify at least five potential hazards present in the automotive repair workshop.*
2. *Assess the risks associated with each hazard and explain their potential impact on the health and safety of individuals working in the workshop.*
3. *Propose specific safety measures and procedures to mitigate the identified risks. Provide clear justifications for each safety measure*.

**Rubric for assessment**

How many levels of performance did you include in your rubric? Did you describe the levels of performance and include a numerical score?

* The rubric exemplified below has five levels of performance.
* Two rows have been filled in as an example.
* When designing a rubric for a written output/artefact (a report, or PowerPoint presentation, etc.) as in this instance, you should include criteria for assessing the quality of the written pieces as well as the quality of the content.

Table 3 provides an exemplar of a rubric format.

**Table 3: Rubric for assessing authentic activity**: **Understanding health and safety requirements in an ARM workspace**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Criteria** | **5**  **Excellent** | **4**  **Good** | **3**  **Satisfactory** | **2**  **Needs Improvement** | **1**  **Unsatisfactory** | **TOTAL** |
| *Identifies potential hazards* | *Accurately identifies hazards* | *Identifies most* | *Identifies some* | *Identifies few hazards* | *Fails to identify any* |  |
| *Assesses the risks associated with each hazard* |  |  |  |  |  |  |
| *Explains potential impact of hazard on health and safety* |  |  |  |  |  |  |
| *Proposes specific safety measures to mitigate identified risks* |  |  |  |  |  |  |
| *Justifies each safety measure* |  |  |  |  |  |  |
| *Overall presentation of written report* | Organised and coherent | Mostly organised | Somewhat organised | Disorganised | Extremely disorganised |  |
| ***Possible total*** | 30 |  |  |  |  |  |
| ***TOTAL SCORE*** |  |  |  |  |  |  |

**Note:** The rubric assesses the TVET students’ understanding of health and safety requirements in ARM through a written report. The criteria and corresponding scoring levels are designed to reflect the quality and depth of their responses. The rubric ensures that students are evaluated based on their ability to identify hazards, assess risks, propose safety measures, and provide well-justified explanations for their choices. The overall presentation of the report (the artefact) is also assessed.

## Bloom’s Taxonomy: Its relevance to learning design and assessment

Traditional assessments often focus on recalling facts, concepts, and principles through questions. Some may go a step further by asking students to explain ideas in their own words. On rare occasions, students might have hands-on tasks to apply their knowledge and skills. However, in this module, we aim to move away from these older, less effective methods of teaching and assessment. Instead, we will adopt teaching and assessment techniques supported by sound educational research.

Research indicates that students learn best when they actively engage in the learning process and construct their understanding of new concepts and skills. Consequently, assessment tasks should also encourage active engagement. When designing assessments, it is crucial to move beyond mere recall of facts or occasional explanations. Instead, we should focus on authentic assessment that allows students to apply their knowledge and skills.

Moreover, it’s essential for lecturers to gradually increase the complexity of authentic assessment tasks over time. Students should be challenged to apply higher-order thinking skills, such as critical thinking and problem-solving. This involves developing their ability to analyse, synthesise, and evaluate new information presented to them.

Bloom’s Taxonomy is a widely recognised framework that categorises educational objectives and learning outcomes into a hierarchy of cognitive levels – levels of thinking and reasoning. This taxonomy or categorisation of learning levels was developed by Benjamin Bloom and his colleagues in the 1950s and has been revised over the years. The taxonomy consists of six levels, each representing a different cognitive skill set, from lower-order thinking skills to higher-order thinking skills. The levels, in ascending order of complexity, are:

1. **Knowledge**: Remembering or recalling facts, concepts, and principles.
2. **Comprehension**: Demonstrating an understanding of the material by explaining ideas or concepts in one’s own words.
3. **Application**: Applying acquired knowledge to solve problems or complete tasks.
4. **Analysis**: Breaking down complex information into its constituent parts and understanding the relationships between them.
5. **Synthesis**: Combining elements in novel ways to create a new understanding or product.
6. **Evaluation**: Making judgments based on criteria and evidence, critiquing ideas, or providing arguments.

**Relevance to designing learning:**

*Learning progression:* Bloom’s Taxonomy provides a clear progression of cognitive skills, starting with basic knowledge and moving towards higher-order thinking. This framework helps instructors design learning activities that scaffold students’ learning and gradually challenge them to develop more complex cognitive abilities.

*Targeted learning objectives:* By aligning learning activities with specific Bloom’s levels, educators can clearly define the intended learning outcomes. For example, if the objective is to assess students’ comprehension, instructors can design activities that require them to explain concepts or phenomena in their own words.

*Encouraging critical thinking:* Higher levels of Bloom’s Taxonomy (analysis, synthesis, and evaluation) focus on critical thinking skills. Designing activities that require students to analyse, evaluate, and synthesise information helps them develop critical thinking abilities, which are essential for problem-solving and decision-making.

*Differentiation and personalisation:* Bloom’s Taxonomy allows educators to cater to diverse students’ needs by offering activities at various cognitive levels. Students with different learning styles and abilities can engage with tasks that match their readiness and interests.

**Relevance to designing assessment activities:**

*Assessing depth of understanding:* Bloom’s Taxonomy helps educators create assessments that go beyond simple recall of facts. By incorporating questions and tasks that assess higher-order thinking, educators can gauge students’ depth of understanding and application of knowledge.

*Formative and summative assessment:* Bloom’s Taxonomy is valuable for both formative and summative assessment. Formative assessments can be designed to monitor students’ progress across the cognitive levels, while summative assessments can evaluate their overall mastery of the subject matter.

*Encouraging application and transfer:* Assessments that involve real-world scenarios and problem-solving tasks (application level) promote the transfer of knowledge and skills to practical situations.

*Validity and reliability:* A well-designed assessment that is aligned with Bloom’s Taxonomy enhances the validity and reliability of the evaluation process. It provides a clear structure for assessing the breadth and depth of students’ understanding.

In conclusion, Bloom’s Taxonomy serves as a valuable tool for designing learning and assessment activities that promote critical thinking, depth of understanding, and personalised learning experiences. It helps educators create a balanced and comprehensive approach to teaching and evaluating students’ progress.

See Appendix 3 for more detail on [Bloom’s Taxonomy](#_Appendix_3:_Bloom’s) and a ‘verb wheel’, also based on Bloom’s Taxonomy which is a useful tool to support the design of authentic assessment activities.

## The importance of assessment criteria and rubrics

Including clear criteria when designing an assessment rubric is essential. Not only does it ensure that both students and lecturers are clear about the specific expectations of the assessment task, but it also clarifies the level of proficiency required. Clear criteria facilitate constructive feedback, allowing students to understand their strengths and identify areas for improvement. Specific feedback empowers them to enhance their skills and knowledge effectively, leading to an improved overall quality of education and a better learning experience for students.

Rubrics are important in ensuring that assessment is fair and serves its purpose. A well-designed rubric can ensure that assessment remains focused on developing a student and can assist the lecturer to understand the teaching process better. Below is a scenario that exemplifies the importance of rubrics in assessment.

Stop and think about this scenario

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| **Scenario:**  Mr Johnson, an ARM lecturer at a TVET college set his students a practical assessment task that he believed would challenge the students to apply their knowledge and skills in real-world scenarios.  The students gathered in the workshop, where a faulty four-stroke engine was placed on a workbench. Their task was to identify and troubleshoot various issues affecting the engine’s performance. Some students focused on diagnosing electrical problems, others on mechanical issues, and a few emphasised fuel system problems.  A few days later, when the results were released, students were surprised and disappointed with their marks. Even though everyone in the class was sure that they had followed the assessment guidelines carefully, most had only just scrapped through. They had expected their results to have been much better. Many of them felt that they had put in their best effort and deserved higher scores. They had also hoped for detailed feedback on their performance to identify areas for improvement, but the feedback provided was brief and vague.  The students decided that the class representative should meet with Mr Johnson and tell him that they were concerned about the assessment results and feedback. Mr Johnson replied that most students had focused on diagnosing electrical problems instead of on the mechanical issues, so he had no option but to give low marks.  **Discussion of scenario:**  What was the problem here? There were no explicit performance criteria to provide guidance to students undertaking the given assessment or to guide the lecturer in assessing them. A rubric in this instance, could have helped to address this situation.  How do you think the students felt? Probably the same way that students in any course might feel when the criteria for an assignment are not provided or are ambiguous and the assessment process seems arbitrary. When the curriculum is ‘hidden’, students who can’t guess what the expectations are will be more at risk than those who know how to ‘play the game’ (Jackson, 1990). A good rubric can take the mystery out of assignments for all students. As Eisner notes:  *More than what educators say, more than what they write in curriculum guides, evaluation practices tell both students and teachers what counts. How these practices are employed, what they address and what they neglect, and the form in which they occur speak forcefully to students about what adults believe is important.*  (Eisner, 1991, p. 81) |

Setting an authentic assessment on troubleshooting fault finding in a four-stroke engine, without providing a rubric or assessment criteria, can lead to several problems for ARM students:

*Ambiguity:* Without clear assessment criteria, students may not fully understand what is expected of them in the task. This ambiguity can result in confusion and uncertainty about the specific skills and knowledge they need to demonstrate.

*Lack of focus:* Students may struggle to prioritise their efforts and focus on the most critical aspects of the troubleshooting process. They might spend too much time on trivial issues or overlook essential components because they are unsure of what the assessment prioritises.

*Inconsistent evaluation:* The absence of a rubric can lead to inconsistent evaluation as the lecturer/ workshop facilitator relies on their memory of what they had taught, rather than on the set of criteria. Some may grade leniently, while others might be overly strict, resulting in unfair and unreliable grading.

*Miscommunication:* Without a clear rubric, students might misinterpret the assessment’s objectives (as illustrated in the scenario above) and emphasise different aspects of the task, leading to misunderstandings and misalignment between what instructors intend to assess and what students attempt to showcase.

*Subjective grading:* In the absence of objective assessment criteria, grading can become subjective and open to bias. Students may feel their grades are based on personal preferences or factors unrelated to their performance.

*Lack of motivation:* When students are uncertain about how they will be assessed, they may become demotivated and less engaged in the learning process. They may perceive the task as arbitrary or unfair, leading to reduced effort and interest.

*Reduced learning effectiveness:* A well-designed rubric with clear assessment criteria can serve as a guide for students, helping them understand their strengths and weaknesses and providing direction for improvement. Without it, students might miss valuable learning opportunities.

*Limited feedback:* Without specific assessment criteria, feedback provided to students might be vague or lack actionable insights for improvement. Detailed feedback tied to a rubric enables student to understand precisely where they can enhance their skills.

To avoid these problems, it is crucial to design a rubric with clear assessment criteria that outline the specific skills, knowledge, and behaviours expected from the students during the troubleshooting task. The rubric should be communicated to the students in advance, ensuring they understand the grading process and can align their efforts accordingly. This approach promotes fairness, consistency, and better learning outcomes in the assessment of automotive repair students.

Activity 27: Design the criteria for a rubric for an authentic activity

**Suggested time: 60 minutes**

1. With a colleague, design and discuss the criteria to be used in a rubric for an authentic assessment activity on troubleshooting fault finding in a four-stroke engine.
2. To prepare yourself for the task, you can access lots of very useful information and examples of authentic assessment tasks and rubrics on the *Authentic Assessment Toolbo*x website: <https://jonfmueller.com/toolbox/>
3. Use the following tools to help you design the assessment criteria: [Bloom’s Taxonomy](#_Appendix_3:_Bloom’s) and the ‘verb wheel’.
4. Do the activity in your [learning journal](#learning_journal).

Discussion of the activity

Read through and reflect on the factors that you should take into consideration when designing a rubric. Did you factor in all these, or some of them? Do you think that there might be too many criteria linked to each aspect of the assessment? Or do you think that having such a comprehensive set of criteria is actually very useful? As you read through them, decide which are the most important.

Did you think of including criteria for the troubleshooting report, or just for the content of the report? As preparing various reports is also one of the learning outcomes in ARM, it is important to set criteria for assessing not just the content but also the format and structure of the report itself.

After reading through all these factors that need to be considered, reflect on how you might strengthen your own rubric design.

When troubleshooting an engine, various criteria need to be considered with regard to performance level: problem identification, solution implementation, efficiency and timeliness, communication and documentation:

**Performance levels:**

1. Advanced: Demonstrates exceptional proficiency in troubleshooting engine issues, consistently exceeding expectations.
2. Proficient: Consistently performs at a high level of competence in troubleshooting engine issues.
3. Competent: Meets the expected standards and requirements in troubleshooting engine issues consistently.
4. Developing: Shows potential but requires further improvement and guidance in troubleshooting engine issues.
5. Below expectations: Falls significantly below the expected standards and requires substantial improvement in troubleshooting engine issues.

**Specific criteria:**

1. Diagnostic process:
   * Advanced: Systematically follows a comprehensive diagnostic process, considering various potential causes and utilising advanced diagnostic tools.
   * Proficient: Follows a logical diagnostic process, considering multiple possible causes and utilising appropriate diagnostic tools.
   * Competent: Follows a basic diagnostic process, considering common causes and utilising standard diagnostic tools.
   * Developing: Demonstrates an understanding of the diagnostic process but may lack consistency or overlook certain steps.
   * Below expectations: Fails to follow a structured diagnostic process and lacks understanding of proper troubleshooting techniques.
2. Problem identification:
   * Advanced: Accurately identifies the root cause of engine issues with precision, utilising advanced knowledge and expertise.
   * Proficient: Consistently identifies the correct cause of engine issues, applying relevant knowledge and experience.
   * Competent: Generally, identifies the cause of engine issues, considering common causes and applying fundamental knowledge.
   * Developing: Sometimes identifies the cause of engine issues but may miss key factors or misdiagnose problems.
   * Below expectations: Struggles to identify the cause of engine issues accurately and often makes incorrect diagnoses.
3. Solution implementation:
   * Advanced: Successfully implements effective solutions, demonstrating expertise in repairing engine issues and utilising advanced techniques.
   * Proficient: Consistently implements appropriate solutions, utilising standard repair procedures and techniques.
   * Competent: Implements basic solutions effectively, following standard repair procedures.
   * Developing: Implements solutions but may require guidance or supervision to ensure proper execution.
   * Below expectations: Struggles to implement solutions effectively, resulting in incomplete or incorrect repairs.
4. Efficiency and timeliness:
   * Advanced: Troubleshoots engine issues efficiently and completes repairs within optimal timeframes.
   * Proficient: Troubleshoots engine issues effectively and completes repairs within reasonable timeframes.
   * Competent: Demonstrates satisfactory efficiency in troubleshooting and repairs, meeting acceptable timeframes.
   * Developing: Requires additional time and guidance to troubleshoot engine issues and complete repairs.
   * Below expectations: Demonstrates significant delays or inefficiencies in troubleshooting and repair processes.
5. Documentation and communication:
   * Advanced: Provides clear and detailed documentation of the troubleshooting process and repairs performed and communicates effectively with team members and customers.
   * Proficient: Provides adequate documentation of the troubleshooting process and repairs and communicates relevant information to team members and customers.
   * Competent: Provides basic documentation of the troubleshooting process and repairs and communicates essential information to team members and customers.
   * Developing: Inconsistently provides documentation and communication, requiring improvement in clarity and completeness.
   * Below expectations: Fails to provide proper documentation or communicate effectively with team members and customers.

Stop and Think

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| Authentic assessments should provide opportunities for students to receive constructive feedback from lecturers/workshop facilitators or industry professionals. Feedback is an integral part of the learning process, enabling students to identify areas for improvement and refine their skills. Incorporating feedback mechanisms into the assessment design ensures that students receive timely and meaningful guidance on their performance, helping them progress and grow in their ARM competencies. |

When you read the scenario above, did you notice that not only were the students puzzled by the disappointing results of the assessment, but that their confusion and uncertainty was worse because they had not received any detailed feedback? Feedback may have helped them to better understand why they had not performed as well as they had hoped in their assessment.

**Extract from the scenario**

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| *A few days later, when the results were released, students were surprised and disappointed with their marks. Even though everyone in the class was sure that they had followed the assessment guidelines carefully, most had only just scrapped through. They had expected their results to have been much better. Many of them felt that they had put in their best effort and deserved higher scores. They had also hoped for detailed feedback on their performance to identify areas for improvement, but the feedback provided was brief and vague.* |

## Giving assessment feedback: Beyond ticks and crosses

Feedback has a significant impact on learning (Cohen & Singh, 2020); it has been described as “the most powerful single moderator that enhances achievement” (Hattie, 1999). The main objectives of feedback are to:

* Justify to students how their mark or grade was derived.
* Identify and reward specific qualities in student work.
* Guide students on what steps to take to improve.
* Motivate them to act on their assessment.
* Develop their capability to monitor, evaluate and regulate their own learning. (Nicol, 2010)

Assessment feedback should be viewed as an integral facilitator of teaching and learning.

To benefit student learning, feedback needs to be aligned with the assessment criteria. A rubric can help you as you mark, ensuring that you don’t overlook critical components of the intended learning outcomes in your feedback.

You can use an assessment rubric:

* To guide the interpretation and grading of student work.
* To help you frame feedback by making explicit the relationship between assessment criteria and the grade.
* To help students understand the rationale for their grade through criterion-based feedback.

To be of benefit to student learning, feedback needs to be:

* *Constructive.* As well as highlighting the strengths and weaknesses of a given piece of work, it should set out ways in which the student can improve the work.
* *Timely.* Give feedback while the assessed work is still fresh in a student’s mind and before the student moves on to subsequent tasks.
* *Meaningful*. It should target individual needs, be linked to specific assessment criteria, and be received by a student in time to benefit subsequent work.

Activity 28: Modes in which assessment feedback can be given in ARM

**Suggested Time: 15 Minutes**

Work with a colleague or two and brainstorm as many different forms or modes in which you think feedback can be provided to ARM students.

Write these down in your [learning journal](#learning_journal).

Discussion of the activity

Providing effective assessment feedback to automotive repair students is crucial for their learning and improvement. How many ways were you able to identify for giving feedback to students? Read the suggestions below and see how they compare with what you have written in your learning journal.

**1. Establish clear rubrics and grading criteria:** Establish clear rubrics and grading criteria for assignments and practical tasks. Once the student’s assessment task has been evaluated using the criteria as set out in the rubric, this can be shared with students so that they can see exactly how they scored on each aspect of the activity. This will help to pinpoint strengths and weaknesses.

**2. Provide written feedback on assignments:** After students’ complete assignments, provide written feedback that highlights their strengths and areas for improvement. Be specific and constructive, pointing out steps in the repair process where they excelled or made mistakes.

Example: *“Great job diagnosing the engine issue accurately and following the repair manual. However, pay more attention to torque specifications when tightening bolts to avoid over-tightening.”*

**3. Use lists of common mistakes or issues:**To increase efficiency, when marking written assignments develop a numbered list of common mistakes or issues, along with tips on how to address them. Then, when individual students make one of these common errors, you only need to write the issue number. You may want to distribute the feedback sheet to the students while they are working on the assessment, as well as when returning the class assignments.

**4. Provide verbal feedback during practical workshop sessions:** While students are working on hands-on repair tasks, offer real-time verbal feedback. This allows you to correct any mistakes immediately and encourage good practices.

Example: “*Well done on removing the brake callipers smoothly. Now, remember to clean and lubricate the guide pins before reassembling to prevent sticking.”*

**5. Schedule one-on-one feedback sessions:** Schedule individual feedback sessions to discuss students’ overall progress and performance. This personalised approach helps address specific concerns and set goals.

Example: “*Let’s go through your performance in the last few weeks. You’ve improved on electrical repairs, but we need to focus on enhancing your diagnostic skills furthe*r.”

**6. Encourage peer review:** Encourage students to review each other’s work and provide feedback. Peer feedback fosters teamwork and allows students to learn from one another.

Example: “*Work in pairs and assess each other’s brake repair procedure. Share what you think was done well and offer suggestions for improvement.”*

**7. Provide video feedback:** Record students’ repair work during practical sessions and provide feedback by reviewing the video together. This visual approach allows students to see their actions and understand areas that require improvement.

Example: “*Let’s watch the video of your transmission repair. Notice how you missed a step during disassembly. Try to identify that step and see how it impacted the overall process.”*

**8. Incorporate self-reflection exercises:** Incorporate self-assessment exercises where students evaluate their own performance. This helps them identify areas for improvement and take ownership of their learning.

Example: “*Take a few minutes to reflect on your suspension repair. What do you think you did well, and what could have been done differently?”*

**9. Provide learning resources:** Provide additional learning resources, such as articles, videos, or books, that can help students improve their skills in specific areas.

Example: “*To enhance your understanding of hybrid vehicle repairs, check out these online resources and complete the supplemental reading*.”

Remember, the key to effective feedback is to be specific, timely, and encouraging. By using a variety of feedback methods, automotive repair students can receive the support they need to excel in their learning journey.

The last activity of this module provides an opportunity for TVET lecturers to practice giving constructive feedback to students.

Activity 29: Giving feedback to ARM students on motor vehicle testing

**Suggested Time: 3 hours** (planning, preparation and writing feedback reports)

1. Design, prepare, and implement an authentic assessment task with a rubric that can be used to assess students’ understanding of motor vehicle testing in ARM.

2. Design a rubric with clearly specified assessment criteria and make it available to your students ahead of time.

3. Mark the assessments using the rubric.

4. Provide each student with written feedback based on how they scored on each aspect or dimension of the rubric.

Discussion of the activity

Providing constructive feedback to students on their assessment of motor vehicle testing is essential for helping them understand their strengths and areas for improvement.

When giving positive reinforcement, don’t just make generic comments like, “good work”. Your feedback needs to be targeted, e.g. “*You explained* *identifying the specific testing procedure for engine compression clearly and accurately*.” Or “*You demonstrated a solid understanding of the different types of emissions tests.”*

Feedback may also comprise clarifications and explanations, e.g. *“You mentioned the importance of checking the battery voltage, but you need to expand more on why it’s crucial and how it affects the vehicle’s performance.”* Or *“When discussing the on board diagnostic (OBD)-II test, it would be helpful to include some common reasons for failed emissions readings.”*

Feedback is also an opportunity for lecturers to correct misconceptions, e.g. *“You mentioned that a misfire occurs when the air-fuel mixture is too lean. However, it’s actually when the mixture is incorrect or incomplete, either too lean or too rich.” Or* “*You stated that the catalytic converter reduces NOx emissions, but it primarily works to reduce harmful pollutants like carbon monoxide and hydrocarbons.”*

To encourage critical thinking, affirm what the student has done well, but also try and challenge the student to think deeper, e.g. “*Your explanation of the compression test was good but think deeper about how variations in compression readings can help diagnose specific engine problems.” Or “You’re on the right track with the emission control system test, but consider discussing how different components interact to achieve optimal emissions.”*

Feedback on attention to detail is important in many subjects, including in ARM. Students need to be supported to think logically and sequentially, to accurately follow through on certain ARM procedures. It is therefore important that lecturers pinpoint instances where high levels of detail are required, e.g., “*When describing the steps of a coolant pressure test, ensure you list the proper safety precautions and the significance of the test for identifying coolant leaks.”* Or *“Make sure to specify the correct intervals for performing routine emissions testing based on local regulations.”*

Remember, feedback should be constructive and supportive, aiming to guide students in their learning journey. It should focus on both the strengths displayed and areas where improvement is needed, offering specific suggestions for enhancing their understanding of motor vehicle testing.

## In conclusion

Designing authentic assessments in ARM is crucial for evaluating students’ practical skills, knowledge, and problem-solving abilities in a relevant and meaningful way. By aligning assessments with programme objectives, incorporating practical tasks, and providing constructive feedback, lecturers can better prepare students for the challenges they will face in the automotive industry. Through authentic assessment, students can develop the skills necessary for success and gain the confidence to excel in their future careers as ARM professionals.

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# Conclusion to the module

In conclusion, this module on active methods of teaching and assessing ARM in TVET colleges has provided valuable insights into enhancing the learning experience for students and improving their practical skills in this dynamic field.

By adopting active teaching methods, such as hands-on workshops, group discussions, and problem-solving exercises, lecturers and workshop facilitators can actively engage students and foster a deeper understanding of automotive concepts. The use of real-world scenarios and case studies allows students to apply their knowledge in practical situations, preparing them for the challenges they may face in the industry.

Moreover, the incorporation of active assessment methods, such as performance-based tasks, projects, and simulations, enables a comprehensive evaluation of students’ competencies beyond traditional written exams. These assessments encourage critical thinking, teamwork, and effective communication skills, which are essential for success in the ARM profession.

Embracing active teaching and assessment methods not only enhances students’ learning experiences but also strengthens their problem-solving abilities and practical skills. By nurturing a student-centred and interactive learning environment, TVET colleges can produce well-rounded automotive technicians capable of meeting industry demands and contributing positively to the future of ARM.

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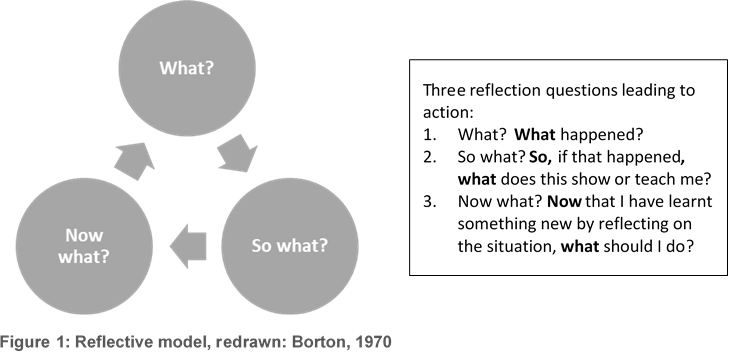
Appendices

## Appendix 1: Learning journal template

The Adv. Dip TVT module called [Reflective Practice](https://oerafrica.org/system/files/13691/assets/13702/advdiptvtmodulereflective-practice.docx?file=1&type=node&id=13702&force=0) covers the concept of reflection in the life of a TVET lecturer. The simplest reflective model in unit 2, is that of Terry Borton (1970).

Using a journal for reflection

Throughout the Advanced Diploma modules, we encourage you to use a learning journal. Start your learning journal at the beginning of the programme, and keep it regularly updated throughout. In each *activity* or *stop and think* reflect on the questions or problems raised.

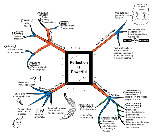
For your learning journal, you can use:

* an A4 notebook with at least 100 pages lined and blank, or
* this template.

In your journal write notes and reflections, complete activities, add drawings, letters, stick in pictures or objects, use pens or paint or do anything else that makes it meaningful for you. Record your thoughts verbally, using the voice recorder on your cell phone, or even take a video.

Journaling styles

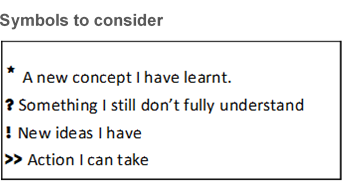
In the module on Reflective Practice in Unit 1 you can explore different ways to document your reflections and how to develop a reflection journaling style that suits you. Consider using mind maps, sketch notes and symbols too.



Mind map



Sketch notes



Begin your journal on the next page, if you are using this template.

**Learning Journal**

Just keep adding pages as you go along …

Module name:

Unit #

Remember to put a date each time you write in your journal.

Activity #

Appendix 2: Lesson Plan Template: Step 1 - The Big Picture (you can add or remove rows)

|  |  |  |  |
| --- | --- | --- | --- |
| **Lecturer** |  | **Date** |  |
| **Lesson Title** | *(Your own title for the lesson.)* | | |
| **Programme, Level** |  | **Subject** |  |
| **Module/Topic** | *(“Topics” as in 5 main Topics in NCV Subject Guidelines.)* | | |
| **Teaching Aims/ Lesson Rationale** | *What is the purpose of learning about this topic, why is it important? What will it enable students to know/do?*  *(Should not be expressed in the same way as the LOs.)* | | |
| **Learning/Subject Outcomes** | *(e.g. By the end of this unit, you should be able to: Generally, one or part of one LO, but not more than two LOs in a lesson.* | | |
| **Assessment Criteria/Standards** | *(Summative assessment and ACs may still be a long way off, but in “backward planning”, the students should know of the ACs as well as the LOs up front.)* | | |
| **Content** | *(What content needs to be introduced to enable students to achieve LOs?*  *Note down one or two key “Take away” points)* | | |
| **Overall teaching approach/method** | *(e.g. Eliciting prior knowledge; Identifying and addressing possible misconceptions; Demonstration followed by practising of skill; video followed by Q&A and problem- solving; short lecture followed by role-play; jig-saw learn-and-teach lesson, etc.)*  *What will I do? What will the students do?* | | |
| **Student output** | *What sort of output are students expected to produce – written piece /research/presentation/ product of some sort/ practical application etc.* | | |
| **Resources & equipment** | *What resources/materials/equipment will you as the lecturer need / will the students need?* | | |
| **Learning Environment** | *What sort of learning environment is needed, classroom or workshop? How should the learning environment be organised?* | | |
| **Formative assessment and feedback from students** | *How will I – and the students – know whether they are learning and/or progressing? Provide students with feedback - What was successful, and what did not work so well?* | | |
| **Closure** | *What key concepts or terms do I want the students to take away – and bring back to the next lesson?* | | |
| **Lecturer self-reflection and review** | *What worked well and what could be improved?* | | |

Lesson Plan Template: Step 2 - Detailed planning(you can add or remove rows)

| **Time**  (mins) | **Steps** | **Lecturer activity** | **Student activity** | **Resources/media/equipment** |
| --- | --- | --- | --- | --- |
| *e.g. 5* | Step 1: Spur motivation; link to experience or previous learning & work context | *Engage* ***-*** *describe how you will capture students’ interest,create curiosity, spur motivation; link to students’ own experience, previous learning, and/or work context* | *(Students should preferably be active as early as possible)* | *(Fill in only where applicable)* |
| *5* | Step 2: Identify misconceptions and address them and introduce new content/ input | *Show video, demonstrate, make a presentation, discuss, provide notes and handouts etc. Guidelines for activity must be clear; input only what content is necessary for activity* | *(Students as active listeners/ readers)* |  |
| *25* | Step 3: Activity-based, self-directed, collaborative work | *Checks individuals’ progress; guide; support; takes note of errors and triumphs; challenges: “Have you tried this…?”* | *(Self-directed, collaborative work – individually, or in pairs or groups)* |  |
| *15* | Step 4: Presentation & discussion | *Takes a back seat and takes notes, or acts as “master of ceremonies”* | *(Students make presentations to class; discussion can be organised in variety of ways)* |  |
| *10* | Step 5: Reflection & closure | *Lecturer in charge of reflection and closure: link to LO(s), key concepts or terms. What will students* ***take away****?* | *(Students to engage in reflection and writing)* |  |
| **Formative assessment** | | *(Many strategies for FA. Student feedback may include pre- and/or post-assessment, quick checks, e.g. What do the students know already that is relevant? Do they understand the content or can they demonstrate initial competence?)* | | |
| **Student output** | | *(e.g. Written classwork, ‘poster’ presentation or physical product – if any.)* | | |
| **Extended learning** | | *(e.g. Invite someone from the industry/colleague with expertise, downloaded videos for students to watch?)* | | |

**Source: AD TVT Module: From curriculum interpreting curriculum to lesson planning (DHET 2020: pp 187 -188)**

## Appendix 3: Bloom’s Revised Taxonomy of Learning Domains

Bloom’s three domains of educational activities or learning are: cognitive (knowledge/thinking), affective (feelings/emotive) and psychomotor (actions/skills). Typically, educators have mostly used Bloom’s **six cognitive levels** to design learning processes and outcomes, sequence and diversify learning tasks, set assessment activities and/or ask questions that go beyond recall (rote learning). In order of increasing complexity, these levels are:

**Remember** – Memorise verbatim facts and/or definitions.

Cognitive levels are not linear (thinking does not operate in hierarchies). Rather, use it in the sense of knowledge levels: **factual** (terms/info), **conceptual** (systems, categories), **procedural** (techniques/ methods) and **metacognitive** (thinking about thinking).

**Understand** – Explain content in own words, give examples/analogies.

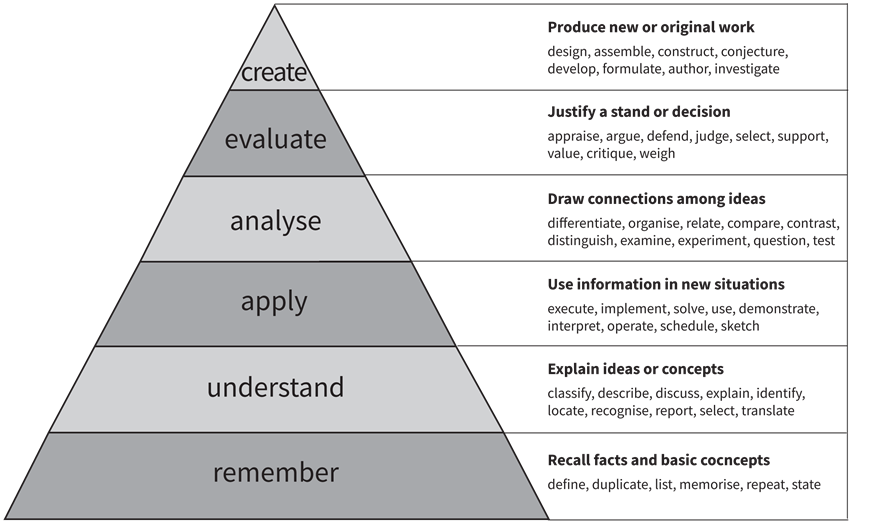
**Apply** – Use information to solve new problems/challenges.

**Analyse** – Take concepts and break it down into smaller components, or critically look at a given context and question assumptions.

**Evaluate**: Differentiate between different processes and determine which one is better/more suitable, etc.

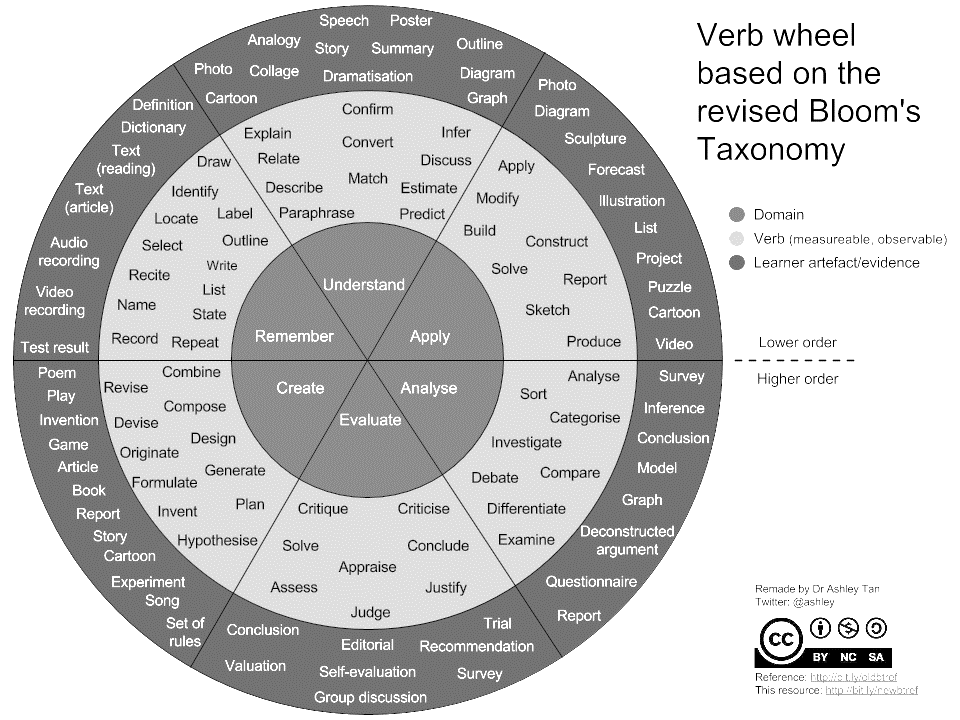
**Create**: Design own processes or create new artefacts (products or evidence of learning) e.g. a piece of creative writing, a poster, the solution to mathematical problem or a piece of research.

Bloom’s (revised) taxonomy is often presented as a diagram in the form of a triangle as illustrated below.



Bloom's (revised) taxonomy

(Source: Re drawn from Armstrong, 2016[[1]](#footnote-1))



1

2

3

|  |  |  |
| --- | --- | --- |
| 1. **Core - Cognitive levels**  The wheel has no cognitive outcome start point. A teacher can start by challenging learners with a complex problem, requiring them to generate projects (Creating). | 2. **Hub - Verbs**  The wheel offers a number of verbs that are more observable and measurable and can be used in the formulation of learning activities and assessment tasks. | 3. **Rim – Example artefacts**  The wheel model also has examples of learner artefacts (products or evidence of learning). This not only reinforces the observable and measurable principle, it also provides examples of various types of assessment tasks. |

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1. Armstrong, P. 2016. *Bloom's taxonomy*. Nashville: Vanderbilt University Centre for Teaching. Accessed from: <https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/> [↑](#footnote-ref-1)