# **Computer Science**



## **Knowledge for Educators**



C Bosch Editor

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#### PREFACE

In the digital tapestry of the 21st century, education, particularly in the realms of Computer Applications Technology (CAT) and Information Technology (IT), stands at the forefront of innovation and transformation. It is with immense pride and enthusiasm that we present this pioneering Open Educational Resource (OER) Textbook, a testament to the collaborative spirit and intellectual rigor of a group of distinguished postgraduate students from North-West University, South Africa: L. Van der Walt, B. Molokwane and N. Mbele. Under the editorship of Dr. C. Bosch, this textbook emerges as a beacon of knowledge, co-creation, and dissemination, meticulously crafted to serve the vibrant community of computer science educators.

Embarking on a journey through the rich landscapes of learning theories in CAT and IT education, this textbook unveils the multifaceted dimensions of teaching and learning strategies that resonate with the demands of contemporary education. It meticulously navigates through the intricacies of effective pedagogical approaches, ensuring that educators are well-equipped to foster environments where learning is not just absorbed but experienced and enacted.

Chapter 3, a cornerstone of this academic endeavor, delves deep into "Effective Teaching and Learning Strategies for CAT and IT," presenting a compendium of innovative practices and methodologies that are designed to elevate the educational experience. From engaging learning tasks to strategic teaching approaches, this chapter lays down a robust framework for educators to enhance their instructional design and delivery, tailored specifically to the unique landscape of CAT and IT education.

The narrative further unfolds to explore the "Advancements in Artificial Intelligence: Impact, Challenges, and Educational Integration," offering a forward-looking perspective on how AI is reshaping the educational paradigms within computer science. This segment not only highlights the transformative potential of AI but also addresses the nuanced challenges that come with integrating such advanced technologies into the curriculum, providing educators with insights to navigate this evolving terrain.

A pivotal theme woven throughout the book is the empowerment of learners and teachers through "Self-directed Learning and Cooperative Learning in the CAT and IT Class." This approach underscores the significance of nurturing autonomous learners who are capable of steering their educational journey, complemented by the collaborative essence of cooperative learning. These pedagogical strategies are emblematic of the skills necessary to thrive in the 21st century, fostering a learning culture that values independence, collaboration, and critical thinking.

The golden thread that runs through the fabric of this textbook is the emphasis on self-directed learning as a quintessential skill for the 21st century. This theme is not just a narrative thread but a philosophical underpinning that champions the development of learners who are proactive, self-motivated, and resilient in the face of the ever-changing technological landscape.

As you immerse yourself in the pages of this textbook, we invite you to embrace the collective wisdom and innovative spirit encapsulated within. It is a resource conceived not just for academic enrichment but as a catalyst for pedagogical evolution, inspiring educators to cultivate learning environments that are dynamic, inclusive, and aligned with the digital age.

My heartfelt congratulations to L. Van der Walt, B. Molokwane and N. Mbele for their remarkable contribution to the field of computer science education. Their dedication to fostering a culture of knowledge sharing and co-creation is a beacon of inspiration for educators and learners alike. May this textbook serve as a valuable instrument in your educational repertoire, igniting passion, creativity, and a lifelong love for learning in the realms of CAT and IT.

Dr Chantelle Bosch



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# **CHAPTER 1**

## **Exploring Learning Theories in CAT and IT Education**



L Van der Walt

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## Introduction

This chapter delves into the foundational concepts of learning theories and their implications for Computer Applications Technology (CAT) and Information Technology (IT) education. We begin by providing a comprehensive understanding of learning theories and then explore how these theories can be integrated with the Curriculum and Assessment Policy Statement (CAPS) for CAT and IT. By analyzing behaviorist, constructivist, and cognitive theories, we gain insights into their practical applications within the context of teaching and learning. Finally, we undertake a comparative analysis of these theories to illuminate their distinctive contributions to CAT and IT education.



Figure 1 Figure 1 AI generated image from Microsoft Bing

Please note that the AI-generated image would be hypothetical in this context and is used in this way throughout this document.

## **Learning Objectives**

Exploring the principles of learning theories unveils a dynamic landscape that significantly influences education. For Computer Applications Technology (CAT) and Information Technology (IT) educators, understanding these theories is not only enlightening but also crucial for crafting effective teaching strategies that cater to the unique challenges and demands of these fast-evolving fields. These are the learning outcomes you will learn and achieve by studying this chapter :

• **Understand Learning Theories:** Learn what learning theories are and why they're important in education.

- Connect Theories to CAT and IT: See how learning theories relate to teaching CAT and IT subjects.
- Know Behaviourist Basics: Identify the main ideas behind behaviourist learning theories.
- See Effects in CAT and IT: Explore how behaviourist theories affect teaching and learning in CAT and IT.
- Blend Theories with CAPS: Understand how behaviourist ideas can be mixed with CAPS guidelines for CAT and IT.
- **Discover Constructivist Ideas:** Learn the main concepts of constructivist learning theories.
- Find Real Uses in CAT and IT: Explore how constructivist theories can be used practically in CAT and IT teaching.
- Learn Cognitive Basics: Understand the key principles of cognitive learning theories.
- See Effects on CAT and IT: Evaluate how cognitive theories influence teaching and learning in CAT and IT.
- Use Cognitive Strategies: Discover effective ways to bring cognitive theories into CAT and IT education.
- **Compare Different Theories:** Understand how behaviourist, constructivist, and cognitive theories are different from each other.
- **Combine for Impact:** Bring together insights from these theories to see how they work together in CAT and IT education.
- **Create Better Teaching:** Come up with smart teaching methods by mixing multiple learning theories for CAT and IT.

## **Understanding Learning Theories**

The classical learning philosophies of constructivism, cognitivism, and behaviourism are regarded as the cornerstones of education (Masethe et al., 2017). They provide essential guidance and understanding about how people learn and how teaching can be most effective. These philosophies have been studied and discussed by educators and researchers for many years, helping to shape the way we think about learning and teaching methods. The aim of this chapter is to illuminate the practical applications of these three theories within South African Computer Applications Technology classrooms, thereby ensuring that effective teaching and learning practices equip learners to thrive as 21st-century citizens.

Teachers are responsible for preparing and presenting information in a way that helps learners understand and solve problems (Zendler, 2019). The learner's role involves actively engaging with the information, organizing it, and making adjustments as needed. Peers can also be part of this process, influencing how information is understood (Zendler, 2019). Teachers and learners use external tests and self-assessments to monitor progress along the learning path. Regular evaluations occur after completing meaningful learning units, which are integrated into various learning tasks (Zendler, 2019).

### The importance of understanding learning theories in CAT and IT education

The effectiveness of the teaching methods is crucial for learning. The development of teaching strategies is based on the recommendations provided by learning theories (Zendler, 2019). These strategies can be used in varying degrees and in various ways while teaching Computer Science (CS) (Zendler, 2019). Learning theories can be applied in the classroom in order to improve teaching and learning. This enhances the effectiveness of teaching techniques (Zendler, 2019). New teaching methods are needed to prepare learners for lifelong learning (Masethe et al., 2017). Due to the effect of mobile tools and new technologies, learning has experienced significant changes in the twenty-first century (Masethe et al., 2017). Educators need to adapt to new challenges when teaching learners through traditional face-to-face methods. This involves acquiring fresh skills and understanding how to effectively combine technology and learning theories (Masethe et al., 2017).

## Behaviourist Theories and Implications for CAT and IT Teaching-Learning

Generally, behaviour is described by Miltenberger (2001:2), as "what people say and do" (Ng'andu et al., 2013). According to Wubante (2020) the theory of behaviourism it is mainly cantered on behaviour that is measurable and observable. The behaviour is typically studied via conditioning and reinforcement. The behaviourism theory does not acknowledge thought process that occurs in an individual during learning. In behaviourism, the learning transpires when the behaviour has been modified and the modification is visible as a proof (Ezenwa-Ohaeto & Ugochukwu, 2021). The behaviourism educational philosophy is grounded on the perception that human behaviour can be described on the basis of reaction to exterior stimuli (Perez, 2022).According to Salamah et al. (2020, p. 621) learning objectives are acquired from the procedure of reinforcing the reactions that transpire to learning setting that are both inner and outer. In behaviourism, learning implies reinforcing binds, relationships, characteristics and propensities to alter behaviour

(Salamah et al., 2020, p. 621). On assumption that the behaviour of a human is can be unlearned and they can be replaced by new behaviours, for example, when the behaviour is unacceptable it can be replaced by acceptable behaviour (Zhou & Brown, 2017).

Burhanuddin et al. (2021) states that Skinner, the behaviourist, highlights four paramount factors about learning, namely, the first is every single stage in the learning procedure must be succinct and constant from formerly learned behaviour. The second is, for successful learning procedure to transpire, the pupil must be receiving reward and reinforcement frequently, especially at early phases until the behaviour is formed by the pattern of strengthening in a setting. The third is



Figure 2 AI-generated image from GenCraft.com

**Al prompt:** 'Generate an image of Ivan Pavlov and Computer science education"

instant response must be provided to the pupil. The fourth is the pupil must be provided 'stimulusdiscriminations' for pupil to be probable to succeed.

Transfer is defined as the implementation of studied knowledge in new conducts or circumstances also as how pre-existing learning affects new learning, transfer in behaviourist theory is a matter of generalization (Ertmer & Newby, 2013).For example, if a learner has learnt the characteristics of a dog, the learner will be able to differentiate the dog from a cat by consulting learnt characteristics of dogs to be able to identify the characteristics of a cat.

Behaviourism was an initial theory to methodically describe animal and human learning (Kay & Kibble, 2016, p. 18). Behaviourist understand that learning occurs through link or interconnection among stimulus and reaction (Kyuata et al, 2018, p. 196). Behaviouristic theory perceive that humans are highly influenced by occurrences in their setting that provide them with certain experiences (Anindyarini et al, 2018). Behaviourism stresses that what is observed (behaviour) and it does not take into consideration what happens in the mind (Anindyarini et al., 2018).

According to Perez (2022) outlined essential fundamentals of behaviourism, as articulated by Zirpoli (2005), are outlined below:

- Majority of behaviours are studied. Mostly behaviours can be imparted, altered and transformed.
- Behaviours mostly are stimulus precise.
- Behaviour alteration objectives must be precise and well-articulated.
- Behaviour alteration programs must be centred on child's setting.
- Behaviour alteration programs must be centred on here and presently Behaviour alteration programs must be personalised.

### History of Behaviourism

According to Zhou and Brown (2017) there are two main creators of behaviourist methods to learning, namely John B. Watson and B.F Skinner.

#### The Evolution from Behaviorism to Cognitive Integration

A significant change in psychology theory was brought about by behaviorism, which first appeared in the early 20th century and placed an emphasis on the formal construction of principles based on observable behaviors. During this time, prominent individuals like John B. Watson emerged in 1913, promoting a psychology that prioritized observable behaviors over interior mental processes. Behaviorist beliefs were further shaped in 1927 by the groundbreaking work of Ivan Pavlov, which revealed the creation of learned associations and classical conditioning. Operant conditioning was developed in 1938 by B.F. Skinner, who emphasized the power of incentives and penalties to modify behavior. Behaviorism dominated this era and went on to become a well-known paradigm in psychology and education by the middle of the 20th century.

## **Evolution of Behaviourism: Key Events and Influential Contributors**

Year	Event/Contributor	Key Ideas
Early 20th Century	Emergence of Behaviourism	Formal development of behaviourist principles.
1913	John B. Watson	Advocated psychology's focus on observable behaviours.

1927	Ivan Pavlov	Demonstrated classical conditioning and learned associations.			
1938	B.F. Skinner	Introduced operant conditioning, emphasizing rewards and punishments.			
Mid-20th Century	Behaviourism's Dominance	Dominant paradigm in psychology and education.			
1950s - 1960s	Cognitive Revolution	Challenge to behaviourism, integration of cognitiv psychology.			
Ongoing	Contemporary Influence	Continued impact on education, therapy, and behaviour modification.			

## Ivan Pavlov (1849-1936) – Classical Conditioning

According to Krishnamoorthy et al. (2021) the theory of classical conditioning of Ivan Pavlov implies that learning is a procedure that happens via connections among the setting stimulus and normally happening stimulus. In classical conditioning, there are two stimuli, the first is a stimulus that is essential at the start of the experimentation, it might be shock. This stimulus is categorized as unconditional stimulus (UCS). It induces unconditional response (UCR), frequently in the absence of prior coaching. The last stimulus, it could be bell or light, is referred to as conditional stimulus (CS). The conditional stimulus is a formerly impartial stimulus that will afterwards obtain the capability to induce the similar reaction as it does the UCS via conditioning (Kyauta et al., 2018).

There are four significant elements that were brought by Pavlov's experimentation, as outlined by Mangal (2010), they include (Kyauta et al., 2018):

(1) Impartial stimulus referred to as unconditioned stimulus (UCS), example, food.

(2) It ends up in an innate reaction known as unconditioned response (UCR), for example, salivation.

(3) the unnatural stimulus, such as, the sounding of the bell is referred to as conditioned stimulus.

(4) and the system of conditioning procedure.

## Fundamentals of classical conditioning

According to Kyauta et al. (2018) the theory that was created by Pavlov it brought forth few significant ideas and fundamentals in the branch of human learning, such as:

- (a) Extinction: Pavlov noted that, the presentation of CS, which is bell only for several times in the absence of UCS, which is food, reduces the level of CR, which is salivation and may result in fading of the CR. This procedure of continuous fading of CR is known as extinction.
- (b) Spontaneous recovery: it was realized that after the process of extinction, the behaviour unexpectedly resurfaces but at a slower pace. The re-emergence of an extinct CR after a short period of time in which the combination of CS, which is the bell, and UCS, which is the food, has not been iterated is known as spontaneous recovery, which implies that learning is repressed and not elapsed.
- (c) Stimulus generalization: In this case, the dog will react to the stimuli in a generic manner. For example, the dog salivates to food even if it is not in its sight but to every single stimulus such as footsteps, ring of the bell and the presence of light, this is known as stimulus generalization.
- (d) Stimulus discrimination: The subject studies to respond distinctively in various circumstances, for example, a dog can be taught to react (salivate) to only as specific bell not other bells. An individual studies to respond to an only definite stimulus apart from many stimuli and to differentiate and distinguish one stimulus from the other stimuli existing in the setting.
- B.F Skinner (1904-1990) Operant Conditioning

B.F Skinner performed various experiments using animals during the 1930s, since then he started to formulate approaches, vocabulary and fundamentals of learning by reinforcement (Kyauta et

al., 2018) .According to Mwakalinga and Leandry (2021) B.F Skinner is a behaviourist that highlighted learning takes place via making performances in the learning setting, Skinner explained operation as operant conditioning where a connection is done among a behaviour and an outcome which means that learning takes place via reinforcement and punishment. The phrase operant implies how behaviour functions in a setting (Mwakalinga & Leandry, 2021). The operant conditioning comprises of notions such as positive reinforcement which implies reward, negative reinforcement which is elimination or non-reinforcement and also punishment. The term reinforcement is linked to the term reward, therefore, reinforcer is "any consequence that strengthens the behaviour it follows" (Woolfolk, 2016). According to Woolfolk (2016) the reinforcement can be outlined as shown below:

According to Woolfolk (2016) there are two forms of reinforcements, the first is positive reinforcement, which is described as "the contingent presentation of a stimulus following a response", the second is negative reinforcement, which is described as "the contingent removal of an aversive (unpleasant) stimulus right after a response that increases the future rate of the response". The example of a positive reinforcement could be praising a learner that obtained higher marks in a test. A negative reinforcement includes eliminating a stimulus or removing something from a circumstance succeeding a reaction which enhances upcoming possibility that the reaction will happen in that circumstance (Schunk.2012). Negative reinforcement is misinterpreted with punishment, punishment includes reducing or terminating a behaviour (Woolfolk, 2016). The procedure of punishment is outlined in the diagram below (Woolfolk, 2016):

## Fundamentals of operant conditioning

According to Kyauta et al. (2018) stated that operant conditioning theory has four fundamentals, as articulated by Egbule (2009), the four fundamentals are:

(1) Schedules of reinforcement: A reinforcer is described as the stimulus that is the granting or exclusion of which enhances the likelihood of a reaction that is performed regularly. Skinner acknowledges the two types of reinforces that is positive and negative, and implemented a notion of planning of schedules of strengthening for training the operant behaviour of the animal.

- (2) Extinction: If the regularity of a specific behaviour decreases when the behaviour is no longer performed through positive reinforcer is called extinction. In extinction, the positive reinforcer is withdrawn succeeding each event of an involved behaviour.
- (3) Generalization: Generalization implies the capability of an animal experiencing the insight of and reaction to alike stimuli. Generalization, in learning process, is comprehended as, with regard to learner, studies to offer similar operant reactions, they are similar but not the same as conditioning stimulus.
- (4) Discrimination: Discrimination implies the procedure of utilising cues, indications or data to establish when the behaviour is probable to be reinforced or punished. To assist a learner to distinguish (discriminate), appropriate feedback should be implemented on the accuracy or inaccuracy of learners' reactions on the basis of cues and indicators.

## John B. Watson (1878-1958)

An American behaviourist theory, John B Watson perceived that each person changes in behaviour happen as a result of various experiences in learning (Krishnamoorthy et al., 2021). According to Ng'andu et al. (2013) stated that, as described by Kazdin (2001), Watson investigated the adaptation of animals to their setting, more particularly the specific stimuli causing animals to perform their reactions. Watson perceived that human being are born with minimum reflexes and emotional responds, namely, love and rage.

## E.L Thorndike (1874-1949)

Thorndike contributed to behaviourism with his theory of connectionism which implies that learning includes the development of a connection among a stimulus and reaction (Ng'andu et al., 2013). On the basis of stimulus-response, Thorndike generated three laws which are:

- (1) The first law is called 'law of effect' which state that the association between a stimulus and reaction is reinforced through positive rewarding and reduced through negative rewarding.
- (2) The second law is called 'law of exercise'. When the more stimulus-responses bond is applied, the powerful it becomes.

(3) The third law is called 'law of readiness'. It is based on the construction of nervous system, several conduction elements, in any circumstance are greatly susceptible to conduct than others

### How Behaviourism can be applied

According to Mustafa (2021) describe learning as "a form of change experienced by students in terms of their ability to behave in new ways as a result of the interaction between stimulus and response" and further describe that learning "is a relatively long-lasting observed behaviour change as a result of experience and environment". In behaviourism, the learning process occurs as an outcome of a change in behaviour in an individual (Burhanuddin et al., 2021). The behaviouristic learning implies an attempt to establish suitable behaviour or desirable behaviour (Faiza, 2022).

The education can successfully implement the behaviourism theory through rewarding acceptable behaviours and diminishing undesirable behaviours in the classroom setting (Zhou & Brown, 2015). According to Al-Shammari et al. (2019) the educator's part during the instructional procedure is to : (1) discover which activities are able to induce the scholar's well-suited reactions, (2) organise strategies where elicits are aligned with target stimuli which are anticipated to evoke reactions in natural surrounding and (3) organise contextual states so that scholars are able to perform relevant reactions in the existence of those target stimuli and obtain strengthening for those reactions. According to Kay and Kibble (2016) stated that behaviourism is an educator centred, the educator's role is to regulate the setting, plan environmental cues or stimuli, and recognize the suitable reward constructions to strengthen wanted behaviours and reduce unwanted behaviours or reactions. To achieve this, the learner should understand how to perform appropriate reaction and also circumstances under which that reaction must be performed (Ertmer & Newby, 2013).

## Strategies to implement behaviourism theory

There are various behaviour adjustment procedures that can be implemented in the classroom, they include, chaining, moulding, extermination, positive and negative reinforcement, plans of discipline and economy tokens (Ng'andu et al., 2013). Teachers must not presume that learners are learning except they observe the behaviour is altering by assessment. The behaviourism has made contribution to education through 'drill and practice methodology' during lessons. In this method an educator introduces a topic to learner, providing a stimulus and the expectation is that learners will react to stimuli by continuous practice.

Teachers can implement the following strategies to ensure that they are able to make a lesson effective. According to Kyuata et al. (2018) stated that educators should follow a consecutive cumulative learning and following should be kept in mind:

- Humans learn in many various kinds. Educators must identify individual variances between learners so that they are able to comprehend and lead the learning process.
- Educators should promote the advancement of abilities in their learners particularly those educated via reinforcement
- Learning is a procedure of associating a link between the foreknowledge and improved data, educators must associate the new lesson with former lesson.
- Educators must use various instruction approaches to facilitate their lessons successfully.
- Educators must constantly utilise different reinforcement to retain learners busy and reassurance to class contribution.
- Educators must devise various teaching aids to simplify the understanding of learners.

According Kyauta et al. (2018) stated that instrumental theory contends that:

- (1) A behaviour or reaction is based on its repercussions. What children learns is based on distinctive reinforcement and non-reinforcement.
- (2) Educators must reward appropriate behaviours and eradicate inappropriate behaviour as foundation of motivation.
- (3) Educators recommended that punishment should be evaded as a result of punishment is ineffective when it comes to teaching and learning.

- (4) The theory transformed teaching and learning through putting forward machines that could educate and computer aided lessons to substitute the educator-centred school room lessons.
- (5) Educators must use various things affordable to them to encourage learners toward classroom tasks.

Educating is a procedure of establishing a setting, the educator requires to arrange the learning setting to encourage and give learners chances to participate in a learning-task that is engaging (Kyuata et al., 2018). There are various behaviour adjustment procedures that can be implemented in the classroom, they include, chaining, moulding, extermination, positive and negative reinforcement, plans of discipline and economy tokens (Ng'andu et al., 2013). Teachers must not presume that learners are learning except they observe the behaviour is altering by assessment. The behaviourism has made contribution to education through 'drill and practice methodology' during lessons. In this method an educator introduces a topic to learner, providing a stimulus and the expectation is that learners will react to stimuli by continuous practice

## Constructivist Theories and Implications for CAT and IT Teaching-Learning

Constructivism is described as a theory that is "people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences" (Ng'andu et al., 2013). According to Amineh and Asl (2015) the term constructivism implies the manner which pupils can create understanding of the material and similarly in what way the materials can be imparted successfully. According to Bada (2015) describe constructivism as a method to instruction and learning grounded on the principle that learning g is an outcome of "mental construction". It is theory grounded on how humans learn (Ebo, 2018). Human beings are capable of constructing their own understanding and assimilating and accommodating the new knowledge (Khan, 2019). When individuals use their prevailing knowledge and experience learning transpires (Khan, 2019). According Bada (2015) constructivism learning theory, as described by Driscoll (2000) is a philosophy that increases learners' logical and conceptual development. From the viewpoint of this theory, learning is comprehended as self-regulated procedure of solving internal battles that becomes visible via abstract experience, debate and reflection (Gilakjani et al., 2013).

Constructivists perceive that human beings during learning can construct their knowledge via active involvement (Golder, 2018). According Gilakjani et al. (2013) the main idea of constructivism is that the knowledge should be formulated by the learner and further added, the knowledge is not provided by the educator



Figure 2 Constructivism in the CAT and IT Class

Al Prompt Constructivism is described as a theory

According to Ebo (2018) stated that McLeod (2009), expressed that Jean Piaget is the first psychologist to conduct cognitive research in development. Constructivism is grounded on the Jean Piaget's theory of cognitive development that proposed that human beings cannot be provided with information rather it is generated through experiences and prior knowledge (Ahmad et al., 2015). It emphasizes that knowledge exist in individuals, whereby the knowledge cannot be completely shifted from an educator to learners, so learners have to attempt to comprehend what is being facilitated by trying to suit it with their experience (Ahmad et al., 2015).

Constructivism as a theory, it associates learning with generating understanding from experience (Ertmer & Newby, 2013). The two elements that are critical in

constructivism, include learner and setting elements, particular interrelation among the two elements generate knowledge (Ertmer & Newby, 2013).

The view of learning in constructivism, acknowledges a learner as operative agent in the procedure of knowledge accession (Bada & Olusegun, 2015).

According to Isik (2018) the focal values of constructivist method, as described by Turgut et al. (1997) are:

• The information is assigned to mind and referred as assimilation. The information that is recognised it makes no attempt to dispute the current prior knowledge of a person and is included in prevailing classes in an individual's mind.

- The imbalance will occur in one's mind if the perceived data does not suit any groupings in the mind. To integrate the imbalance, a collection of cognitive processes must be used. The rearrangement procedure is referred to as accommodation whereas the method of rearrangement is known as self-adjustment. The method of integrating imbalance is influenced by individual's prior knowledge and cognitive abilities. When one of these procedures becomes inadequate, self-adjustment method becomes unsuccessful and one's unaccounted behaviours resumes with their existence.
- Individuals can experience the imbalance without getting data from exterior world and through probing with questions.

Investigation studies revealed that constructivism learning setting aid to advance learners' academic performance, inspiration, commitment, improved involvement and contemplation (Seraji & Musavi, 2023). According to Khan (2019) when creating a constructivist learning setting, the following significant features should be considered:

- Learners must be confronted by ideas and difficulties that create internal intellectual conflicts
- learners are persuaded for active involvement in a schoolroom task and ask questions.
- The learning setting must motivate learners to arrive in a dialogue with an educator and their companions.
- learners must be provided with adequate time for reflection, for developing association and for debate.

According to Pande and Bharathi (2020) there are three philosophical views of constructivist theory, as outlined by Savery and Duffy (1995), they include:

- Interpretation is in our collaboration with the setting: This proposal is based on the fact that what is learned and how it is learned are two indivisible things. The key to effectual learning is based on the following the content, learner's tasks and learner's objectives.
- Cognitive disagreement or bafflement is the stimulant for learning and regulates the association and nature of what is learnt: the stimulus for studying includes what the learner deals with, what is the learner's former experience in constructing an interpretation of what is being imparted and what is the ultimate interpretation constructed in the learner.

 Knowledge develops via social cooperation and via the assessment of the practicality of one's interpretations: a cautious reconciliation is called for among the practicality of individual's own interpretation (knowledge)n and practicality of interpreting about social setting to which an individual is part of. Collective tasks give both intra and inter teamwork avenues to improve, intertwine and widen the interpretation of a provided phenomenon.

According to Ah-Nam & Osman (2017) stated that the constructivist and constructionist leaning theories are based on three focal guiding fundamentals that were identified by authors, they are:

- involve learners in discovery and problem-solving activities via collaboration. Learners should be permitted to collaborate with each other to learn and discover notions and perceptions. These collaborative activities intensify learners' interpretation as they determine or develop new interpretation for themselves.
- Give chances for transmitting ideas. Learners should be given chances to engage in debate and to distribute and exchange notions in collectives. Learners can transmit ideas and involve themselves in debate through design justification. Through design justification learners should allow each other to communicate their ideas and defend them if needs be.
- engage learners in the procedure of design.

According Bada and Olusegun (2015) the attributes of constructive learning settings, include the following when applying learning strategies:

## How Constructivist theory can be applied

This theory creates learning settings based on real-world challenges and problems, establishment of various perceptions, collaboration and cooperation, establishment of real-time task, reflection, feedback and contribution between learners so that learners are actively involved in the method of generating their own interpretation and play an important role in a certain cultural or social setting (Seraji & Musavi, 2023). In teaching and learning, the main role of an educator in the constructivist method is to guide learners to developing their new information via experimental tasks and learners make their own interconnections and formulate their own conclusions (Ahmed et al., 2015).

To achieve effectual teaching and learning in school rooms the significance of educators' interpretation of constructivism theory, fundamentals and pedagogy must be stressed (Gunduz & Hursen, 2015). According to Gunduz and Hursen (2015) emphasized the learning process is regarded as construction, the following roles should be assigned to educators, they include:

- [to influence] or generate motivating situations for learners.
- take accountability for generating problem contexts
- encourage attainment and recall of preceding knowledge
- generate the procedure of learning rather than product of learning

In instruction and learning, the basic responsibility of an educator, specifically in the constructivist method, is to guide learners generating their new knowledge via experimental tasks and learners make their own links and come into their own conclusions (Ahmad et al., 2015). According to Ahmad et al. (2015) highlighted the following regarding the constructivism theory, the first is that the educator will assist learners to restructure the information in manners that are both significant and reasonable to learners. Secondly, learning approach generated from constructivist theory comprise learner-cantered learning which emphasizes that the central point is a learner and encourages self-regulating learning. Thirdly, learner-cantered encompasses principles, namely, formative evaluation, query project grounded learning, united curricular, professional knowledge in the learning setting and learner lecture, concentration and revolution in varied learning tasks. Additionally, leaner-cantered learning centres on higher order thinking and learners as experimenters, direct instruction, and one-on-one instruction.

Educators must be capable to acknowledge the oneness of each learner in the classroom and create an educational plan on the basis of oneness experience (Ahmad et al., 2015). The responsibility of an educator in giving information reduces and is exchanged by the responsibility of inducing and assisting learners' own thinking and meaning-making capabilities (Ahmed et al., 2015). Collaboration among educator and leaner is increased as the educator will assist learners to attain pedagogical aim and to generate knowledge grounded on learners' preceding knowledge (Ahmad et al., 2015). Constructivist instruction includes debate where constructivist educators will request learners to be included in conclusions regarding their learning (Ahmad et al., 2015). The power and control are distributed among a learner and educator in the constructivism classroom,

additionally, educators should construct classroom setting that will enable learners to become autonomous (Ahmad et al., 2015).

## Assessment of Constructivist Theory

## Engaging Constructivist Learning through an IT/CAT Theory Treasure Hunt

Learning has surpassed traditional ways in the ever-evolving field of education, aligning with modern pedagogical philosophies is pivotal for fostering profound comprehension and purposeful learning encounters. Embracing constructivism, that accentuating learners' active role in knowledge construction through engagement, collaboration, and personal encounters, we introduce the "IT/CAT Theory Treasure Hunt." This interactive classroom activity seamlessly melds theory and practice, inviting learners to construct their grasp of IT/CAT (Computer Applications Technology) concepts collaboratively. By deciphering QR codes, participants engage deeply with theory, utilizing constructivist principles to explore, discuss, and collectively decipher information. This activity champions collaboration, social interaction, personal relevance, and autonomy, aligning with the essence of constructivism and transcending conventional methodologies. Through this innovation, we nurture learners to actively construct knowledge, collaborate effectively, and derive individual significance in the school subjects of IT/CAT theory components, thereby honouring the enduring impact of constructivism and fostering skills that transcend classroom confines, integrating technology for the 21-century learner.

## **Classroom Activity: IT/CAT Theory QR-Treasure Hunt**

#### **Objective:**

Engage learners in a fun and interactive treasure hunt to reinforce IT or CAT (Computer Applications Technology) theory terminology and content from the textbook.

#### Materials Needed:

- IT or CAT theory content/questions
- QR code generator (there are various online tools available)
- Printed QR codes

- Mobile devices with QR code scanning apps (one per team or student)
- Prize for the winning team/student (optional)

#### Instructions to the Teacher:

#### 1. Preparation:

Select specific IT or CAT theory content/questions that you want to reinforce through this activity.

Create corresponding QR codes for each content/question using a QR code generator. Link each QR code to a webpage, document, or text that provides the information or asks the question.



Figure 3: QR Code - Scan with mobile phone

QR Code Placement:

Print out the generated QR codes and hide them in various locations around the classroom. Make sure they are not too obvious but still accessible.

### 2. Group Formation:

Depending on your class size, divide students into small groups (2-4 members per group) or have them work individually.

#### Instructions to Learners:

- 1. Introduction:
  - Gather all the students and explain that they will be participating in an IT/CAT theory treasure hunt.
  - Emphasize that this activity is designed to help them review and apply their understanding of the subject matter.
- 2. QR Code Scanning:
  - Each group or student will be given a mobile device with a QR code scanning app.

• Explain how to use the QR code scanner to access the content/questions hidden around the classroom.

#### 3. Treasure Hunt Rules:

- Instruct students that their goal is to find all the hidden QR codes and scan them in the correct order.
- Each scanned QR code will reveal IT/CAT theory content or a question related to the subject.
- They must discuss and answer the question or understand the content together as a group.
- The next QR code location will be revealed in the content or question they have just accessed.
- Remind them to work as a team, share ideas, and collaborate effectively.

#### 4. Completion of Activities:

- For each question or content piece, students should discuss and formulate their answers or understanding.
- Encourage them to refer to their textbooks or class notes if needed.
- The activity continues until all QR codes have been found and scanned, and all corresponding questions or content have been addressed.

#### Finishing the Hunt:

Once all QR codes have been scanned and activities completed, students should report back to you. Review the answers and understanding with the whole class.

### Winner (Optional):

If you decide to make it competitive, the first team or student to complete the treasure hunt correctly could be rewarded with a small prize.

#### Debriefing:

After the activity, have a discussion with the students about their experience. Have them reflect on their own level of understanding and the benefits of this activity. Ask them about the challenges they faced, what they learned, and how this activity helped reinforce the IT/CAT theory content.

This activity aims to make learning IT/CAT theory more engaging and interactive while encouraging teamwork and critical thinking. It's a creative way to review important concepts from the textbook in an enjoyable manner.

## **Cognitive Theories and Implications for CAT and IT Teaching-Learning**

The foundation of the cognitive approach to teaching and learning is the notion that learning is an active process that involves the organizing, processing, and transformation of information in the mind. Cognitivism learning theory emphasises how our minds work and how we actually learn (Add source). It looks at things like thinking, remembering, and solving problems to help us gain knowledge. However, a weakness of this theory is that sometimes people can complete a task, but not in the way that suits them best. This happens because they are taught to do things the same way as others to keep things consistent (Masethe et al., 2017)

To integrate the concepts of cognitivism into your teaching approach, it's important to remember that when learners understand new ideas, they gain knowledge that can be used in different situations and develop the skill to handle challenges (Zendler, 2019). Tailor your teaching materials to align with the learners' existing knowledge and their level of progress. Your aim should be centred around sharing information and assisting learners in enhancing their understanding (Zendler, 2019).

According to the CAPS (Curriculum and Assessment Policy Statement) for Information Technology, assignments, learning tasks, and learning activities all play crucial roles in assisting learners learning and evaluating their level of comprehension (Department of Basic Education, 2011). The cognitive approach to teaching and learning is centred on understanding how learners process and organize information mentally (Bell, 2021). It emphasizes active engagement, problem-solving, critical thinking, and metacognition. When applied to teaching and learning in IT and CAT, the cognitive approach has several implications that can enhance the learning experience and promote a deeper understanding of the subject:

# Activating Prior Knowledge: Bridging Cognitive Foundations for IT/CAT Learning

The cognitive approach acknowledges that learners may already possess some familiarity with certain concepts in the context of CAT and IT. By activating their prior knowledge, educators can establish connections and scaffold new information upon existing foundations. This approach facilitates the acquisition of new concepts and enhances the learning experience for learners (Masethe et al., 2017).

In the Grade 10 Information Technology curriculum, learners are introduced to the fundamental concepts of programming (Department of Basic Education, 2011). One of the topics covered is "Introduction to Programming Concepts," which includes learning about variables, data types, and basic programming constructs like conditional statements (if-else) and loops (for and while).

To establish connections and scaffold new information upon existing foundations, teachers can start by activating learners' prior knowledge of mathematics and logic. They can draw parallels between mathematical variables and programming variables, explaining that just like in algebra, variables in programming hold values that can change during the program's execution.

For example, educators can ask learners to recall their knowledge of algebraic equations, where they might have worked with variables like "x" and "y" representing unknown quantities. By making this connection, learners can understand that variables in programming serve a similar purpose, representing data that can be manipulated within a program.

### Example from mathematics:

### Variables:

Activating learners' prior knowledge of mathematics and logic by using mathematical variables:

4x + 2y = 12

### y = 2

Draw parallels between mathematical variables and programming variables

Example for the IT class:



Figure 4 Example of variable use in Delphi

#### **Reflection activity:**

- Describe in your own words what a variable is in programming.
- Give an example of something you can represent using a variable in a program.
- Think about a situation where you might use variables in real life (not programming).
  Explain it briefly.
- If you were creating a program to calculate the total cost of items in a shopping cart, how could you use a variable? Write a simple equation like we did in math!

#### Cognitive scaffolding

Teachers can scaffold new information by gradually introducing programming concepts with relatable examples. For instance, when teaching conditional statements, educators can use reallife scenarios that learners can easily comprehend. They might present a problem like, "If the temperature is above 30 degrees Celsius, print 'It's a hot day!'; otherwise, print 'It's a pleasant day!" This way, learners can relate to the concept of making decisions based on certain conditions, making it easier for them to grasp the idea of conditional statements in programming.

As the lessons progress, teachers can continue to build upon the foundation laid by these connections and examples. They can further delve into more complex programming concepts, continually relating them to prior knowledge and providing ample practice exercises to reinforce learning.

By establishing connections between programming concepts and learners' existing knowledge, and scaffolding new information with relevant examples and exercises, educators can create a more engaging and effective learning experience for Grade 10 Information Technology learners, helping them develop a deeper understanding of programming fundamentals.

# Fostering Problem-Solving Proficiency: Nurturing Cognitive Exploration in IT/CAT Learning

As problem-solving plays a crucial role in IT, the cognitive approach advocates presenting realworld challenges for learners to solve. By engaging in practical scenarios, learners can apply their knowledge and programming skills, fostering a deeper understanding of the subject matter. This approach cultivates analytical and critical thinking abilities, essential in the IT field (Masethe et al., 2017).

In the Grade 10 Information Technology curriculum, learners learn about network topology, which refers to the physical or logical arrangement of network devices and their connections (Department of Basic Education, 2011). Theoretical knowledge of network topology includes understanding different types of topologies, such as star, bus, and ring, topologies, as well as their advantages and disadvantages.

To promote learner engagement and comprehension in network topology, educators can design hands-on activities and group projects that involve building and simulating different network topologies.

The objective of this activity is for learners to explore various network topologies practically, understand their characteristics, and analyse their suitability for different scenarios.

In the hands-on activity, each learner is provided with network devices (representative objects) and connections (cables or strings) to build different network topologies on a table or a designated space. The educator can assign specific topologies to each learner, such as star, bus, or ring topology.

The learners physically arrange the devices and make connections following the rules of the assigned topology. They observe how data flows, how devices are interconnected, and how the topology affects the overall network performance.

The provided rubric serves as a tool for assessing and evaluating learner understanding and comprehension.

## Grade 10 Information Technology Rubric: Exploring Network Topologies

Criteria	Excellent (4)	Proficient (3)	Basic (2)	Limited (1) Mark
Understanding	Learner	Learner shows	Learner	Learner's
of Network	demonstrates a	a good	displays a basic	understanding
Topologies	deep	understanding	understanding	of network
	understanding of	of various	of some	topologies is
	different network	network	network	limited and
	topologies, their	topologies and	topologies but	may contain
	characteristics,	their key	may not fully	inaccuracies.
	advantages, and	features.	grasp all	
	disadvantages.		aspects.	
Application of	Learner effectively	Learner	Learner	Learner
Practical	applies theoretical	successfully	attempts to	struggles to
Knowledge	knowledge to build	constructs	build network	construct
	and simulate	network	topologies but	network
	assigned network	topologies and	might	topologies
	topologies.	observes their	encounter	accurately, and
	Observations	behaviour,	challenges in	the application
	show a strong	linking theory to	demonstrating	of theoretical
	connection	practice.	accurate	knowledge is
				minimal.

	between theory		practical	
	and practice.		application.	
Analysis of	Learner thoroughly	Learner	Learner offers	Learner's
Network	analyses the	provides a	basic insights	analysis of
Suitability	suitability of each	reasonable	into the	topology
	topology for	analysis of	suitability of	suitability lacks
	different	topology	network	coherence and
	scenarios,	suitability,	topologies, but	may be
	considering factors	addressing key	the analysis	incomplete or
	such as scalability,	factors related	may lack depth	inaccurate.
	fault tolerance,	to network	or	
	and ease of	performance	thoroughness.	
	maintenance.	and		
		management.		
Collaboration	Learner actively	Learner	Learner	Learner's
and	collaborates within	collaborates	engages in	collaboration
Communication	the group,	and	group activities	and
	communicates	communicates	but may	communication
	ideas clearly, and	well,	struggle with	skills are
	effectively	contributing to	effective	limited,
	participates in	group	communication	hindering
	discussions about	discussions	or active	group
	topology choices	and sharing	participation.	dynamics and
	and observations.	observations		discussions.
		and insights.		
Overall	Learner presents	Learner	Learner	Learner's
Presentation	findings and	presents	presents	presentation
and Reflection	observations with	findings	findings with	lacks
	clarity and insight,	coherently and	some	organization,
	showcasing a	reflects on the	organization	coherence,
	deep reflection on	activity's	but might lack	and
	the experience	outcomes,	thorough	meaningful
	and the	providing	reflection or	reflection.
			insight.	

	understanding	meaningful		
	gained.	insights.		
TOTAL				/20

## **Comparative Analysis of Learning Theories in CAT and IT Education**

## **Blended Learning Environments:**

Blended learning, a hybrid educational approach combining traditional in-person instruction with online components, presents a unique platform for applying learning theories effectively.

## Integration of Learning Theories in Blended Learning

In blended learning environments, learning theories come to life through the fusion of traditional and online teaching methods. Behaviourism is reflected in the structured online modules, quizzes, and assessments that offer immediate feedback, mirroring the principles of rewards and reinforcements. Meanwhile, cognitive theories find application in the online discussions, collaborative projects, and critical thinking tasks, emphasizing mental processes essential for problem-solving and knowledge application. The blend caters to both behaviourist elements, like tracking progress, and cognitive aspects, such as fostering deep understanding and metacognition.

## **Examples in CAT and IT Education**

Blended learning has gained prominence in Computer Applications Technology (CAT) and Information Technology (IT) education. For instance, learners can access online tutorials and practice exercises to reinforce their programming skills, aligning with behaviourist concepts. Simultaneously, collaborative coding projects and virtual labs provide opportunities for cognitive development by encouraging problem-solving, teamwork, and in-depth understanding of IT concepts. Blended learning in CAT and IT thus effectively incorporates and balances both behaviourist and cognitive theories to optimize the learning experience.

## **Gamification in Learning:**



In education, the complexities of teaching programming, especially at introductory stages, often leave students grappling to acquire essential skills. Programming courses can appear challenging, leading to less-than-ideal learning outcomes. To address these challenges, a promising strategy involves gamification. Gamification integrates game-like elements, like points and rewards, into non-game contexts to enhance learner prompt behaviour engagement and changes (Gari & Radermacher, 2018).

Figure 5 AI generated Image from https://www.bing.com/

Al prompt: Depict in infographic style the concept of gamification. Include books, game controllers, leaderboards and prizes Within gamified learning settings, the principles of behaviourism and cognitive theories find practical application.

Behaviourism aligns with the idea of using rewards and reinforcements, such as earning points, commonly seen in gamified setups. Cognitive theories, meanwhile, connect with the mental processes essential for problem-solving and critical thinking, skills often emphasized in gamified activities. This two-fold approach caters to both external motivation via rewards and the internal cognitive processes that boost learning effectiveness.

Additionally, there are notable instances of gamification in Computer Applications Technology (CAT) and Information Technology (IT) education (Gari & Radermacher, 2018). For instance, interactive coding challenges could offer points for correct solutions, reflecting behaviourist concepts. Similarly, cognitive theories align with problem-solving quests, where students engage with complex scenarios, enhancing their cognitive abilities in the process (Gari & Radermacher, 2018).

## **Challenges and Future Trends**
Implementing learning theories in CAT and IT classes presents a host of challenges, including navigating diverse learner backgrounds, overcoming technological barriers, managing time constraints, addressing resistance to change, and effectively assessing learning outcomes

#### Challenges in Implementing Learning Theories in CAT and IT Classes:

- Diverse Learner Backgrounds: Students in CAT and IT classes often come from varied educational backgrounds, making it challenging to apply a one-size-fits-all learning theory.
- Technological Barriers: Access to technology and reliable internet can be uneven, hindering the effective implementation of online learning aligned with learning theories.
- Time Constraints: The packed curriculum in CAT and IT classes can limit the time available for in-depth application of learning theories.
- Resistance to Change: Both educators and students may resist shifting from traditional teaching methods to those aligned with modern learning theories.
- Assessment Challenges: Measuring and assessing learning outcomes in line with learning theories can be complex, especially in IT where practical skills matter.

In the face of these challenges encountered while applying learning theories in CAT and IT classes, educators have developed a range of strategic approaches aimed at overcoming these obstacles and fostering effective learning environments. These strategies encompass differentiated instruction, addressing technological gaps, optimizing time management, enhancing faculty development, and deploying varied assessment methods, all designed to ensure that learning theories can be successfully integrated into the dynamic world of CAT and IT education

# Strategies to Overcome These Challenges in CAT and IT Classes:

- Differentiated Instruction: Tailor teaching approaches to accommodate diverse learner backgrounds, offering various resources and support materials.
- Addressing Technology Gaps: Ensure access to technology by providing loaner devices or organizing in-person sessions for those with connectivity issues.
- Effective Time Management: Prioritize essential content aligned with learning theories and implement flipped classroom techniques to optimize in-class time.

- Faculty Development: Offer training and support to educators transitioning to new teaching methods, helping them embrace and apply learning theories effectively.
- Varied Assessment Methods: Implement a mix of assessment tools, including practical assignments, peer assessments, and traditional exams, to align with different aspects of learning theories while ensuring accurate evaluation of IT skills.

# **Future Trends in CAT and IT Education:**

## Pair Programming in Technological Education

In 21st-century South African technological education, particularly in the teaching of objectoriented programming, instructional challenges persist at secondary and tertiary levels. Teaching and learning programming present formidable hurdles (Govender et al., 2013, p. 154). In this context, pair programming emerges as a notable technique employed within educational settings to enrich computer programming education. The method focuses on collaborative problemsolving, as two learners' team up to address challenges using a programming language (Breed et al., 2013, p. 207). In this collaborative process, one participant takes on the role of the "driver," executing the code, while the other, known as the "navigator," observes, provides feedback, proposes alternatives, and encourages metacognitive thinking. This approach enhances planning, design, and evaluation skills, contributing to improved programming quality (Breed et al., 2013, p. 207). Supervised implementation is vital for mutual learning, ensuring that both participants benefit from the experience. To promote fairness and balanced participation, role-switching and measures against dominant tendencies are crucial elements (N. C. C. Brown & Wilson, 2018, p. 3).

# Adapting Learning Theories to Technological Advancements: Unplugged Coding

#### Chapter 1: Exploring Learning Theories in CAT and IT Education

Recently a remarkable shift in Computer Science education has been observed. A series of effective educational activities have emerged, emphasizing an unconventional approach that transcends traditional computer-centric paradigms. These innovative approaches, known as "unplugged" Computer Science educational activities, underscore a vital aspect: that coding goes beyond computers and encompasses mathematical thinking skills (Kert et al., 2019, p. 133). Webb et al. (2017, p. 451) elaborate that unplugged activities facilitate the acquisition of fundamental programming concepts through scenarios depicted on paper, fostering physical learning experiences that unfold independent of AI prompt: Create an image of kids rearranging puzzle computers. This methodology enables students to pieces to finish unplugged coding task engage with concepts uninhibited by the



Figure 6 AI generated image of Unplugged coding

intricacies of programming languages, thereby enhancing comprehension and conceptual grasp.

# **Case Studies**

#### Case Study 1:

#### Case Study: Enhancing Coding Proficiency Through Gamified Learning

Background: At Tech High School, students enrolled in the introductory programming course faced challenges in grasping coding concepts effectively. The course content, centred around various programming languages and algorithms, often left students overwhelmed and demotivated. The teaching team recognized the need for a pedagogical approach that could transform the learning experience and improve student engagement.

**Scenario**: The teaching team decided to implement gamification principles into the programming curriculum to address the existing challenges. The aim was to leverage learning theories to create an engaging and motivating environment that would enhance students' coding proficiency.

#### Application of Learning Theories:

Behaviourist Theory: To incorporate behaviourist principles, the team introduced a point-based system. Students earned points by completing coding challenges, debugging exercises, and participating in coding competitions. Positive reinforcement through points served as extrinsic motivation, encouraging students to actively participate and excel.

**Cognitive Theory**: The curriculum was redesigned to include problem-solving quests that required students to apply coding concepts in real-world scenarios. These quests challenged students to think critically, analyse problems, and devise innovative solutions. This approach aligned with cognitive theories, enhancing students' cognitive processes and problem-solving skills.

**Implementation**: The programming course was transformed into a gamified learning environment. Students could earn points for completing coding exercises, contributing to class discussions, and achieving top scores in coding competitions. The curriculum was enriched with interactive coding challenges, puzzles, and simulation-based activities that promoted active engagement.

**Results**: The integration of gamification and learning theories yielded remarkable results. Student engagement significantly increased, and the coding proficiency of the students showed remarkable improvement. The point-based system provided immediate feedback, motivating students to persevere and earn rewards. The problem-solving quests enhanced students' critical thinking abilities, preparing them for real-world coding scenarios.

**Conclusion**: This case study exemplifies how the application of learning theories, specifically behaviourist and cognitive theories, can transform the learning experience in CAT and IT education. By integrating gamification principles, educators at TechHigh School successfully created an environment that motivated students and enhanced their coding proficiency while fostering cognitive skills crucial for success in the tech industry.

#### Case Study 2:

#### Activity: Collaborative Blended Learning Analysis and Evaluation

**Objective**: To promote collaborative learning and critical analysis of coding decisions using a blended learning approach while applying the "If then Else" statements.

#### Instructions:

Group Formation: Divide the learners into small groups (3-4 members per group).

**Blended Learning Resources**: Provide each group with access to online learning resources related to the "If then Else" statements (e.g., video tutorials, interactive quizzes, and written explanations). Ensure that these resources are available on a learning management system (LMS) or an online platform.

**Coding Challenge:** Within their groups, learners should utilize the provided online resources to analyse and complete the coding tasks based on the "If then Else" statements (e.g., 1.1 - 2.10).

**Collaborative Blended Coding:** Encourage learners to collaboratively use both the online resources and their group members' expertise to complete the coding tasks. Emphasize the importance of effective online communication and cooperation during this phase.

**Evaluation Criteria:** Explain that learners will not only complete the code but also evaluate their group members' contributions based on the five cooperative learning small group skills: Positive Interdependence, Individual Accountability, Group Processing, Skills in Communication, and Promotive Interaction.

**Documentation:** Each group should document their completed code and the specific contributions of each group member. They should also prepare brief explanations for their coding decisions.

**Online Presentation:** Invite each group to present their completed code and the rationale behind their decisions through an online presentation or discussion forum on the LMS. Encourage them to discuss how they applied the "If then Else" statements and whether they considered different conditions.

**Peer Evaluation:** After each group's online presentation, distribute peer evaluation forms to the learners through the LMS. They should assess their group members' performance based on the five cooperative learning skills and provide constructive feedback online.

**Discussion Forum:** Conclude the activity with an online class discussion forum, allowing learners to share their thoughts on the challenges and insights gained through collaborative blended learning. Encourage learners to reflect on how they applied learning theories, such as problem-solving and critical thinking, in their coding decisions in the online environment.

**Assessment**: Assess learners based on their completed code, online group presentations, and the quality of peer evaluations conducted online. Emphasize the importance of active online participation and the application of learning theories in their coding decisions within a blended learning context.

# Conclusion

Learning theories, like constructivism, cognitivism, and behaviourism, are fundamental to education. They help us understand how people learn and how to teach effectively. This chapter focuses on applying these theories in South African Computer Applications Technology (CAT) and Information Technology classrooms to equip learners for the 21st century. In teaching, teachers provide information, and learners actively engage with it, often with peer influence. Assessments track progress. Understanding learning theories is crucial in CAT and IT education as they inform teaching strategies, adapting to new technology-driven challenges while preparing students for lifelong learning in the digital age.

Behaviourism can be linked to John B. Watson's support for the study of observable behaviours in the early 20th century, Ivan Pavlov and B.F. Skinner's groundbreaking work in classical and operant conditioning, its dominance in the mid-20th century, and the subsequent threat posed by the cognitive revolution. The legacy of behaviourism is still being felt today in how it continues to shape industries like education, therapy, and behaviour modification.

A learning philosophy called constructivism stresses that people develop their understanding via experiences and reflection. It is supported by Jean Piaget's cognitive development theory, which postulates that knowledge is created through experiences and prior knowledge. Challenged concepts, active participation, conversation, and reflection are all essential components of constructivist learning settings, which improve performance, motivation, and engagement. Teachers help students build their knowledge through practical experiences, encouraging teamwork and independent thought.

The cognitive approach to teaching and learning highlights that learning involves actively organizing, processing, and transforming information in the mind. It focuses on mental processes like thinking and problem-solving. To apply cognitivism in teaching, align teaching materials with learners' existing knowledge, aiming to enhance their understanding. In IT and CAT education, the cognitive approach promotes active engagement, problem-solving, critical thinking, and metacognition to deepen learning and comprehension.

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# Chapter 2

# Learning styles and the teaching-learning of CAT and IT



**O** Molokwane

**T** Nyatse

## Introduction

Learning styles are defined as preferred ways of collecting, organizing and processing information (Hassan et al, 2021). Thus, learning styles basically refer to the manner in which people understand, recall, and utilize information. Idkhan and Idris (2021) express that teaching and learning becomes more enjoyable when teachers are aware of the preferred information processing methods of their learners. In this regard, learning styles form a crucial component of education. Various models and theories are used to define and categorize learning styles, which may differ with each learner (Johnson et al., 2020). Therefore, this chapter is focused on elaborating on various learning style models which will help improve the effectiveness of teaching and learning in both CAT and IT.

# Influence of learning styles on effective teaching-learning of IT and/or CAT



Figure 7 Learning styles

Al Prompt: Learning styles in education

Teaching IT and CAT students with different learning styles is crucial. To cater to different learning styles, educators can use various strategies. Visual learners can use diagrams, charts, and infographics to explain complex concepts, while auditory learners can use verbal explanations and podcasts. Reading/Writing learners can provide written explanations and step-by-step instructions, while kinaesthetic learners can incorporate hands-on activities and interactive projects. Sequential learners present content in a logical manner, using organized materials like flowcharts to illustrate processes. Random learners can explore and experiment with software, introduce surprise elements or case studies, and allow flexible project choices.

To accommodate different learning styles, educators should provide a variety of instructional methods, emphasizing active learning, real-world applications, and practical problem-solving. Involving students in the learning process and seeking feedback on the effectiveness of different teaching approaches can also enhance engagement. By considering the diverse learning styles of students, educators can effectively engage a wider range of students in their education.

#### Definition and background on Gregorc's learning style model

The Gregorc learning style model, created by Dr. Anthony F. Gregorc, divides people into four different learning styles based on their perceptual characteristics and organizational skills (Dalaman, et al., 2019). This concept seeks to offer insights into how people like to process and learn information, and it contends that education can be improved by being tailored to these preferences (Dalaman, et al., 2019). The model creates four learning style combinations by fusing two perceptual qualities—concrete and abstract—with two ordering capacities—sequential and random. Each learning style reflects the cognitive thought processes of the student (Dalaman, et al., 2019).

#### Kolb's learning style model and the teaching-learning of IT and/or CAT -

In order to understand the various learning styles categorized in the model, it is important to comprehend the experiential learning cycle which forms the basis of the learning styles. Kolb's model of learning through experience is based on the Experiential learning cycle, which implies that the best way to learn is to learn through experience (Kolb, 2007; Lehane, 2020). In another perspective, Wallace (2019) emphasizes that this model is grounded on how teachers can help foster active learning. In this regard, the teaching and learning process is learner-centred, where the learner learns by doing an activity which is content-based. It is worth noting that the four stages of the Experiential learning cycle, which form the basis of the learning styles, remain continuous throughout the teaching and learning process unless interrupted (Kolb, 2007; Behrendt and Machtmes, 2021).

# Kolb's four stages of the model and its learning styles are outlined by McLeod (2017) below:

#### 1. Concrete Experience

In the context of teaching-learning, concrete experience can be exemplified as listening, observing or reading during a lesson (Wallace, 2019; Johnson et al., 2020). In this stage, the learner essentially encounters a new learning experience through their senses. This experience may be in the form of a situation or engaging in an activity (McLeod, 2017).

**Example:** During a lesson, novice CAT learners can be guided on learning the functionalities of computer hardware components, such as the keyboard, mouse or hard disk drive. This would be a concrete experience for AI these learners in the sense that they would be acquiring new knowledge and experience on the basic functionalities of various computer hardware components.



Figure 8 Computer hardware

Al Prompt: Computer hardware components, such as the keyboard, mouse or hard disk drive

#### 2. Reflective Observation of the New Experience

The learner observes and reflects on the new learning experience encountered (McLeod, 2017; Johnson et al., 2020). In this regard, the learner evaluates the experience from different perspectives where applicable. Morris (2020) further elaborates that reflective observation is essential in guiding the learner through meaning making of the new learning experience, prior to the abstract conceptualization stage. The learner observes and reflects on the new learning experience encountered (McLeod, 2017; Johnson et al., 2020). In this regard, the learner evaluates the experience from different perspectives where applicable. Morris (2020) further elaborates that reflective observation is essential in guiding the learner through meaning making of the new learning the learner through meaning making of the new learning experience, prior to the abstract stat reflective observation is essential in guiding the learner through meaning making of the new learning experience, prior to the abstract conceptualization stage.

**Example:** After undergoing the concrete experience of learning about computer hardware components, novice CAT learners can then start reflecting on how they found the experience, whether it was enjoyable or not. The teacher could facilitate the reflection in the form of a class discussion.

#### 3. Abstract Conceptualization

The learner makes sense of the new learning experience or activity and links it to existing knowledge where applicable (Kurt, 2020; Morris, 2020). Thus, abstract conceptualization is essentially focused on analysing a new learning experience after reflecting on it through reflective observation. Kurt (2020) further emphasizes that abstract conceptualization is grounded on drawing conclusions on new learning experiences. At this stage, the learner processes the new learning experience and starts to think about how the new information can be applied and experimented with.

**Example:** The CAT learners who enjoyed learning the basic functionalities of various computer hardware components typically start to develop in-depth understanding and perhaps develop their own theories of further comprehending these hardware components.

#### 4. Active-Experimentation

At this learning stage, the learner applies what has been learned or experienced in the realworld (McLeod, 2017; Kannan et al., 2021). Through active experimentation, the learner gains an in-depth understanding of the real-world relevance of the new knowledge acquired. Furthermore, Morris (2020) expresses that this learning stage entails evaluating how well newly developed concrete experiences fit with abstract conceptualizations.

The learners who are more kinaesthetic or practical may begin to experiment with how the various computer hardware components can be effectively used. For instance, they may experiment with finding the most efficient way of using Random Access Memory (RAM) to improve the overall performance of their computers.

### Learning styles categorized in Kolb's Learning cycle model

#### **Diverging (Concrete Experience/Reflective Observation)**

This learning style takes an original and creative approach. Rather than examining concrete experiences by the actions taken, individuals tend to assess them from various perspectives (Idkhan and Idris, 2021). They value feelings and take an interest in others. Individuals who prefer this learning style tend to enjoy tasks such as brainstorming ideas and working collaboratively in groups (Idkhan and Idris, 2021). This learning style is essentially an amalgamation of Concrete Experience and Reflective Observation. Sanjabi and Montazer (2020) express that diverging activities should be centred on guiding learners to create relational mappings by identifying the connections between concepts. Hence, it is imperative that teachers adapt their pedagogical approaches to be able to facilitative diverging activities.

**Example activity:** Using Microsoft Excel graphs/charts to present data and reflecting on the learning experience.

Tools to be used: Microsoft Excel and sample dataset of CAT Term 2 exam results.

**Scenario:** A newly appointed administration assistant is struggling to present the Term 2 exam results of grade 11 CAT learners in graph/chart form.

**Instruction:** With your knowledge and expertise in Microsoft Excel, create meaningful and appropriate graph/chart representations of the Term 2 Exam results of CAT learners. Record your overall observations and reflections on the CAT class reflection journal.

#### Assimilating (Abstract Conceptualization/Reflective Observation)

This learning style emphasizes the capability of reasoning. Individuals who demonstrate this learning style are able to sort through information and organize it in a clear, comprehensible manner (Idkhan and Idris, 2021). Hence, they can review the facts and assess the experience as a whole. Additionally, individuals with this learning style are generally focused on theory rather than its applicability (Idkhan and Idris, 2021). Hence, they tend to enjoy designing experiments and working on projects from start to completion. Sanjabi and Montazer (2020) highlight that assimilating is essentially focused on analysing concepts and topics by breaking them into smaller manageable parts.

#### Example activity: Comprehending complex concepts in IT

Tools to be used: Internet resources and textbooks

**Objective:** Helping students comprehend and internalize complex theoretical concepts in IT.

**Instructions:** Using credible sources, research and analyse the topic area of Network Protocols. Thereafter, compile an organized report of the key aspects of this topic in a word processor.

#### Converging (Abstract Conceptualization/Active Experimentation)

This learning style highlights problem solving as an approach to learning. Individuals who prefer this learning style are able to make decisions and apply their ideas to new experiences Kannan et al. (2021). Unlike diverging learners, they tend to avoid people and perceptions, choosing instead to find technical solutions. Converging training methods should be based on expressing ideas in terms of real-world relevance and applying practical solutions (Sanjabi and Montazer, 2020).

#### **Example activity:** Problem-Solving activity

**Aim:** To include learners in a practical problem-solving exercise that calls for the use of both technical know-how and theoretical understanding of CAT.

#### Instructions:

Give learners the problem-solving challenge. Inform them that they will be working alone or in small groups to find solutions to practical technical issues in CAT.

Provide a list of technical issues that are pertinent to the topic. Students should be required to use both their technical and theoretical expertise to solve problems. You might bring up a network configuration issue with CAT, for instance how to set up a Personal Area Network (PAN).

**Problem analysis:** Give students detailed instructions on how to analyse the provided problem. They must recognize the crucial elements, limitations, and goals at play.

#### Accommodating (Concrete Experience/Active Experimentation)

This learning style is adaptable and intuitive. These individuals use trial and error to guide their experiences, preferring to discover the answers for themselves (Kannan et al., 2021). They are able to alter their path based on the circumstance and generally have good people skills. The most effective exercises for this particular learning style should be based on group exercises that focus on solution developments for problems (Sanjabi and Montazer, 2020).

#### Example activity: Project-based learning activity

**Instructions:** In groups of four, compile a short research report of no more than 500 words, in which you explain how Microsoft PowerPoint presentations can more interesting and engaging for junior learners. Use the knowledge you have acquired in compiling your report to create an interesting and engaging PowerPoint on any subject topic of your choice.\ Maximum of 10 slides to be used.

# How the learning styles contribute to effective teaching of IT/CAT:

#### **Diverging (Concrete Experience/Reflective Observation)**

The diverging learning style can contribute to effective teaching in IT and CAT, through the use of brainstorming and reflection activities. Montazer (2020) highlights that brainstorming activities are important in helping diverging learners to identify the key relations of concepts in the subject content. This will be an effective pedagogical approach in IT and CAT because the learners who prefer this learning style, will be able to comprehend the subject content more effectively. In this regard, the IT and CAT learners would be able to have better concrete learning experiences, which will lead to improved reflective observations as well. Both the brainstorming and reflection activities would be more effective in group work, since diverging learners learn better from perceiving content from multiple perspectives (Idkhan and Idris, 2021).

#### Assimilating (Abstract Conceptualization/Reflective Observation)

Kumalasari et al (2022) highlights that a recent study has indicated that learners with an assimilating learning style tend to lack in problem solving skills. This poses a challenge for both CAT and IT teachers since the subjects are aimed at using various computer skills to solve problems (Department of Basic Education, 2011). However, since assimilators lean toward intelligent perception and theoretical conceptualization (Kumalasari et al, 2020). In IT, teachers can use in-depth talks, concept mapping, and hypothetical investigations of programming dialects, calculations, framework structures, and computer program plan standards. Showing IT concepts in an organized way adjusts well with their learning style which will make it easy to for IT teachers to teach them complex topics.

#### Converging (Abstract Conceptualization/Active Experimentation

Sanjabi and Montazer (2020) expresses that convergers are fascinated by unique conceptualization and dynamic experimentation. Thus, CAT teachers can challenge them with problem-solving errands and real-world application ventures. These learners flourish when given the opportunity to apply their hypothetical information and discover arrangements to specialized problems (Kurt, 2020). Therefore, the converging learning style will contribute to effective teaching of IT and CAT, by making easier for teachers to guide learners towards acquiring problem solving skills.

#### Accommodating (Concrete Experience/Active Experimentation)

Accommodators appreciate hands-on encounter and dynamic experimentation (Kannan et al., 2021; Idkhan and Idris, 2021). For IT, teachers can arrange them in coding bootcamps, hackathons, and common-sense workshops where they construct basic applications, explore with program instruments, and work in hands-on equipment exercises. This approach can empower learners to investigate through trial-and-error improve their learning capabilities (Kurt, 2020).

**Reflection activity:** Consider how your lesson plans will incorporate various learning styles using Kolb's model. Plan out how you will use Kolb's learning styles model to improve your pedagogical approach as a CAT or IT teacher.

# Other learning style models

#### Fleming's VARK learning style model.

The VARK learning style model is essentially based on categorizing learners in terms of their sensory characteristics (Mirza and Khurshid, 2020). In essence, learners can easily be identified based on their preferred learning style. In this regard, teachers can better prepare for lessons through incorporating different pedagogical elements that accommodate the four learning styles of the model.

To better understand this model, it is important to unpack the four learning styles that form part of the VARK learning style model.

Amaniyan et al. (2020) outline the various learning styles proposed in the model:



## Evaluation on the appropriateness of Fleming's VARK learning style model in the teachinglearning of IT and/or CAT.

Fleming's VARK learning style model is appropriate in both CAT and IT because it will significantly benefit how learners comprehend these subjects. Considering that both CAT and IT are focused

Chapter 2: Learning tasks and strategies for teaching and learning in CAT and IT

on problem solving using computers (Department of Basic Education, 2011), it is essential that learners are guided to acquire these problem-solving skills, through their preferred learning styles.

The VARK model can be advantageous in the teaching-learning process due to its simplified structure which can be easily comprehended by teachers (bin Ismail and Haniff, 2020). In this regard, CAT or IT teachers would be would be best placed to plan for accommodating the four learning styles outlined in the model. For instance, the use of technology itself during CAT or IT lessons can be categorized as the kinaesthetic aspect of the model (bin Ismail and Haniff, 2020). Thus, CAT or IT learners with a kinaesthetic learning style would be able to maximize their learning capabilities due to practicality and engaging with the technological devices commonly used in a modern-day CAT or IT classroom.

#### Limitations and Considerations: -

Combination of Styles: Since many people have a variety of learning preferences, it can be difficult to place them neatly in one of VARK's four categories. Depending on the situation, IT and CAT professionals frequently need to apply different learning approaches.

Adaptability to new technologies and approaches is essential in the quickly developing disciplines of CAT and IT. The VARK approach can assist teachers in adapting content to various sensory preferences, but it might fall short in addressing the demands of flexibility and ongoing learning.

#### Relevance on 21st Century and Self-directed-learning

Although this model was originally proposed by Fleming in 1992, it is still relevant in modern day teaching-learning of Computer Science Education. In particular, it can help guide modern Computer Science Education learners towards self-directed learning since adapting individual learning styles can improve attitudes towards learning (Paturusi, 2022).

Kayembe and Nel (2019) highlight that enabling self-learning and discovery is one of the challenges the South African education system is faced with in this 4IR era. (How the model could help address such issues).

**Reflection activity** : Consider how your lesson plans will incorporate various learning styles using Fleming's VARK model.

Plan out how you will use Fleming's learning styles model to improve your pedagogical approach as a CAT or IT teacher.

#### Herrmann Brain Dominance Instrument (HBDI) learning style model-

Ned Herrmann created the Herrmann Brain Dominance Instrument (HBDI) model in the 1970s as a framework for understanding and describing different cognitive styles and thinking preferences.



Figure 9 Herrmann Brain Dominance Instrument different cognitive learning styles into four quadrants (HBDI)

This approach is predicated on the notion that individuals and organizations may improve communication, problem-solving, decisionand making processes by better understanding the various prevalent thinking styles that exist.

The Herrmann Brain Dominance Instrument model is defined as a model that is concerned with cognitive learning style preferences of learners (Dlamini, 2020). This implies that the model is focused on an in-depth understanding of how learners think and process information. In this regard, the model categorizes

namely; Analytical (A), Sequential (B), Interpersonal

(C) and Imaginative (D) (Du Toit and Harding, 2022). Al Prompt: Design an animated image), featuring a brain with 4 squares

#### **Analytical (A Quadrant)**

This quadrant represents logical and analytical thinking. People who prefer this quadrant tend to focus on facts, data, and objective analysis (Du Toit and Harding, 2022). They are often critical thinkers who seek precision and are comfortable with quantitative and structured approaches.

**Example activity:** Sequential problem-solving and planning using Databases.

Instructions: Analyse the provided database and create query to arrange the relevant data in tables.

#### Sequential (B Quadrant)

This quadrant is associated with practical and organized thinking. Individuals with a preference for this quadrant are systematic and prefer structured, step-by-step approaches (Du Toit and Harding, 2022). They excel in tasks that require planning and attention to detail.

**Example activity:** Creating MS Word diagrams to represent theoretical understanding of networks.

**Instructions:** Using your understanding of Computer Networks, create diagrams to simplify this topic.

#### Interpersonal (C Quadrant)

This quadrant is based on interpersonal and emotional intelligence. People who lean toward this quadrant are skilled at understanding and connecting with others (Du Toit and Harding, 2022). They value empathy, collaboration, and the human aspect of communication and decision-making.

**Example activity:** Using Spreadsheets to solve data error

**Instructions:** Using your advanced knowledge of MS Excel, solve the formatting and mathematical errors in the Spreadsheet.

#### Imaginative (D Quadrant)

This quadrant involves creativity and holistic approaches to problem-solving. Those who favour this quadrant are imaginative, innovative, and comfortable with ambiguity(Du Toit and Harding, 2022). Hence, these learners excel in generating new ideas and thinking outside the box.

**Example activity:** Using reflective journals to brainstorm understanding the complexity of Internet Technologies as a CAT Topic Area.

# Evaluation on the appropriateness of Herrmann Brain Dominance Instrument (HBDI) learning style model in the teaching-learning of IT and/or CAT.

An understanding and implementation of the Hermann Brain Dominance Instrument (HBDI) model can significantly help teachers to improve their pedagogy by engaging learners with different cognitive learning styles (Randewijk, Du Toit and Harding, 2022:2). This is more especially relevant in the teaching-learning of IT and CAT since both these subjects are grounded on the complexities of problem solving with computers, as highlighted in the Curriculum and Assessment Policy Statement (Department of Basic Education, 2011).

It is imperative that IT and CAT teachers understand the cognitive learning styles of their learners, in order to help them improve their comprehension of knowledge and skills that form the content of both these subjects. Kayembe and Nel (2019:90) state that making learning more learner focused and interesting is one of the challenges faced by South African education system in this twenty-first century era.

Although the HBDI can be an effective instrument for identifying a person's preferred methods of thinking, its suitability for application in the teaching and learning of information technology (IT) can be assessed in the following ways:

Individualized Approach: The HBDI acknowledges that every person has a unique set of cognitive preferences. It can be advantageous to adapt education to take into account various thinking patterns in the field of IT, since students frequently have a varied range of experiences and skills. The HBDI can be used by teachers to create lessons that complement their students' cognitive preferences.

IT experts typically deal with difficult problems when tackling them. The HBDI can assist students in identifying their innate problem-solving style and inspire them to adopt a more holistic viewpoint. For instance, analytical thinkers might be excellent at resolving technical problems, whereas creative thinkers might be excellent at coming up with novel solutions.

**Reflection activity:** Consider how your lesson plans will incorporate various learning styles using the HBDI model. Plan out how you will use the HBDI learning styles model to improve your pedagogical approach as a CAT or IT teacher.

# Evaluation of the influence of learners' learning styles on the effectiveness of their learning in IT and/or CAT within the context of the CAPS and recommendations.

The effectiveness of students' learning in IT (Information Technology) can be significantly impacted by their learning preferences. For the purpose of developing a learning environment that maximizes engagement, comprehension, and retention, it is essential to recognize and accommodate distinct learning types (Dlamini, 2020).

Impact on IT Learning: Visual aids, diagrams, and charts generally work best for visual learners. They might be particularly skilled in IT activities involving flowcharts, flow diagrams, and data visualization (Dlamini, 2020). When visual learners can visualize how various components relate to one another, they frequently find it easier to understand complicated subjects.

#### Auditory learners:

Impact on IT Learning: Lectures, audio explanations, and dialogues may be useful for auditory learners. Even though IT is frequently thought of as a visually-oriented area, auditory learners can still succeed by taking part in technical discussions, listening to podcasts, and verbally discussing topics to ensure that they fully grasp them.

#### **Physical learners:**

Impact on IT Learning: Kinaesthetic learners excel in IT when given the chance to engage in hands-on activities like coding, hardware configuration, or problem-solving in the real world (Du Toit and Harding, 2022). Practical exercises, laboratories, and projects are crucial for their comprehension of IT concepts because they learn best by doing.

#### Learners of reading and writing

Impact on IT Learning: Textbooks, printed materials, and taking notes are generally advantageous for reading and writing learners. They can succeed in IT by reading books on the subject, creating code, and producing technical reports.

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# **Chapter 3**

# **Effective Teaching and Learning Strategies for CAT and IT**



Dr C Bosch

L Van der Walt

## Introduction

The 21st century has brought about a profound transformation in the way we live, work, and communicate, driven largely by advancements in technology and changes in our global society (Agaoglu & Demir, 2020, p. 106). In this rapidly evolving landscape, the field of education stands at the forefront of adaptation and innovation (Agaoglu & Demir, 2020, p. 106). Teaching and learning strategies have undergone a fundamental shift to meet the demands of a digitally connected world, where information is readily accessible, and the skills required for success are continuously evolving (Warnich, 2022, p. 1).

Traditional pedagogical methods that served us well in the past are no longer sufficient to prepare learners for the complex challenges and opportunities of the 21st century (Warnich, 2022, p. 1). To address this, teachers are tasked with reimagining their roles and approaches in the classroom, and learners must acquire a new set of skills to thrive in a knowledge-based economy (Agaoglu & Demir, 2020, p. 106). This necessitates an exploration of teaching and learning strategies tailored to the unique demands of this century.

Distinguishing between teaching and learning tasks, strategies, and models is fundamental in the field of education, particularly in the context of South African school subjects like Computer Applications Technology (CAT) and Information Technology (IT), to effectively design and implement instructional practices tailored to these specialized domains. Teaching tasks in CAT and IT encompass a range of actions and activities undertaken by teachers to facilitate the learning process (Department of Basic Education, 2011, p. 1–73). These tasks involve the selection and organization of subject-specific content, the establishment of clear learning objectives, and the delivery of instruction through methods such as lectures, discussions, or hands-on activities (Department of Basic Education, 2011, p. 1–73). Teaching activities take on a crucial role in transmitting technical information and practical skills, empowering learners to successfully navigate the digital world (Warnich, 2022, p. 1).

Problems In contrast, learning tasks within CAT and IT relate directly to the activities and assignments assigned to learners with the specific aim of achieving subject-specific learning outcomes (Department of Basic Education, 2011, p. 1–73). These tasks demand that learners apply their acquired knowledge, engage in critical thinking, and hone their problem-solving

abilities, all of which are particularly relevant in the rapidly evolving fields of CAT and IT (Department of Basic Education, 2011, p. 1–73). Learning tasks in these subjects may encompass tasks like software development, database design assignments, or the analysis of real-world IT challenges, challenging students to actively engage with the subject matter and fostering their growth in these specialized domains (Department of Basic Education, 2011, p. 1–73).

In the context of CAT and IT, teaching strategies assume another critical role, referring to the methodologies and approaches teachers must employ to effectively teach the intricate and

dynamic subject matter (Bailey & Mentz, 2015, p. in CAT and IT serve to cater to the specific needs learners, enhancing their learning experiences achieve the desired subject-specific learning Mentz. 2015, p. 141). These strategies spectrum of techniques, such as active learning to coding exercises, collaborative problembased learning, flipped classrooms, and learning.

Lastly, instructional models continue to in the South African educational landscape, including CAT and IT. These models Instructional offer systematic Models frameworks and theoretical paradigms that quide educators in the planning, implementation, and assessment of their Figure 10 Quality Teaching and Learning teaching strategies and practices. Teaching models can be classified across a spectrum of teacher-centered, learnerteacher-centred, up to totally learner-centred, and their applicability to IT and CAT. These models

# Teaching **Strategies**

Quality

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141). Teaching strategies and preferences of and enabling them to outcomes (Bailey & encompass a broad methodologies tailored solving scenarios, blended

> relevant be

Learning Tasks

**Computer Science: Knowledge for Educators** 

offer systematic frameworks and theoretical paradigms that guide educators in the planning,

implementation, and assessment of their teaching strategies and practices, aligning them with established pedagogical principles (Zhang, 2021, p. 233).

Quality teaching and learning are central to the three concepts of teaching strategies, instructional models, and learning tasks. These concepts are intricately interrelated and inseparable in the educational context (Killen, 2015, p. 18). Teaching strategies inform how educators approach the delivery of quality instruction, instructional models provide a structured framework for implementing those strategies effectively, and learning tasks are the practical manifestations of both strategies and models, designed to facilitate and assess the attainment of specific learning outcomes (Bailey & Mentz, 2015, p. 141). Together, they constitute the core components of an effective educational ecosystem.

# **Teaching Models for IT and CAT**

Teaching models exist on a spectrum that reflects the distribution of instructional control between the teacher and the learner. One end of this spectrum embodies the teacher-centred model, wherein the educator assumes a prominent role in directing the learning process (Petersen et al., 2020, p. 1). In this approach, the teacher primarily imparts knowledge, sets objectives, and orchestrates the learning environment, often associated with traditional lecture-style teaching (Petersen et al., 2020, p. 1).

Conversely, the other end of the spectrum embraces the learner-teacher-centred model, which places a greater emphasis on learner autonomy and self-directed learning. In this scenario, the educator serves as a facilitator, guiding students in their exploration of knowledge and fostering critical thinking and problem-solving skills. Learner-centred models often align with active learning methodologies, collaborative projects, and inquiry-based learning

# **Teacher-centred approach**

Teachers' shared objective is to aid learners in understanding the fundamental concepts within the curriculum (Petersen et al., 2020, p. 1). The transmission of knowledge, comprehension, skills, and critical thinking habits related to a particular field of study is a key educational task (Petersen et al., 2020, p. 1). The traditional method, which dates back to medieval institutions, uses lectures to convey information when

there wasn't much written material available (Petersen et al., 2020, p. 1). Even though modern lectures now contain things like learner questions and multimedia additions, their fundamental goal still remains to deliver content (Petersen et al., 2020, p. 1). Delivering content is seen by several teachers as a key duty of their teaching role (Petersen et al., 2020, p. 1).



Figure 11 Teacher Centred approach **AI Prompt:** Give me an image of a teacher in the centre of an orange board

Teachers often approach teaching in a teacher-centred manner due to what is commonly known as "the coverage issue" (Petersen et al., 2020, p. 2). This issue encompasses the challenges arising from the necessity of addressing an extensive curriculum within a limited timeframe. Consequently, educators may resort to didactic, teacher-centred methods to ensure comprehensive content delivery (Petersen et al., 2020, p. 2). The persistent struggle lies in striking a balance between covering the required material and fostering learner engagement and deeper understanding, a challenge that frequently results in the continued prevalence of teacher-centred teaching approaches (Petersen et al., 2020, p. 2).

# Learner-centred approach

Learner-centred approaches to teaching represent a pedagogical philosophy that places the learner at the forefront of the educational experience (Zhang, 2021, p. 231). In this approach, the focus shifts from a primarily teacher-centred model, where the teacher is the central authority delivering knowledge, to one where learners actively engage in their own education (Zhang, 2021, p. 231). Learner-centred teaching recognizes that learners possess diverse backgrounds, learning styles, and interests (Zhang, 2021, p. 231). It seeks to customize instruction to cater to these individual differences, fostering a more interactive and participatory learning environment. Learner-centred approaches prioritize active involvement, critical thinking, problem-solving, and collaborative learning, empowering students to take ownership of their learning journey, set their goals, and develop essential skills that extend beyond the classroom (Zhang, 2021, p. 231). The teacher in a learner-centred approach serves as a facilitator, guiding and supporting students in their exploration of subject matter, fostering a deeper understanding of concepts, and promoting lifelong learning skills (Abraham et al., 2016, p. 15).

# **Strategies and Methods for Effective Teaching**

Learner-centred teaching strategies, such as active learning tailored to coding exercises, collaborative problem-solving, project-based learning, flipped classrooms, and blended learning, can significantly enhance the quality of teaching and learning in Computer Applications Technology CAT and IT (Schulz et al., 2022, p. 2). By encouraging hands-on practice, teamwork, and real-world problem-solving, these strategies align closely with the demands of professions catered to by CAT and IT (Department of Basic Education, 2011, p. 8). Furthermore, problem-based learning immerses students in authentic, application-driven experiences, while the flexibility and personalization offered by the flipped classroom and blended learning approaches cater to diverse learning styles (Havenga, 2020, p. 339; Nja et al., 2022, p. 2). Collectively, these learner-centred strategies promote critical thinking, creativity, and adaptability, which are essential qualities for success in the dynamic and ever-evolving fields of CAT and IT (Havenga, 2020, p. 339).

# Collaborative problem-solving

Cooperative learning or collaborative learning are pseudonyms for group work where two or more learners work to finish a task (Gray et al., 2019, p. 1190; Mentz & Goosen, 2013, p. 127). However, it is important to note that this approach's primary focus is not solely on completing the task, but rather on the learning that occurs through the collaborative process. According to Bosch and Laubscher working collaboratively and interactively helps learners develop their self-esteem (Bosch & Laubscher, 2022, p. 136). Cooperative learning offers other benefits, according to Mentz and Goosen, by working with others, learners can gain exposure to diverse opinions, perspectives, viewpoints, and problem-solving strategies. Additionally, learners can benefit from the knowledge, skills, and resources of more experienced group members. Through communication and explanation of ideas and thought processes with others, learners can achieve a more thorough understanding of key concepts (Gray et al., 2019, p. 1190). Finally, cooperative learning can lead to the improvement of social and interpersonal skills, which can be beneficial both inside and outside of the classroom (Mentz & Goosen, 2013, p. 130).

In the IT class, one prominent example of collaborative problem-solving is through the practice of pair programming. This method, extensively discussed in Chapter 1 of "Emerging Trends in the Field: Pair Programming in Technological Education," involves two learners working together at a single computer, with one actively writing code while the other reviews and provides real-time feedback (Mentz et al., 2008, p. 138). Pair programming not only fosters teamwork but also promotes a deep understanding of coding

concepts. It encourages learners to communicate effectively, share insights, and troubleshoot issues collaboratively, ultimately leading to more robust and efficient solutions to programming challenges (Katira et al., 2004). This approach reflects the evolving trends in technological education, where collaborative problem-solving plays a pivotal role in preparing learners for the dynamic field of IT (McDowell et al., 2006).

# **Project-Based Learning**

In accordance with the Curriculum and Assessment Policy Statement (CAPS) for Information Technology in grades 10 to 12, learners are mandated to undertake a Practical Assessment Task (PAT) in the form of project-based learning (PBL) (Department of Basic Education, 2011, p. 50). PBL involves learners applying a combination of techniques, knowledge, and skills to new situations, aiming to complete a task or achieve a specific goal (Saad & Zainudin, 2022, p. 2). It encourages the integration and synthesis of information, data, and ideas to address problems, identify patterns, relationships, and predict outcomes (Saad & Zainudin, 2022, p.2). A project within this framework encompasses various stages: planning, preparation, investigation, research, data gathering, task execution, and the production of a final product, often a software application (Department of Basic Education, 2011, p. 50). Importantly, it necessitates the demonstration of critical thinking, decision-making skills, innovation, and creativity (Department of Basic Education, 2011, p. 50). To facilitate PBL effectively, teachers play a crucial role in defining the project's content, setting clear criteria and instructions, managing scope, ensuring access to necessary resources, establishing timelines, determining assessment criteria, and actively monitoring and guiding learners throughout the project's completion (Saad & Zainudin, 2022, p. 2).

Despite the stringent time constraints often associated with the need to cover the entirety of content stipulated in the curriculum, the incorporation of supplementary smaller projects, adhering to the same fundamental principles as the Practical Assessment Task (PAT), can yield substantial advantages for learners.

# Flipped classroom and blended learning

In contemporary education, the concepts of the flipped classroom and blended learning have emerged as transformative pedagogical approaches that place learners at the centre of the teaching and learning process (Schwichow et al., 2022, p. 282). These methodologies, grounded in the principles of learner-centred instruction, signify a departure from traditional, teacher-centric paradigms (Nja et al., 2022, p. 1).

Instead, they prioritize the individual needs, pace, and learning preferences of students, fostering a more customized and engaging educational experience (Erbil, 2020, p. 1).

# Flipped Classroom Approach:

The flipped classroom model challenges the conventional sequence of instruction (Erbil, 2020, p. 1). In this approach, instructional content, typically delivered through lectures, is pre-recorded and made accessible to learners before class sessions. Classroom time is then repurposed for interactive activities, discussions, problem-solving, and collaborative projects (Erbil, 2020, p. 1). This inversion of traditional teaching not only allows students to engage with course material at their own pace but also empowers them to take ownership of their learning (Nja et al., 2022, p. 1). It encourages active participation, critical thinking, and peer-to-peer interaction, all of which contribute to a deeper understanding of the subject matter (Nja et al., 2022, p. 1). The flipped classroom, essentially, aligns with the learner-centred philosophy by providing opportunities for self-directed exploration and application of knowledge (Erbil, 2020, p. 1).

# **Blended learning:**

Blended learning, conversely, represents a fusion of traditional face-to-face instruction with online learning components (Bosch & Laubscher, 2022, p. 18). It acknowledges that learners possess diverse learning styles and preferences (Bosch & Laubscher, 2022, p. 18). By integrating digital resources, such as video lectures, discussion forums, and interactive simulations, alongside inperson classroom sessions, educators create a more flexible and adaptable learning environment (Vijayan, 2021, p. 1). Learners can access content anytime and anywhere, catering to their individual schedules and needs. This approach allows educators to cater to a broader range of learners, offering more personalized instruction and support (Vijayan, 2021, p. 1). Blended learning promotes learner autonomy, as it encourages learners to navigate between online and offline resources, take responsibility for their learning progression, and seek a deeper understanding of the topics they are studying (Bosch & Laubscher, 2022, p. 18). This approach allows individuals to tailor their learning experience to their own pace and preferences, fostering self-directed learning and the development of essential skills for the digital age (Bosch & Laubscher, 2022, p. 18).

# **Learning Strategies and Skills**
In the school subjects of Information Technology (IT) and Computer Applications Technology (CAT), acquiring knowledge is just the beginning. Success in these rapidly evolving domains demands not only technical expertise but also a set of learning strategies and essential skills (Yang & Bai, 2019, p. 43). This section explores the critical cognitive, metacognitive, and affective/social skills required for a triumphant journey in IT and CAT.

#### **Cognitive Skills**

Cognitive skills form the foundation for problem-solving, innovation, and effective decision-making in IT and CAT (Messinis & Ahmed, 2013, p. 1) (Maule & Maule, 2016, p. 1). Mastery of these skills is essential for tackling complex challenges in these fields:

**Analytical Thinking:** The ability to dissect intricate issues, identify patterns, and apply logical reasoning is vital in IT and CAT (Kwangmuang et al., 2021, p. 2). This skill empowers learners to break down problems into manageable components (Kwangmuang et al., 2021, p. 2).

**Logical Reasoning:** Proficiency in logic is indispensable for programmers, system architects, and troubleshooters (Cheng et al., 2021, p. 22). It allows learners to make informed decisions, construct coherent solutions, and anticipate potential issues.

**Problem Solving Skills:** In IT and CAT, the ability to approach and solve complex problems efficiently is crucial (Cheng et al., 2021, p. 24). Developing strong problem-solving skills is essential for addressing a wide range of technical challenges (Breed & Bailey, 2018, p. 2). These skills empower learners to analyse issues, design effective solutions, and troubleshoot effectively (Breed & Bailey, 2018, p. 2).

#### **Metacognitive Skills**

Metacognition is the art of self-aware learning (Loksa et al., 2022, p. 2). It involves understanding one's own cognitive processes and regulating them for optimal learning outcomes. In the dynamic realms of IT and CAT, metacognitive skills are the compass guiding learners towards improvement and adaptability:

**Goal Setting:** Defining clear learning objectives keeps learners focused, motivated, and purpose-driven (Breed & Bailey, 2018, p. 11). Goals provide direction and milestones for measuring progress (Breed & Bailey, 2018, p. 11).

**Self-Monitoring:** Regularly assessing one's comprehension and progress allows for fine-tuning learning strategies (Breed & Bailey, 2018, p. 9). It ensures that misunderstandings are addressed promptly and learning stays on track (Loksa et al., 2022, p. 8).

Adaptability: Given the pace of technological advancement, adaptability is a cornerstone skill. The ability to adjust one's learning



Figure 12 Metacognitive skills Al Prompt: design a background for metacognitive skills in orange

strategies to embrace emerging technologies is indispensable (Loksa et al., 2022, p. 4).

#### **Affective/Social Skills**

In IT and CAT, affective and social skills are increasingly vital as collaboration and communication become cornerstones of success (Loksa et al., 2022, p. 4). These skills encompass emotional intelligence, interpersonal relations, and effective teamwork:

Effective Communication: Proficiency in articulating technical ideas, both in writing and verbally, is critical (Cheng et al., 2021, p. 22). Effective communication is an indispensable learning strategy that empowers learners to engage with teachers, peers, and educational resources, facilitating learning and enhancing critical thinking (Warnich, 2022, p. 3). It is essential for collaboration, preparing learners for future careers where clear communication is vital (Warnich, 2022, p. 3). Developing these skills boosts confidence, encourages empathy, and fosters adaptability to diverse audiences, fostering a culture of lifelong learning (Masethe et al., 2017, p. 2).

Teamwork and Problem Solving: Collaborative projects are commonplace. Skills in conflict resolution, negotiation, and consensus-building are vital for productive teamwork (Schulz et al., 2022, p. 319).

By nurturing these cognitive, metacognitive, and affective/social skills, learners in IT and CAT will be well-prepared to excel in their studies, adapt to fast-evolving technology, and contribute to innovative solutions.

#### Successful Teaching of IT and CAT

The role of CAT and IT teachers extends beyond imparting knowledge; it encompasses shaping future professionals equipped to thrive in an ever-evolving technological landscape (Warnich, 2022, p. 3). Beyond the traditional classroom model, we seek insights into how technology, handson learning, and real-world application play pivotal roles in the realm of successful teaching.

#### Case Study: "Flipping the Flipped" - An Unconventional Flipped Classroom Approach

#### Introduction:

The traditional flipped classroom model involves learners watching content videos at home and completing homework or activities in the classroom under the guidance of the teacher. In this case study, we explore an unconventional approach to the flipped classroom, taking the concept one step further. This approach, referred to as "Flipping the Flipped," involved learners watching video content at home while the teacher assumed the role of a learner by completing homework independently and applying their knowledge in the practical component of the subject. It's important to note that the teacher intentionally made the most common mistakes and misconceptions to provide a richer learning experience.

#### Inverting the Learning Process:

In the traditional flipped classroom, learners typically consume content at home, while the teacher provides support and guidance in class. In this unconventional approach, the teacher inverted this process. The teacher watched the video content at home, becoming the "learner" in this scenario.

The deliberate introduction of misconceptions aimed to replicate the challenges learners might face.

#### Independent Homework Completion:

In the theory aspect of the subject, the teacher intentionally made common mistakes and misconceptions while independently completing the homework and assignments. This strategy was employed to create a more authentic learning experience, where learners encountered and corrected these misconceptions.

#### **Practical Application:**

In the practical component of the subject, the teacher wrote a Delphi program, incorporating the lessons learned from the deliberate misconceptions. This practical experience reinforced the teacher's understanding of the subject matter and the real-world challenges learners might encounter.

#### Learner-Led Evaluation:

To complete the flipped approach, learners took on the role of educators. In the classroom, they assumed the position of the teacher and assessed the teacher's assignments. This evaluation included identifying and correcting the misconceptions introduced by the teacher, enhancing the overall learning experience.

#### Outcome:

This unconventional approach with the intentional introduction of common mistakes and misconceptions had several notable outcomes:

#### Deeper Understanding:

The intentional introduction of misconceptions by the teacher provided learners with a unique opportunity to identify and correct these common mistakes. This promoted a deeper understanding of the subject matter.

#### **Practical Application:**

Writing a Delphi program, considering the misconceptions, allowed the teacher to demonstrate how to address and resolve these errors in a real-world context. It emphasized the practical aspect of learning.

#### Learner Empowerment:

The deliberate inclusion of misconceptions encouraged learners to critically analyse the content and actively participate in the correction process. This empowerment enhanced their ability to identify and rectify common errors.

#### Enhanced Teacher-Learner Relationship:

This approach not only strengthened the teacher-learner relationship but also established an environment of mutual learning. The deliberate introduction of misconceptions provided a shared challenge for both the teacher and learners to overcome.

#### Conclusion:

"Flipping the Flipped" represents an unconventional approach to the flipped classroom model, where the teacher becomes the learner and learners take on the role of educators. The intentional introduction of common mistakes and misconceptions creates a unique and dynamic learning experience. This method fosters a deeper understanding of the subject, promotes practical application, empowers learners to identify and correct errors, and strengthens the teacher-learner relationship. It highlights the flexibility and adaptability of the flipped classroom concept while emphasizing the importance of addressing misconceptions in the learning process.

#### Enhancing Learning Strategies and Skills in an IT Classroom

#### **Class Activity: Delphi Coding Challenge**

#### Introduction

To reinforce the learning strategies and skills discussed in Section 3, this class activity aims to engage learners in a dynamic and competitive coding challenge using the Delphi programming language. The activity is designed to enhance cognitive skills, metacognitive skills, and foster an environment for effective communication and teamwork.

#### Materials Needed:

- Computers with Delphi programming environment
- A timer or stopwatch

#### Procedure

**Divide Learners into Teams:** Organize the learners into small teams of 3-4 individuals. Each team should have access to a computer with the Delphi programming environment.

**Coding Challenge Instructions:** Explain the challenge to the learners. Each learner in a team will have exactly 1 minute to write a small piece of Delphi code that accomplishes a specific task. The task can be a simple program or a code snippet that requires logical reasoning and problem-solving skills.

**Error Rule:** If a learner's code produces no errors, they will earn an extra 30 seconds of coding time. However, if they encounter an error within the initial 1-minute period, it's another learner's turn in the same team.

**Scoring:** Keep track of the number of successful code segments completed by each team. For every correct piece of code, the team earns a point. The learner who completes the most code segments correctly within the allotted time wins the challenge for their team. **Rotation:** After each turn, learners should rotate to the next computer in a clockwise or counterclockwise direction, ensuring that all team members get a chance to code.

**Discussion Rounds:** Between coding rounds, encourage learners to discuss their approaches and solutions as a team. This encourages effective communication, as they share their thought processes and solutions with one another. It also promotes collaboration and metacognitive thinking as they collectively fine-tune their strategies.

**Time Limit:** The activity can last for a predetermined duration, such as 30-45 minutes, with multiple coding rounds. At the end of the activity, tally the points and declare the winning team based on the number of successful code segments.

#### Learning Outcomes of this activity

- Learners will sharpen their cognitive skills by solving coding challenges under time constraints, enhancing analytical thinking and logical reasoning.
- Metacognitive skills will be cultivated as learners adapt their strategies, learn from their mistakes, and set goals for completing the coding tasks.
- Effective communication and teamwork will be encouraged as learners collaborate to discuss coding solutions and share insights.
- This class activity not only reinforces the essential learning skills in IT and CAT but also provides an engaging and competitive environment where learners can apply their knowledge and problem-solving abilities effectively.

#### Conclusion

Traditional teaching methods are no longer sufficient, and both teachers and learners must adapt to this evolving landscape (Warnich, 2022, p. 1). Teaching Tasks in CAT and IT encompass activities teachers undertake to facilitate learning, involving content selection, clear learning objectives, and delivery methods (Department of Basic Education, 2011, p. 1–73). Learning Tasks relate to assignments designed to achieve specific learning outcomes, demanding that learners apply their knowledge, engage in critical thinking, and enhance problem-solving abilities (Department of Basic Education, 2011, p. 1–73). Teaching Strategies in CAT and IT are critical to

effective instruction and aim to cater to learners' specific needs and preferences, enhancing their learning experiences (Bailey & Mentz, 2015, p. 141). Instructional Models provide structured frameworks for the planning and implementation of teaching strategies, aligning them with established pedagogical principles (Schulz et al., 2022, p.2). In the context of Teaching Models, one end of the spectrum embodies the teacher-centred model, where the teacher imparts knowledge, while the other end embraces the learner-centred model, emphasizing learner autonomy and self-directed learning (Petersen et al., 2020, p. 1). Learner-Cantered Teaching Strategies such as active learning, collaborative problem-solving, project-based learning, flipped classrooms, and blended learning enhance the quality of teaching and learning in CAT and IT matter (Erbil, 2020, p. 1) (Nja et al., 2022, p. 1).

#### Key takeaways and best practices for teaching IT and CAT.

- The 21st century has brought significant changes in technology and global society, impacting education.
- Education must adapt and innovate to meet the demands of a digitally connected world with evolving skills.
- Traditional teaching methods are no longer sufficient for preparing learners for the 21st century.
- Teachers and learners need to reimagine their roles and acquire new skills.
- Teaching and learning strategies tailored to this century are essential.
- Teaching tasks involve selecting content, setting objectives, and delivering instruction.
- Learning tasks involve applying knowledge, critical thinking, and problem-solving.
- CAT and IT subjects emphasize active engagement with the subject matter.
- Teaching strategies in CAT and IT cater to learner needs and preferences.
- Teaching strategies include active learning, collaborative problem-solving, project-based learning, flipped classrooms, and blended learning.
- Instructional models guide educators in planning, implementing, and assessing teaching strategies.
- Teaching models can be teacher-centred, learner-teacher-centred, or learner-centred.

- Teaching strategies, instructional models, and learning tasks are interconnected and essential for quality education.
- Teaching models in IT and CAT exist on a spectrum, ranging from teacher-centred to learner-centred.
- Teacher-centred models involve the teacher imparting knowledge, often through lectures, and are used due to the need to cover extensive curriculum content.
- Learner-centred models emphasize the active role of learners in their education, catering to individual differences and fostering interactive and participatory learning.
- Learner-centred teaching prioritizes active involvement, critical thinking, problem-solving, and collaborative learning, with the teacher serving as a facilitator.
- Strategies for effective teaching in IT and CAT include active learning tailored to coding exercises, collaborative problem-solving, project-based learning, flipped classrooms, and blended learning.
- These learner-centred strategies promote critical thinking, creativity, and adaptability, essential qualities for success in these fields.
- Collaborative problem-solving involves group work that focuses on learning through the collaborative process.
- It benefits learners by exposing them to diverse opinions, perspectives, and problemsolving strategies.
- It promotes the development of self-esteem and social skills.
- In IT, pair programming is an example of collaborative problem-solving that fosters teamwork and a deep understanding of coding concepts.
- Project-based learning (PBL) in IT involves applying knowledge and skills to complete a task or achieve a specific goal.
- PBL integrates information, data, and ideas to address problems and encourage critical thinking and creativity.
- Teachers play a crucial role in defining project content, setting criteria, managing resources, and guiding learners.
- The flipped classroom approach involves pre-recording instructional content and repurposing classroom time for interactive activities.

- It empowers students to engage with course material at their own pace and fosters active participation and critical thinking.
- Blended learning combines face-to-face instruction with online components, offering flexibility and catering to diverse learning styles.
- Learners can access content anytime and anywhere, promoting learner autonomy and selfdirected learning.
- In IT and CAT, success requires not only technical knowledge but also a set of learning strategies and essential skills.
- Cognitive skills include analytical thinking, logical reasoning, and problem-solving, which are crucial for tackling complex challenges in these fields.
- Metacognitive skills involve goal setting, self-monitoring, and adaptability, guiding learners toward improvement and adaptability.
- Affective/social skills, like effective communication and teamwork, are increasingly vital as collaboration and communication become key to success.
- Effective communication empowers learners to engage with teachers, peers, and educational resources and prepares them for future careers.
- Nurturing these skills helps learners excel in their studies, adapt to fast-evolving technology, and contribute to innovative solutions.

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# **Chapter 4**

#### Learning tasks and strategies for teaching and learning in

#### **CAT and IT**



O Molokwane

N Mbele

#### Introduction

A learning task can be defined as a confluence between learners and the subject content (Zhang et al., 2019). Learning tasks serve the key purpose of evaluating learners' knowledge and skills (Sembayev et al., 2021). In this regard, learning tasks are key to helping learners gain a more indepth understanding of what they learn. In the context on CAT and IT, learning tasks are focused on guiding learners to apply acquired subject knowledge and skills for problem solving (Department of Basic Education, 2011). Thus, it is important that teachers knowledgeable in learning tasks and what they should comprise of.

#### **Components of a learning task**

Learners prefer to be guided towards understanding subject content through a simple and relatable approach (Munna & Kalam, 2021). Hence, it is important that learning tasks are based on such an approach. Pertaining to this, teachers must have a good theoretical background and understanding of the key components of learning tasks.

#### Learning objectives

Learning objectives can be defined as a means to guide learners to focus on specific aspects of subject content (Mitchell & Manzo, 2018). Furthermore, learning objectives are key in a learning task because they essentially outline the purpose of the task (Sembayev et al., 2021). In this regard, learning tasks are used as a measure to evaluate whether learners have achieved the set learning objectives or not. In modern times, developing skills is the primary and more significant objective of learning tasks than, as in the past, acquiring theoretical knowledge. (Sembayev et al., 2021). This is more especially relevant in CAT and IT because one of the keys aims of both these subjects is to nurture learners to understand and be skilled in the various functionalities of Information and Communication Technologies (ICTs) (Department of Basic Education, 2011). Therefore, learning objectives form a key component of learning tasks, which are used in modern times to guide learners to acquire key twenty-first century skills and competencies.

#### Example of learning objectives in a CAT learning task:

#### Task: Developing Microsoft Word skills

Grade 10 CAT learners are tasked with editing and rectifying typing mistakes on an erratic document.

#### Learning objectives:

- The learner must be able to identifying typing and grammatical errors.
- The learner must demonstrate expertise in using Microsoft Word functionalities.
- The learner must be able to use Microsoft Word to problem-solve.

#### Instructional materials

Instructional materials are key components that serve the main purpose of improving the educational process, successfully communicate knowledge, and engage learners (Ogbaji, 2017). In the context of learning tasks, it is important that instructional materials are diversified Materials used to deliver content and promote learning are called advanced in accordance with modern technological advancements (Kristanto & Mariono, 2017). Thus, instructional materials are imperative in learning tasks because they help guide and diversify the way in which learners are evaluated on subject content and skills.

#### Example of how instructional materials can be applied in IT learning tasks:

#### Task: Using online-based tools to code

Grade 11 IT learners are tasked with using online coding platforms such as GitHub, CodePen, and StackOverflow to work on collaborative learning tasks projects with fellow peers. In this case, computers and online coding platforms are using as instructional materials for the learning task at hand.

#### Feedback and assessment

Feedback can be regarded as information on certain areas of a learner's comprehension or performance (Wisniewski et al., 2020). Furthermore, feedback is essential in learning activities

because it informs students about their development, areas for improvement, and strengths (Wang & Heo, 2020). Thus, constructive feedback in particular is essential in order to identify areas of growth and consolidate their knowledge or skills of subject content. In addition, feedback is an imperative aspect of learning task because it can foster cooperative learning through peer support (Lipnevich & Panadero, 2021).

#### Example of constructive feedback on a CAT learning task

#### Task: Using Presentation software to creative exemplary presentations

Grade 12 CAT learners had to create presentations to show and explain how they are going to work on the final phase of the Practical Assessment Task.

**Learner 1 feedback:** Good attempt on your overall presentation, however, you must improve on limiting text on your presentation slides.

Learner 2 feedback: Poor attempt on your presentation slides. You need to improve on your Microsoft PowerPoint skills, we will work through this in the after-school interventions.

**Reflections on learning task** 

(2019).

#### Reflections refer to opportunities for learners to consider what they have learned, evaluate their own development, and pinpoint areas in need of more work (Chang, 2019). Reflecting on learning activities support metacognitive thinking in learners and aid in the consolidation of their knowledge and abilities (Moseki & Schulze, 2019). IT and CAT Educators can enable learners to have an active role in their own learning process by incorporating learner reflections into learning tasks. This will help learners to gain a better awareness of their

areas of strength and progress, as well as encourage Self-directed learning approach (Chang, B.

AI Prompt: two learners with Computers facing each other

Figure 13 Feedback to learners



#### Example of learner reflections on an IT learning task

#### Task: Online Journal reflections on Relational Databases task

Grade 11 IT learners were required to create online reflection journals where they reflect on the relational database learning task they completed in class.

**Learner 1:** "At first, I struggled with understanding the purpose of relating data in Microsoft access, however, I gradually began to understand as the teacher clarified using relatable examples of real-world relational data."

**Learner 2:** "I found the collaborative learning approach very effective in completing this learning task because my friends simplified how to apply relations in data."

## How teachers' choice of learning tasks in IT and/or CAT can make learning more effective

The choice of learning tasks is important because these tasks ultimately determine whether the learning objectives are being achieved or not (Mitchell & Manzo, 2018). Therefore, it is crucial that IT and CAT teachers choose the most appropriate learning tasks in facilitation of the teaching and learning process.

In order to clarify how IT and CAT teachers' choice of learning tasks can make learning more effective, three approaches are used to explain and exemplify:

#### **Authentic learning**

Authentic learning can be defined as a learning approach that guides learners to work on challenges and tasks that they would encounter in the real world (Beier et al. 2019). In this regard, authentic learning tasks are based on using subject knowledge and skills in ways that are representative of real-world circumstances and settings outside of the classroom (Singer et. 2020). Therefore, authentic learning tasks evaluate learners' creativity, critical thinking, and problem-solving skills, which are key areas of focus in both IT and CAT (Department of Basic Education, 2011).

The choice of authentic learning tasks in IT and/or CAT can significantly improve the effectiveness of learning, through improving learners' meaning making. It can be quite a challenge for either IT or CAT learners to fully comprehend the real-world relevance of what they learn. For instance, IT learners would have a challenge understanding the practical applications of coding if they are not shown the real-world application of coding. In this case, authentic learning tasks would improve the effectiveness of learning coding, through incorporating real-world examples to enhance learners' understanding and problem-solving skills. For example, an authentic learning task that requires the IT learners to code an interactive website that will be used as an open resource for exam revision, would contribute to how learners understand and apply their coding skills in the real-world context. Therefore, choosing an authentic learning task would make learning more effective IT and/or CAT teachers.

#### **Problem-Based Learning**

Problem-based learning is a learning strategy that is focused on cooperatively tackling real-world issues, building critical thinking and developing problem-solving abilities (Lazic et al., 2021). It involves having students investigate and solve complicated, open-ended problems in groups, many of which are based on real-world situations (Ali, 2019). In this regard, Problem-based learning tasks place a strong emphasis on using collaboration to apply acquired subject knowledge and skills in problem solving.

Problem-based learning tasks can foster effective learning in IT and/or CAT through development of collaboration and critical thinking skills. Through collaborative efforts of sharing ideas and guiding each other, IT and CAT learners can enhance their knowledge and skills in subject content. For instance, by working on a data handling and analysis problem-based learning task, CAT learners would be able to guide each other through applying the appropriate skills and techniques to complete the learning task. In this case, the learners would also need to use their critical thinking skills to complete the task through a collaborative effort. The CAT teacher can intervene should the learners struggle with various aspect of the problem-based learning task. Therefore, problem-based tasks would be a viable choice for IT and CAT teachers to maximize the effectiveness of learning in their classrooms.

#### **Differentiated Instruction**

Differentiated instruction refers to a teaching strategy that is based on adjusting lesson plans and learning tasks to meet the various learning styles, interests, and skill levels of learners (Abety & Zayas, 2019). This approach is based on acknowledging that every learner is unique in their learning style, abilities, and areas for improvement (Smale-Jacobse et al. 2019).

Differentiated learning tasks can improve the effectiveness of learning IT and CAT, through the use of various multimedia resources. By using various multimedia resources in learning tasks, IT and CAT learners with varying learning styles can learn more effectively through their preferred learning styles. For example, a CAT learning task that allows learners to use their preferred online resources to explain complex subject concepts, would be regarded as an effective learning task. This would be due to the fact that the CAT learners would be able to work on the learning task using their learning preferences. In such a task, the teachers would be able to identify the various strengths of learners and use this information in planning for future lessons and improving the overall effectiveness of learning during lessons.

Through application of these teaching and learning approaches, it is clear that the choice of a learning task can improve the effectiveness of learning in IT and CAT. The use of only one approach may not significantly improve the effectiveness of learning in these subjects, but a combination of these approaches would be the best strategy.

#### The content and form of a learning task

#### The learning task content

The content of a learning task refers to subject matter that learners are supposed to interact with and gain knowledge from as part of an educational activity. Learning task content is further clarified as the knowledge and skills that learners must learn, acquire, evaluate, and comprehend within a specific time included in the content (Wekerle et al. 2022). It is intended to support the acquisition of information, skills, and competences in a particular subject area and forms the basis for the learning objectives (Wekerle et al. 2022). Hence, to promote a significant learning experience and

activity, the content of a learning assignment should be in line with the learning objectives and arranged logically.

#### Example of learning task content on Coding

The process of creating, writing, testing, debugging, and maintaining the source code for computer programs is referred to as coding or programming. It entails utilizing specific tools and languages to write commands that a computer can follow. When these commands are carried out, they accomplish particular jobs or functions, from straightforward computations to intricate procedures.

#### The main parts of coding are broken down as follows:

Programming languages are formal languages that contain sets of instructions that can be used to generate a variety of results. Python, Java, C++, JavaScript, and many other languages serve as examples. The syntax and semantics of each programming language specify how the instructions should be expressed and understood.

A source code is referred to as the human-readable instructions written in a programming language. After that, the source code is converted into bytecode or machine code, which the computer can comprehend and use.

Designing an algorithm is formulating a series of rules or detailed instructions to handle particular issues or carry out particular tasks. The foundation of coding is made up of algorithms, which specify the logical order of operations that must be performed in order to get the intended result.

Integrated Development Environments (IDEs) are computer programs that include all the tools needed for software development. Code editors, interpreters, and other tools for debugging and testing code are frequently included in IDEs. Popular IDEs include DELPHI, PyCharm, Visual Studio, and Eclipse.

#### The form of a learning task

The precise layout or style of an instructional task or activity that students must perform as a part of their learning process is referred to as the form of a learning task (Wekerle et al. 2022). The form includes the task's general structure, requirements, and instructions as well as the directions and instructions given to students to direct their participation in it (Algurén, 2021). Therefore, the structure of a learning assignment is crucial in determining how well students comprehend, participate in, and finish a task. A learning task's format should be created to encourage students' understanding, participation, and successful completion of the given task (Algurén, 2021). Hence, it should be easily available, well organized, and in line with the learning objectives.

#### Example of the form of a learning task

### Improving Learning Methods and Techniques in an IT Classroom Coding Exercise in Delphi for class

#### Introduction

This class exercise seeks to include students in a dynamic and competitive coding challenge using the Delphi programming language in order to reinforce the learning strategies and abilities covered in Section 3. The practice is intended to improve cognitive and metacognitive abilities as well as to promote an atmosphere that is conducive to productive teamwork and communication.

Grouping students into teams: Arrange the learners into small groups of three to four people. Access to a computer with the Delphi programming environment should be available to every team. Instructions for the coding challenge: Inform the students of the challenge. Each student in a team will have precisely one minute to create a brief section of Delphi code that completes a particular job. A straightforward program or piece of code may be required for the task, which calls for logical thinking and problem-solving abilities.

Instructions for the coding challenge: Inform the students of the challenge. Each student in a team will have precisely one minute to create a brief section of Delphi code that completes a particular job. A straightforward program or piece of code may be required for the task, which calls for logical thinking and problem-solving abilities.

It's critical to distinguish between a learning task's form and content. While the form refers to the particular format, structure, or technique used to communicate the content successfully, the content refers to the subject matter that learners must understand. In order to ensure that learners comprehend the theoretical and practical components of IT and CAT and have opportunities to

apply their knowledge in real-world, well-designed learning tasks establish a balance between form and content.

#### Routine and non-routine learning tasks in IT and CAT

#### **Routine Learning Tasks**

Routine learning tasks are the instructional activities that learners are assigned in their academic coursework (Kablan & Uğur, 2021). Thus, these activities frequently follow a set format, are predictable, and designed to strengthen the fundamental knowledge and abilities of a given subject (Saygılı, 2017). Practice, repetition, and application of previously learned concepts and content are common components of routine learning tasks (Kablan & Uğur, 2021). Regular learning assignments are crucial for developing fundamental information and abilities, but in order to promote critical thinking, problem-solving, and creative expression, teachers should incorporate challenging and interesting learning activities. Therefore, in order to achieve the set learning outcomes, effective learning experiences establish a balance between basic routine tasks and more complex tasks

#### **Role in IT and CAT**

In IT and CAT, routine learning tasks are essential since they help to strengthen basic concepts, technical abilities, and develop a solid understanding of them. These tasks are crucial for giving IT and CAT learners a strong foundation and getting them ready for more difficult and real-world applications.

The main role of routine learning tasks in IT and CAT is they guide learners towards problemsolving proficiency. Through these tasks, learners are encouraged to use logical reasoning and problem-solving strategies to solve typical IT and CAT issues. For instance, a Microsoft Excel task focused on basic calculations, can be used as a routine task. Such a task will foster the basic analytical and critical thinking abilities needed to solve real-world relevant problems, which would be the foundation of non-routine learning tasks.

#### Non-routine learning tasks

These can be classified as activities that foster learners to use their creative, critical thinking, and problem-solving abilities in challenging circumstances (Saygılı, 2017). Thus, non-routine learning tasks essentially go beyond basic memorizing or repetition and instead encourage learners to examine, synthesize, and evaluate knowledge. Higher-order cognitive abilities and a deeper comprehension of the material are the essentially the goals of non-routine tasks (Saygılı, 2017). Students can improve their cognitive capacities, encourage creativity, and acquire the skills needed to deal with real-world problems in their academic, professional, and personal life by completing these assignments.

#### Role in IT and CAT

Non-routine tasks are important in IT and CAT because they develop critical thinking, creativity, and problem-solving skills which are imperative in modern times. In IT and CAT, these tasks promote innovation and creativity through encouraging learners come up with various effective ways to solve technical problems. This leads to the creation of new programs, systems, and applications. For example, the creation of online AI tools was a result of a creative and innovative type of thinking. Furthermore, through non-routine tasks, IT and CAT learners can assess new developments, trends, and technologies, keeping them up-to-date and informed about the most recent developments and difficulties of this modern era.

# Poor learning habits that lead to ineffective learning and how they can be resolved using problem-solving techniques to the design of learning tasks in IT and CAT

According to Urh and Jereb (2014, p. 350) define learning habits as "methods and means of obtaining information". It occurs on the conscious or unconscious position, it assists students to organize their efforts to resolve issues, advance abilities, obtain knowledge and accomplish school responsibilities (Urh & Jereb, 2014, p. 350). According to Murni and Helma (2021, p. 2) stated that learning habits are student behaviours that are repeated occasionally in the context of putting their learning into practice, and further stated that learning habits are ways or processes that students have ingrained in them, such as how to attend classes, read books, complete assignments, and schedule time to complete tasks. Learning habits are acts that student can constantly perform

rather than inherited features (Murni & Helma, 2021, p. 2). One of the most important aspects of learning that affects students' academic success is their learning habits and the quickest approach for a person to assimilate, organize, and access the information obtained is through learning habits (Pahamzah & Febriyani, 2022, p. 126). Because some learning successes are influenced by attitudes and learning habits, the learning habit becomes a crucial component of learning (Pahamzah & Febriyani, 2022, p. 128).

According to Schunk (2014), as articulated by Hidayati and Ismail (2018, p. 74) stated that the learning process entails the following steps:

- 1. training (repeating information, highlighting, and summarizing);
- 2. elaboration (imagination, memorizing keywords, asking and taking notes);
- 3. composing (memorizing, grouping, outlining, and mapping);
- 4. monitoring understanding (self-inquiring, reading back, checking consistency, and paraphrasing) and
- 5. affective (relieving anxiety, holding positive beliefs, generating an encouraging setting and regulating time).

According to Hidayati and Ismail (2018, p. 74) emphasized that Slameto (2010, p. 82) asserted that the following behaviours will have an impact on the quality of learning itself as influenced by learning habits:

- 1. Making a schedule and carrying it through,
- 2. Reading and taking notes,
- 3. repeating the subject from the lecture,
- 4. focus, and
- 5. carrying out the task.

According to Siahi and Maiyo (2015, p. 136) define study habit as "a well-planned and deliberate pattern of study which has attained a form of consistency on the part of the students towards understanding academic subjects and passing examinations". Study can be seen as a carefully thought-out mastery program (Siahi & Maiyo, 2015, p. 136). The main objectives of study, according to Crow and Crow (2007), as outlined by Siahi and Maiyoi (2015, p. 136), are to develop

habits and knowledge that will be helpful in interpreting concepts, making decisions and comping up with new ideas as well as to hone existing skills. Effective study involves reading, drawing, comparing, memorization, and testing oneself over time (Ebele & Olofu, 2017, p. 584).

According to Murni and Helma (2021, p. 2) there are two types of study habits:

#### 1. Good study habits comprise:

- i. Perform daily, routine study
- ii. Before departing the following day, prepare all study materials the night before.
- iii. Attend class before lessons begin at all times.
- iv. It's unforgettable to become used to studying until you really comprehend anything.
- v. Used to going to the library to read more or reading through dictionaries to find definitions.

#### 2. Bad study habits comprise:

- i. Just study assiduously after the upcoming test.
- ii. You can swiftly get any necessary books and equipment just before departing.
- iii. A frequent absentee.
- iv. Learning is generally required because many facts are lost and the grains of information are still opaque.
- v. Hardly ever went to the library and had no access to encyclopaedias and other reference materials.

## Critical evaluation of the assessment strategies and methods that can be used for effective assessment in IT and CAT

According to ColegaOli (2021, p. 1251) describe the term assessment as "the process pf gathering information and interpreting evidence to make judgements about the student learning". It is essential for connecting learning objectives, content, and teaching and learning activities since the outcome defines how effectively the activities perform in delivering the desired learning

outcomes (ColegaOli, 2021, p. 1251). Assessment is defined in teaching and learning as a process used by instructors and learners throughout instruction to give teachers the feedback, they need to change ongoing learning and teaching to help learners achieve specified instructional goals (Ismail et al., 2022, p. 2). According to Ismail et al. (2022, p. 2) states that assessment seeks to enhance learning and bridges the gap between learners' current learning environment and their desired learning aims. Examining a student's work and passing judgment on his performance is what assessment is all about (Nagowah & Nagowah, 2009, p. 1). An essential part of learning is assessment (Ketonen et al., 2023, p. 1). Aligning assessment with learning objectives and instruction is essential because summative and formative assessment approaches together effectively steer learning (Ketonen et al., 2023, p. 1).

#### Importance of assessment

According to Thi Thu Huyen (2017, p. 24) stated that Black (2002) identifies three primary goals for assessment: to give accountability to public stakeholders; to certify learners' achievement for certification or transition to the next step; and to enhance learners' learning.

#### Assessment types

Two kinds of assessment include formative and summative (Ismail et al., 2022, p. 2). More emphasis is placed on providing reflecting data during formative assessment in order to enhance learner learning as it happens (Thi Thu Huyen, 2017, p. 24). According to Wilson (2017, p. 4) describe the term formative assessment as "a systematic process to continuously gather evidence about learning", and further stated that teachers utilize formative assessment to learn more about their learners' zones of proximal development or current levels of understanding. Teachers can better address learner requirements by recognizing particular problems with the learning process and then assisting learners in filling in any gaps or misunderstandings before commencing to build on the material by reaching learners at their zone of proximal development (Wilson, 2017, p. 5). A critical part of the teaching and learning process is formative assessment (Yan & Pastore, 2022, p. 2). Feedback is data gathered from evidences of learning progress obtained by educators and learners themselves and provided, in a detailed and timely manner, to learners in order to inform, guide, and enhance the way they learn (Voinea, 2018, p. 10). The definition of feedback, a crucial

component of formative assessment, is typically information on the effectiveness of something that was previously done or is being carried out (Voinea, 2018, p. 10).

#### **Critical evaluation of existing taxonomies of cognitive levels**

According to Sobral (2021, p. 149) there are three fields of learning in Bloom's Taxonomy such as cognitive, psychomotor and affective domain (or interpretation, capabilities and attitudes). The original Bloom's taxonomy consisted of six main types which were of cognitive domain such as: Knowledge, comprehension, application, analysis, synthesis and evaluation (Sobral, 2021, p. 149). They were arranged from simple to complicated and from concrete to abstract: from low-order abilities that necessitates less cognitive processing to high-order that necessitates deeper learning and huge level of cognitive processing. During the year 2002, there was a document published by David R. Krathwohl, that depicted the revised Bloom's taxonomy. The document indicated that the original Blooms taxonomy was renamed as follows: Knowledge to Remember, Comprehension to Understand, Synthesis to Create, Application to Apply, Analysis to Analyse and Evaluation to Evaluate. The revised Bloom's Taxonomy is given as a two-dimensional framework with knowledge and cognitive aspects, in contrast to the original Bloom's Taxonomy (Dos Reis et al., 2022, p. 40). According to Dos Reis et al. (2022, p. 40), stated that Anderson et al. (2001) emphasized that there are four basic forms of the Knowledge Dimension:

- 1. Factual knowledge is defined as discrete facts, components, and vocabulary words that students need to be familiar with. It includes terminology expertise as well as understanding of specifics and components.
- Conceptual Knowledge: In contrast to discrete information, conceptual knowledge focuses more on the interactions between variables, basic knowledge components, and bigger structures. It includes understanding of categories and classifications, generalizations and principles, theories, models, and structures.
- 3. Procedural knowledge: Knowing how to accomplish things in relation to procedures, techniques, and processes is known as procedural knowledge. It encompasses understanding of subject-specific abilities and algorithms, techniques, and methodologies, as well as criteria for selecting the proper course of action.

4. Meta-cognitive knowledge: General cognition and self-cognition, including contextual and provisional information, are all considered to be parts of meta-cognitive knowledge.

#### The original Bloom's taxonomy, cognitive domain



Figure 14 Original Bloom's taxonomy of cognitive domain (1956) (Sobral, 2021, p. 149)

#### The Revised Bloom's taxonomy, cognitive domain



Figure 15 Revised Bloom's taxonomy of cognitive domain (2002) (Sobral, 2021, p. 149)

According to Sobral (2021, p. 149) the construction of the cognitive procedure dimension of the revised Taxonomy can be described as follows:

#### 1. Remember: bringing forth pertinent information from long-term memory.

- a) Remembering (or recovering)
- b) Acknowledging (or Identification)
- 2. Understanding: determining the objective of instructional messages, including those communicated orally, in writing, and visually.
  - a) Interpreting (or enlightening, rephrasing, illustrating, or interpreting)
  - b) Exemplify (or demonstrating or establishing)
  - c) Categorizing (or sorting, encompassing)
  - d) Recapitulating (or abstracting, generalizing)
  - e) Making an inference (or drawing a conclusion, extrapolating, interpolating, or forecasting)
  - f) Contrasting (or contrasting, visualization, or matchmaking)
  - g) Defining (or creating a model)
- 3. Apply: executing or applying a process in a circumstance.
  - a) Putting into Practice (or doing)
  - b) Applying (or deploying)
- 4. Analyse: separating a piece of content into its component components and figuring out how those parts connect with each other and to a larger structure or goal.
  - a) distinguishing (also known as Discriminating, Differentiating, Concentrating and Choosing)
  - b) Organizing (or incorporating, laying out, interpreting, and organizing)
  - c) Crediting (or Dismantling)
- 5. Evaluate: forming conclusions based on rules and criteria.
  - a) Examining (or arranging, spotting, keeping an eye on, testing)
  - b) Criticism (or Evaluation)

#### 6. Create: combining pieces to create a new, coherent whole or a unique product.

- a) Creating (or speculating)
- b) Organizing (or creating)
- c) creating (or producing).

According to Oosthuizen et al. (2019, p. 7) stresses that: Learners' learning and performance in the classroom are influenced by their metacognitive knowledge and self-awareness; as a result, if the learners are unaware of the strategies for learning and thinking, they will be unable to put them into practice. Learners won't be able to apply their knowledge and skills to a new task if they lack the metacognitive understanding.

## The appropriateness of existing taxonomies of cognitive levels in assessment in IT and CAT

In order to promote higher types of thinking in education, such as analysing and evaluating concepts, processes, procedures, and principles rather than simply recalling facts (rote learning), Bloom's Taxonomy was developed in 1956 under the direction of educational psychologist Dr. Benjamin Bloom. (Zhou & Brown, 2015, p. 89). To categorize educational goals, Bloom's cognitive field taxonomy was essentially created as a hierarchical (in contrast to a relational) learning paradigm (Reeves, 2012, p. 18). Educators are utilizing this taxonomy to construct the learning process and lead learners from low to high orders of thinking in their studying experiences (Akintolu et al., 2022, p. 41).

According to Oosthuizen et al. (2019, p. 4) emphasized that remembering, comprehending, applying, analysing, evaluating, and creating are the six domains through which learning takes place. Each field represents a level of progression, and remembering is the recovery, recognition, and reinstitution of pertinent information from the long-term memory, according to Shabatu (2013, p. 1). Understanding is defined as the accurate understanding of the content, whereas applying is the implementation of that knowledge in practice. The ability to break down information into different components and comprehend how each component relates to the other is what it means to analyse. Evaluation is the process of scrutinizing and examining data with the ultimate goal of developing new knowledge and structures.

According to Oosthuizen et al. (2019, p.5) stressed that Davis (2014) has emphasized that the foundation of Bloom's taxonomy is the sequential mastery of learning outcomes; mastering outcomes at the base of the hierarchy and moving up or advancing to levels that are more complicated. The creation of learning objectives that are centred on the abilities that a learner needs to master is encouraged by Bloom's taxonomy (Oosthuizen et al., 2019, p. 7). As stated by Adams (2015, p. 153) and articulated by Oosthuizen et al. (2019, p. 7) stresses that the easiest way to do this is to use action words to structure learning objectives. The classification system, according to Adams (2015, p. 153), as stressed by Oosthuizen et al. (2019, p. 7) fosters the inclusion of learning objectives that call for higher levels of cognitive ability. Higher level objectives allow for more in-depth learning and the transfer of skills and knowledge, which can result in the mastery of a wider range of tasks and settings.

According to Serfontein and Breed (2013, p. 27) the revised Bloom's taxonomy of learning outcomes can be illustrated as follows:

Level	Revised Bloom Taxonomy	Example of lesson objective
Level 1	Remember (Knowledge): Shallow processing is included at this level, such as the act of recalling specific facts and other information without necessarily understanding them. Action verbs for remember: omit, organize, collect, define, remember, recite, relate, reproduce, match, find, identify, name, match, retain information, choose, demonstrate, tabulate, duplicate, explain, state, clarify, quote, describe, list, reiterate, and tell.	For IT: A learner is anticipated to describe what is a program. For CAT: The learner is anticipated to be capable to provide a list of three functions of operating system.

Level 2	Understand (Comprehension): Learners must not only be able to recollect facts and other information, but also grasp the knowledge and be able to articulate its meaning. This group of cognitive tasks reflects the initial level of comprehension.	For IT: The learner should be capable to describe the steps in the IT problem-solving procedure. For CAT: The learner should be capable of debating the functions of an operating system.
Level 3	Apply: This relates to the capability of applying knowledge (such as rules, processes, methods, concepts, or ideas) in novel contexts. Action verb for apply: Implement, compute, change, select, categorize, finish, create, dramatize, use, analyse, explain, generalize, illustrate, interpret, judge, operate, adjust, schedule, suggest, relate, draw, resolve, employ, and write.	For IT: The learner can implement problem-solving steps to resolve a programming challenge. For CAT: A learner should be capable to calculate the values utilizing a standard spreadsheet function.
Level 4	Analyse: This level's learner objective is the capacity to dissect a whole into its constituent parts. In this manner, the relationships between the elements are detected, and the elements embedded in a whole are identified. Action verb for analyse: assess, categorize, organize, compare, contrast, criticize, differentiate, discriminate,	For IT: The learner must be capable of distinguishing the critical phases of a method through flow chart. For CAT: Learners must be capable of identifying the various disciplines that were inputted by typist/secretary during the creation of a provided form and elaborate why the various disciplines in the

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	distinguish, divide, examine, construct, identify, infer, investigate, order, propose, pick, separate, and test.	form are accurate or not for the information the secretary/typist intends to attain from the customer/client.
Level 5	Evaluate: At this stage, conclusions are drawn and justified using predetermined criteria. Action verb for evaluate: appraise, argue, assess, attach, choose, compare, convince, conclude, contrast, criticize, defend, decide, discriminate, estimate, grade, interpret, judge, justify, measure, predict, prove, rank, rate, recommend, score, select, summarize, support, test, value.	For IT: the learner must be capable criticize a graphical user interface created by a co-learner on the basis of criteria that related to relevant interface design. For CAT: The learner must be capable to criticize a prevailing application form on the basis of the criteria that resonates with good form design.
Level 6	Create (Synthesis): This category describes the capacity to combine parts to create a brand-new whole. Action verb for synthesis: plan, prepare, produce, propose, rearrange, rewrite, reconstruct, set up, substitute, write) arrange, assemble, collect, combine, compose, construct, create, design, develop, formulate, generalize, hypothesize, integrate, invent, manage, modify, organize, plan, prepare, produce.	For IT: The learners must be capable to create an algorithm utilizing the variables and processing phases. For CAT: The learner must be able to develop a new application form while taking into account the form's purpose, professional layout, analogous forms used in practice, and the appropriate word processing features to utilize.

#### Figure 16 Revised Bloom's taxonomy and their six cognitive levels

Table 15 that depicts the revised Bloom's taxonomy and their six cognitive levels along with action verb that can be associated to each level and the example of lesson objective in each cognitive level. Considering the lesson objectives, they can be used to assess learner knowledge as depicted in lesson objective row that relates to every level in the revised Bloom's taxonomy.

When implementing the Revised Bloom's taxonomy for cognitive domain, it is simple to observe that is appropriate for facilitating problem-solving in IT and CAT (Serfontein & Breed, 2013, p. 29)
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# **Chapter 5**

## Advancements in Artificial Intelligence: Impact, Challenges, and Educational Integration



L van der Walt

Computer Science: Knowledge for Educators

## Introduction

The evolution of artificial intelligence (AI) in education can be traced back to the mid-1900s when computers and computing technologies began to make their way into educational institutions (Chen et al., 2020, p. 75265). This marked the beginning of computer-aided instruction and learning (CAI/L) and the integration of computers into various departments within these institutions (Chen et al., 2020, p. 75265). As computers continued to advance, driven by developments like networking, the internet, and enhanced processing capabilities, their applications in education expanded further. This evolution ultimately paved the way for the emergence of artificial intelligence in education (Chen et al., 2020, p. 75265). Artificial intelligence, as defined by Coppin, encompasses the ability of machines to adapt to new scenarios, address emerging challenges, solve problems, answer questions, devise plans, and execute tasks that traditionally require human intelligence (Chen et al., 2020, p. 75265).

Al has been widely incorporated into educational practices thanks to advances in computing and information processing technology, commonly referred to as artificial intelligence in education (AIEd) (Ouyang & Jiao, 2021, p. 1). These applications cover a wide range of tools, including "intelligent tutoring systems, teaching robots, learning analytics dashboards, adaptive learning systems, and human-computer interactions" (Ouyang & Jiao, 2021, p. 1). In the nearly three decades since the founding of AIEd, AI has become recognized as a powerful instrument with the ability to alter instructional design, technological development, and education research outside the bounds of conventional educational paradigms (Ouyang & Jiao, 2021, p. 1). AIEd presents both potential and difficulties in the field of education by opening up new channels for educational innovations like individualized learning, changing the role of teachers, and developing complex educational systems (Ouyang & Jiao, 2021, p. 1).

## **History of Artificial Intelligence**

Artificial intelligence (AI) is the ability of a system to "correctly interpret external data, learn from such data, and use such learnings to achieve specific goals and tasks through flexible adaptation" (Haenlein & Kaplan, 2019, p. 5). Since its establishment as a field of study in the 1950s, artificial intelligence has received little practical attention. Today, Big Data has become a topic of discourse

in both the business world and the general public as a result of its growth and advancements in computer power (Haenlein & Kaplan, 2019, p. 5).

The 1940s are when artificial intelligence (AI) first emerged, especially in 1942 when American science fiction author Isaac Asimov released his short tale "Runaround" (Haenlein & Kaplan, 2019, p. 6). The Three Laws of Robotics were introduced in the above story, which required that robots must respect humanity and carry out their directions (Haenlein & Kaplan, 2019a, p. 6). Subsequently, generations of scientists, such as Marvin Minsky, a well-known American cognitive scientist who then played a crucial part in co-founding the MIT AI laboratory, were greatly influenced by Asimov's work (Haenlein & Kaplan, 2019a, p. 6). This literary influence marked a pivotal moment in the history of artificial intelligence by laying the groundwork for the advancement of AI and robotics (Haenlein & Kaplan, 2019, p. 6).

During the Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI), Marvin Minsky and John McCarthy officially developed the phrase "Artificial Intelligence" in 1956 (Haenlein & Kaplan, 2019, p. 7). The beginning of AI as a field was recognized by this experiment, which was supported by the Rockefeller Foundation and hosted at Dartmouth College (Haenlein & Kaplan, 2019a:6). It brought together important individuals including Claude Shannon, the creator of information theory, and Nathaniel Rochester, the architect of the IBM 701 (Haenlein & Kaplan, 2019, p. 6). The DSRPAI sought to bring together academics from many fields to establish a brand-new discipline devoted to building artificial intelligence-impersonating computers (Haenlein & Kaplan, 2019, p. 6).

#### Expert Systems

Expert systems are computer programs designed to mimic the decision-making capabilities of a human expert in a specific domain (Xu et al., 2019, p. 2). They rely on a collection of rules and knowledge that are established by human experts. These rules are formulated in a way that makes them easily comprehensible and interpretable by humans (Xu et al., 2019, p. 2). Expert systems are particularly useful for automating decision-making processes and providing explanations for their decisions and uses structures called Decision Trees (Xu et al., 2019, p. 2).





Figure 17 Decision tree: Making breakfast

Diagram adapted from (Xu et al., 2019, p. 2)

Expert Systems, like IBM's Deep Blue chess program, excelled in areas that could be formalized, but they experienced difficulty with tasks like facial recognition or image distinction that required

subtle interpretation and learning from outside input (Haenlein & Kaplan, 2019, p. 8). Due to these drawbacks, it became clear that true AI required systems that could accurately understand and adapt depending on outside data, a break from Expert Systems' top-down rule-based methodology (Haenlein & Kaplan, 2019, p. 8).

## **Neural Networks and Deep Learning**

The most advanced machine learning methods used today are primarily based on "deep learning," a technology that takes its cues from how human brains function (Sinz et al., 2019, p. 967). Multilayered artificial neural networks, which resemble simplified representations of brain cells called neurons, are used in deep learning (Sinz et al., 2019, p. 967). Similar to how genuine neurons function in our brains, these artificial neurons are adept at adapting and digesting information (Sinz et al., 2019, p. 967). They receive information from other neurons, integrate it in a particular way (similar to adding weighted integers), and then generate an output (Sinz et al., 2019, p. 967).

Al has transformed due to deep neural networks, which have made it possible to solve perceptual problems that were previously very difficult for Al but simple for humans (Sinz et al., 2019, p. 968). The ImageNet benchmark is one illustration of this; deep networks can now classify photos into 1,000 different categories just as well as people (Sinz et al., 2019, p. 968). What's more intriguing is that using ImageNet to train deep networks has surprisingly turned out to be advantageous for a variety of different tasks, a notion known as "transfer learning" (Sinz et al., 2019, p. 968). With transfer learning, a network that has been first trained for one task, such as object recognition, can be reused for another task by being modified and using the useful properties it has already picked up (Sinz et al., 2019, p. 968).

Shifting away from considering just the computer, its hardware, and software as the sole components of artificial intelligence, even though computers played a crucial role in its development, nowadays, artificial intelligence is integrated into various objects, such as buildings and robots, thanks to embedded computers, sensors, and other advanced technologies (Chen et al., 2020, p. 75268). This shift is accompanied by advanced human-machine interfaces that offer natural language interaction, speech recognition, and emotion detection, all of which collectively enhance the learning experience and extend AI's reach beyond traditional computing systems (Chen et al., 2020, p. 75268).

## **Al's Impact on Education**

The field of education has changed significantly in the 21st century, especially as a result of technological developments like AI (Baidoo-Anu & Owusu Ansah, s.a., p. 53). In today's educational world, a teacher's value is determined by how well they can use teaching strategies and instructional techniques effectively(Yang et al., 2021, p. 3). AI can play a crucial role in creating comprehensive learning activities and adapting teaching methods and resources to help learners learn better and develop effective learning strategies (Yang et al., 2021, p. 3). Because teaching and learning methods can vary, the ways teachers teach and learners learn must change, and a digital AI platform can bring about significant improvements (Yang et al., 2021, p. 3).

Other uses of AI in education aims to provide personalized learning support to students based on their unique learning status, preferences, and personal characteristics (Hwang et al., 2020, p. 1). In the context of precision education, which focuses on offering tailored prevention and intervention practices by analysing students' learning behaviours, the integration of experienced teachers' knowledge and intelligence into the decision-making process of learning systems is a critical concern (Hwang et al., 2020, p. 1). The concept of intelligent tutoring systems (ITSs) was introduced by educational technology and computer science researchers in the early 1980s, reflecting the aspiration to create systems that can tutor students intelligently (Hwang et al., 2020, p. 1). More recently, the term "adaptive learning system" has gained significant attention, emphasizing the goal of enhancing individual students' learning experiences by adjusting various aspects of learning systems, including user interfaces, learning content, and learning paths, to align with each learner's unique needs and progress (Hwang et al., 2020, p. 1).

Additionally, AI has streamlined administrative processes, such as grading and providing feedback, through automation using web-based platforms and computer applications, resulting in increased efficiency (Chen et al., 2020, p. 75271). The application of AI in curriculum development and instructional strategies, leveraging tools such as virtual reality, web platforms, robots, video conferencing, and 3-D technology, has significantly enhanced the learning environment (Chen et al., 2020, p. 75271). This transformation has not only improved the effectiveness and efficiency of educators but has also afforded students more personalized and enriching educational experiences (Chen et al., 2020, p. 75271).

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The rapid development and extension of machine learning, which has given rise to cutting-edge technologies like generative artificial intelligence (GAI), is one noteworthy breakthrough (Baidoo-Anu & Owusu Ansah, s.a., p. 53). GAI is a machine learning framework that can produce human-made artefacts based on statistical and probabilistic principles and runs autonomously (Baidoo-Anu & Owusu Ansah, s.a., p. 53). By evaluating and learning from pre-existing digital content and thereby capturing its underlying patterns and ranges, generative AI, which is powered by deep learning algorithms, may produce artificial artefacts such as video, photos, text, and audio. (Baidoo-Anu & Owusu Ansah, s.a., p. 53). Educators can utilize GAI to develop lesson resources and encourage learners to solidify their understanding of newly acquired content by actively engaging them with GAI tools.

#### Al Chatbots in Education:



Figure 18 AI Chatbot

Al Prompt: generate an image of a chatbot in navy blue

Following COVID-19, there has been a considerable transition, characterized by a heightened embrace of technology in the field of education (Al-Malah et al., 2021, p. 3). This shift includes integrating digital resources like e-books, videos, and interactive learning materials along with the use of online learning platforms like Zoom, Google Classroom, and various video conferencing applications (Heggart & Yoo, 2018, p. 140). As a result, this change has increased the educational environment's adaptability and inclusion, enabling students to access resources and participate in lessons from almost any location with internet connectivity.

Furthermore, there has been a shift towards

self-directed learning, empowering learners with greater control over their education, allowing them to complete their coursework at their own pace(Baidoo-Anu & Owusu Ansah, s.a., p. 54).

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This approach offers the flexibility of studying at a convenient time, which can be beneficial for individuals with other commitments or those facing challenges in attending in-person classes (Baidoo-Anu & Owusu Ansah, s.a., p. 54).

A novel AI tool has recently emerged in the form of a chatbot, which represents a computer program or artificial intelligence application meticulously crafted to emulate conversations with human users, primarily conducted through textual or vocal interactions(Baidoo-Anu & Owusu Ansah, s.a., p. 52). Chatbots serve as valuable assets for the automation and facilitation of a diverse array of tasks encompassing information dissemination, inquiry resolution, customer support provision, and transactional assistance (Baidoo-Anu & Owusu Ansah, s.a., p. 52).

ChatGPT as a Chatbot in the classroom has the potential to improve education and learners' learning. The remarkable proficiency of the generative AI tool ChatGPT in performing highly intricate tasks has garnered worldwide attention (Baidoo-Anu & Owusu Ansah, s.a., p. 52). The responses of educators to ChatGPT's impressive capabilities in the field of education have been multifaceted, as this advancement in AI has the potential to fundamentally transform existing educational methodologies (Baidoo-Anu & Owusu Ansah, s.a., p. 52).

#### I asked ChatGPT to give me a definition of itself. It responded:

"I am a language model developed by OpenAI. I am designed to understand and generate humanlike text based on the input provided to me. My training data includes a vast corpus of text from the internet and various sources, allowing me to answer questions, provide explanations, generate text, and assist with a wide range of natural language processing tasks. My capabilities encompass text generation, comprehension, language translation, summarization, and more, making me a versatile tool for various applications in natural language understanding and generation." (By ChatGPT October 5, 2023).

The usage of ChatGPT is seen as highly beneficial for its time-saving capabilities in generating and summarizing texts, much like how Google revolutionized information retrieval (Halaweh, 2023, p. 360). It is particularly advantageous for tasks like data calculations, sorting, and filtering, similar to the role of MS Excel in education.

### Integration of ChatGPT in the classroom

ChatGPT integration in the classroom has several benefits (Su & Yang, 2023, p. 361). Offering individualized instruction and encouraging trust between teachers and learners, improves the learning process (Su & Yang, 2023, p. 361). ChatGPT accomplishes this by developing personalized recommendations and virtual tutors who deliver focused teaching following the needs of certain learners (Su & Yang, 2023, p. 361). For instance, if learners struggle with math, ChatGPT can offer thorough, step-by-step guidance to guide them through certain difficulties, fostering a more individualized and productive learning environment (Su & Yang, 2023, p. 361). Teachers may streamline their responses to learners' inquiries with the assistance of ChatGPT, allowing them to allocate their time and energy more efficiently to other responsibilities (Su & Yang, 2023, p. 361). ChatGPT can aid teachers by generating potential responses to students' questions and predicting common errors, enabling them to adapt their teaching and learning approaches accordingly (Su & Yang, 2023, p. 361).

## Challenges of implementing AI in education

Al is in the early stages of innovation in the field of education; there are various experiments underway and basic "commercial" applications are also available, though they are not frequently used (Alam, 2021, p. 1). The expansion of Al into new applications domains, such as education, is slower than the technology's progress because the majority of developmental research is focused on AI technologies rather than on its applicable or practical elements (Alam, 2021, p. 1). Additionally, smart assessments and smart learning analytics are required in the 21st-century classroom, which will change with the addition of AI (Alam, 2021, p. 1). Developing these tools requires people with crucial skills, and there is a need for training teachers to effectively implement them.

Also, the transition to online learning has highlighted the digital divide, as learners in low-income or rural areas may lack the necessary access to equipment and internet connectivity for full participation in remote education (Baidoo-Anu & Owusu Ansah, s.a., p. 54). Additionally, it has posed challenges related to accountability, motivation, and reduced interaction (Baidoo-Anu & Owusu Ansah, s.a., p. 54).

One specific concern about Chatbots is that learners may use ChatGPT to generate essays or assignments and submit them as their work, potentially engaging in plagiarism (Nguyen et al., 2023, p. 4224). Some teachers worry that learners who rely heavily on ChatGPT for writing tasks may not develop strong writing skills or the ability to articulate their thoughts effectively (Halaweh, 2023, p. 360).

## Conclusion

The evolution of artificial intelligence (AI) in education has undergone significant changes. Recent advancements in computing technology have paved the way for AI in education (AIEd), presenting opportunities to reshape educational paradigms, particularly by emphasizing personalized learning and redefining the role of educators.

Al's establishment as a field of study can be traced back to the 1950s. The prominence of Big Data and improvements in computing capabilities have propelled Al into the forefront.

Expert systems, designed to emulate the decision-making abilities of human experts, rely on comprehensible rules and knowledge crafted by human experts. While expert systems excel in tasks with well-defined rules, they encounter challenges when it comes to interpreting and learning from external inputs, underscoring the need for more adaptable AI systems.

Inspired by the functioning of the human brain, neural networks and deep learning have sparked a revolution in AI. These multi-layered artificial neural networks excel at processing information, leading to significant advancements, particularly in perceptual tasks like image classification.

Al's impact on education has been transformative, reshaping teaching and learning in the 21st century. It places a strong emphasis on personalized education, adapting teaching methods and resources to cater to the unique needs and preferences of individual learners.

Additionally, administrative processes in education have witnessed notable improvements through AI automation, enhancing efficiency in tasks such as grading and providing feedback. Generative artificial intelligence (GAI) represents another noteworthy advancement that has left its mark on education.

The integration of AI chatbots like ChatGPT into education has introduced significant changes, a transformation that gained momentum, especially in response to the COVID-19 pandemic. Nevertheless, challenges related to AI adoption, disparities in technology access, and concerns about an overreliance on AI tools in education must be effectively addressed to fully unlock the potential of AI in education.

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# Chapter 6

## **Empowering learners and Teachers: Self-directed learning and cooperative learning in the CAT and IT class**



L van der Walt

Computer Science: Knowledge for Educators

## **Defining SDL**

Self-Directed Learning (SDL) is a process in which learners take responsibility for their own education, set their own goals, identify the resources needed to achieve those goals and most importantly assess their progress toward those goals (Petersen et al., 2020, p. 122). This learning approach is characterized by the active participation of the learner in the educational process, with a focus on their own interests and needs, in contrast to the still widespread teacher-centred approach (Mentz & De Beer, 2019, p. 54). Essentially, self-directed learners take an autonomous role in their education, looking for opportunities for growth and development for themselves, rather than relying solely on the guidance of teachers. SDL's flexibility allows learners to customize their educational experience to suit their individual learning styles, preferences and schedules (Mentz & De Beer, 2019, p. 54).

This type of learning is often viewed as a lifelong process, as it enables learners to pursue their goals long after formal education has ended. It is important to note that SDL skills align with that of 21st-century skills. Agaoglu and Demir (2020, p. 106) describe a set of skills that are considered essential for success in the 21st century, under three main categories; "Learning and innovation skills, Life and career skills, and Information, Media, and Technology Skills. With Learning and innovation skills the following included creativity, collaboration, communication, and critical thinking". Life and career skills included productivity, accountability, leadership, responsibility, flexibility, adaptability, and social and cross-cultural skills. Information with Media and Technology Skills, the authors include media literacy, information literacy, information communication and, technology literacy (Agaoglu & Demir, 2020, p. 106). SDL is a vital aspect of the above-mentioned 21st-century skills by placing increasing emphasis on a learner's autonomy and personal responsibility for learning[CB1].

### **Models for SDL**

"Self-direction in learning," "self-initiated learning," "self-plan learning," "self-teaching," "autonomous learning," "independent learning," and "lifelong learning" are among the various terms used to describe SDL. The employment of so many terminologies has made it difficult to adequately describe SDL. To understand the role of the teacher and the learner respectively in SDL, it is essential to examine the fundamental models of SDL that shape our modern-day understanding and applications in the classroom. Candy's Four-Dimensional Model, Brockett and Hiemstra's Personal Responsibility Orientation Model, and Garrison's Three-Dimensional Model are among the most prominent models in this regard. While there are several approaches and strategies to SDL, this discussion will focus on these three models, their approaches and their relevance in today's educational environment.



Figure 19 Candy's Four-Dimensional Mode

Song and Hill describe Candy's" as the basis of the broader concept of ASDL (Song & Hill, 2007, p. 29). Personal autonomy is described as a quality a person possesses in regards to learning (Brockett & Hiemstra, 1991, p. 9). Self-management means having the ability and desire to manage one's own learning and taking charge of one's own learning situations without needing someone else to tell you what to do (Song & Hill, 2007, p. 29). Learner control refers to when learners have more control over what and how they learn in formal settings (Song & Hill, 2007, p. 29). Autodidaxy means learners can seek out opportunities to learn throughout their lives, outside formal educational settings, by engaging with learning in their everyday lives, like reading books

or possibly learning from YouTube video's (Brockett & Hiemstra, 1991, p. 47; Song & Hill, 2007, p. 29).

Song and Hill do criticize this model in their 2007 article by mentioning that this model does not address how SDL would work in different types of learning situations like classrooms or online learning. However, this model does provide teachers and learners framework for SDL. Learners can develop personal-autonomy by setting their own learning goals. Teachers can guide learners on how to find online resources for self-study[CB3].

#### **Brockett and Hiemstra's Personal Responsibility Orientation Model (PRO)**

The PRO model by Brocket and Hiemstra is a philosophy about learning based on the humanistic personal responsibility of learning (Banz, 2009, p. 24). The PRO model says individuals are responsible for their own learning and need to take control of their own learning situations (Banz, 2009, p. 24). What makes this model different from Candy's 4-dimensional model is that the PRO model takes into account the social context of learning and emphasizes how individuals can use their own contexts in learning as learned experiences can be transferred to other situations (Banz, 2009[CB4], p. 25).

The main criticism, according to this article, against this model is the limitations that Brocket and Hiemstra placed on what they defined as the social context of different physical institutions such as "community colleges, libraries, and museums" (Song & Hill, 2007, p. 29). Given the prevalence of mobile technology in the 21st century and its social features, it may be worth considering how the PRO model can be revised to account for modern-day social contexts to include the potential for SDL to occur anywhere and anytime a smartphone has internet connectivity. Teachers may want to reconsider the strict no-phone policies that prohibit and discourage the use of smartphones in class.

#### Garrison's Three-Dimensional Model

The idea of SDL as personal characteristics and as learning processes are both included in Garrison's model of SDL (Song & Hill, 2007, p. 29). Song and Hill describe Garrison's model of self-directed learning (SDL) as consisting of three key elements: self-management, self-monitoring, and motivation (Song & Hill, 2007, p. 29). According to Emad (2016, p. 37), Garrison

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believes task control concerns are at the centre of self-management. Self-management concentrates on the external actions connected to the learning process, making goals and using resources to learn (Emad, 2016, p. 38). Abd-El-Fattah explains Garrison's self-management is about controlling tasks, like making goals and using resources to learn (Abd-El-Fattah, 2010, p. 587). To control tasks, you need to balance three things: how good you are (proficiency), what help you have (resources), and what the rules are (interdependence) (Abd-El-Fattah, 2010, p. 587). Proficiency is about how good the teacher and the learner are at teaching and learning. Resources are things like books, computers, or other support. Interdependence is about the rules and standards for learning, and what the learner thinks is right. Self-management is a symbiotic effort between the teacher and the learner (Abd-El-Fattah, 2010, p. 587).

Self-monitoring (cognitive accountability) involves being aware of one's own thinking as well as having the capacity to reflect on it. Self-monitoring is the process through which the learner assumes accountability for creating their own significance for their learning (Emad, 2016, p. 38). Abd-El-Fattah believes self-monitoring involves being conscious of our own thoughts, reflecting on them, and keeping track of the most effective learning techniques (Abd-El-Fattah, 2010, p. 587). Learners can improve self-monitoring skills by engaging in reflective learning (Abd-El-Fattah, 2010, p. 587).

The third dimension of SDL according to Garrison is motivation which can be described as initiating and maintaining effort toward learning and achieving goals for learning depends heavily on motivational factors (task and entering) (Emad, 2016, p. 38). Choosing objectives and intentions and opting to participate in academic tasks are all parts of the motivating process. This means that Garrison's definition of SDL is an approach where students are encouraged to take on personal responsibility and control of the self-monitoring and self-management processes in creating and confirming meaningful learning goals (Emad, 2016, p. 38). However, Abd-EI-Fattah considers that internal feedback may be insufficiently accurate and explicit and that the teacher can help the learner check the quality (meaning and validity) of the learning outcome by providing meaningful feedback (Abd-EI-Fattah, 2010, p. 587).

Garrison's paradigm ignores the impact that social, cultural, and economic factors have on how people learn. Song and Hill propose their own "Conceptual Model for Understanding SDL in Online

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Environments", which places greater emphasis than any of the previously discussed models on learning context (Song & Hill, 2007, p. 30). It is essential to take into account the contextual elements that affect SDL in various educational settings (Song & Hill, 2007, p. 30). Teachers could receive training in understanding how context influences learning and how to adapt their teaching and learning strategies to account for these variations.

In conclusion, Candy's Four-Dimensional Model, Brockett and Hiemstra's Personal Responsibility Orientation Model (PRO), and Garrison's Three-Dimensional Model are all valuable frameworks for understanding self-directed learning. However, it is important to remember that teachers need more than just a didactic understanding of SDL to effectively foster self-directed learning in their learners. Teachers must also have a deep understanding of the self-directed learner and their unique learning needs, as well as the role that the teacher plays in facilitating and supporting SDL[CB5].

## The self-directed learner

In the previous section, the following characteristics and behaviours were identified that a selfdirected learner should possess:

Table 1	Characteristics	of a self-directed	learner and practical	examples
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Characteristics	Examples
Self- management	When a self-directed learner wants to learn a programming language, they will be able to break the task down into smaller goals, create a learning schedule and search the Internet for suitable resources.
Self-monitoring	A self-directed learner will be able to adapt their learning approach by continuing to analyses their own understanding and self-identify probable misconceptions or weaknesses in comprehending a topic.

Self-motivation	By asking questions such as what do I want to learn, what I enjoy about this topic, when should I schedule my learning and asking what obstacles will I encounter, self-directed learner can motivate themselves and sustain their enthusiasm for the topic.
Personal responsibility	A self-directed learner will establish their own deadlines and make sure they keep to those goals as well as take ownership of their learning and seek above and beyond to deeper their understanding of a topic.
Reflection,	By engaging in self-reflection, a self-directed learner will ask questions like what did I learn today, how can I assess my own learning and celebrate their successes?



Figure 20 Self-directed Learner

Al Prompt: create an clip image of the concept self-directed learner in orange

Self-directed learners are driven to improve, can recognize their own demands for learning, and may create goals for learning (Mentz & De Beer, 2019, p. 54). These learners ought to be able to discover their own educational resources. Teachers, online resources, or local knowledge are just a few examples of these resources. Finally, individuals require evaluation skills to decide whether their choices actually meet their learning needs (Mentz & De Beer, 2019, p. 54).

The requirement for life and career skills, such as productivity, accountability, and responsibility as part of essential 21st Century skills outlined by Agaoglu and Demir (2020, p. 16) are all components of selfmanagement and personal responsibility. Similar to

this, their list of learning and innovation skills which includes critical thinking and creativity requires

self-motivation and goal-setting (Agaoglu & Demir, 2020, p. 106). These abilities and behaviours are reflected in the traits of self-directed learners, with a particular emphasis on self-management, self-monitoring, self-motivation, personal responsibility and reflection.

Coming from a school system where teachers were in charge of teaching and learning, SDL can be challenging to accomplish and to develop as self-directed learners, they need scaffolding (Ments & De Beer, 2020, p. 162).

Scaffolding is a pedagogical technique employed by teachers to support learners as they navigate their learning journey (Reddy *et al.*, 2023, p. 21). The act of scaffolding in education refers to the individualized guidance, aid, and reinforcement provided to a learner by either a teacher, peer, or the task at hand on,(Department of Education, 2011, p. 9). Grévisse *et al* describe scaffolding as a way in which a teacher provides support to a learner to assist them in solving a problem that may be too challenging for themselves to solve on their own (Grévisse *et al.*, 2019, p. 4). Therefore, the goal of scaffolding is to help learners develop their skills and knowledge so that they can eventually complete the task independently. Within the collaborative educational setting, learners should take the lead alongside their peers (Ments & De Beer, 2020, p. 162). Therefore, teachers need to understand their role in fostering self-directed learning.

## The Role of the Teacher to enhance SDL

Even SDL, without the right assistance and direction, learners might not persevere or succeed in what they are learning. The quality of learning is not solely a matter of learner initiative and accountability, from an educational standpoint (Abd-El-Fattah, 2010, p. 593). The teacher also has genuine and frequently required authority and responsibility concerns and plays a crucial part in learning as a transactional process. Goal-setting, planning learning activities, and evaluating learning results all fall under the responsibility of the teacher (Abd-El-Fattah, 2010, p. 593). Teachers must also work with learners to create a balance of control by offering encouragement, guidance, and expectations to promote successful outcomes and ongoing learning efforts (Abd-El-Fattah, 2010, p. 593).

Self-direction doesn't happen inside of official institutions; it happens outside of them (Brockett & Hiemstra, 1991, p. 5). Teachers can gradually hand over control and responsibility for self-

direction to learners so that they can practice the skills in a classroom setting. However, independent learning can only truly take place when people are not forced to learn, and others are not forced to teach them, particularly not to teach them a specific subject (Brockett & Hiemstra, 1991, p. 5).

Furthermore, Agaoglu and Demir's (2020, p. 106) list of critical life and career skills include social and cross-cultural abilities, which can be developed effectively through cooperative learning. These abilities also fit in with the broader set of abilities and behaviours needed for self-directed learning, where learners are expected to cooperate, communicate, and adopt a flexible learning style. Teachers can support learners in the development of these skills as well as the autonomy and self-direction that are essential components of self-directed learning by introducing cooperative learning into their teaching strategies.

## **Cooperative Learning**

A popular approach to teaching in recent years is cooperative learning (CL) (Meyer & Combrinck, 2022, p. 244). Learners collaborate in small groups to accomplish a common objective (Meyer & Combrinck, 2022, p. 244). The advantages of CL extend beyond academic performance since it fosters the growth of social and intercultural competence, which is a crucial aspect of self-directed learning (SDL) (Agaoglu & Demir, 2020, p. 106). As a result, to effectively promote SDL in their classrooms, teachers must be familiar with the CL framework.

## **Defining CL**

More educators and teachers have recently become interested in cooperative learning because of the crucial role it plays in fostering an interactive learning environment in the classroom (Ismail & Al Allaq, 2019, p. 1). When teachers use cooperative learning as a classroom strategy, students engage with each other by explaining the subject matter to one another (Ismail & Al Allaq, 2019, p. 1). The achievement of each learner's goals is linked within the CL environment, and each learner's goals can only be met if the other group members are also achieving their goals (Bosch & Laubscher, 2022a, p. 135). Even though researchers sometimes use CL, collaborative learning and group work to refer to groups of learners working together to accomplish a task or achieve a goal, it is important to distinguish that CL has its emphasis on learning and not cooperation (Mentz

& Goosen, 2013, p. 127). With CL every learner ought to acquire more knowledge about the content or have a deeper comprehension of it as they move closer to their intended learning goals (Mentz & Goosen, 2013, p. 127). This is meaningful learning.

Bv employing cooperative learning techniques, teachers assist learners in developing critical 21<sup>st</sup>-century skills that are necessary for success in both their schoolwork and potential careers (Agaoglu & Demir, 2020, p. 107). Learners develop excellent communication,



teamwork, problem-solving, and critical thinking skill through cooperative activities (Bećirović et al., 2022, p. 1). Additionally, cooperative learning fosters flexibility, creativity, and empathy, enabling students to excel in a world that Figure 21 Cooperative learning is constantly changing and becoming

130).

more linked (Mentz & Goosen, 2013, p. AI Prompt: create an image of the concept cooperative learning with kids working in groups together in orange

#### **Principles of CL**

According to Powell and Kalina (2009), learning is an active process in which students build knowledge through their interactions with others and their environment. The constructivist theory of Vygotsky places a strong emphasis on the influence of language, culture, and social interactions on cognitive development. According to Vygotsky, social engagement and teamwork with others who have more information, such as teachers and peers, improve learning and cognitive development (Kalina & Powell, 2009, p. 243). The zone of proximal development (ZPD), one of his theories, is particularly significant since it has a significant impact on how a student approaches learning. ZPD is described as a zone where learning occurs when a student is helped to

understand a new concept in the literature on educational psychology (Kalina & Powell, 2009, p. 243).

CL is based on several theories, including the social interdependence theory, the theory of cognitive development, and the philosophy of motivation (Bosch & Laubscher, 2022a, p. 135). Teachers need to realize that merely placing learners in groups and instructing them to collaborate does not guarantee successful group work (Mentz & Goosen, 2013, p. 128).

According to Johnson and Johnson (1994, as cited in Petersen *et al.*, 2019, p. 157), successful cooperative learning has five essential elements: "positive interdependence, individual accountability, face-to-face promotive interaction, interpersonal and small group skill (social skills) and group processing skills" (Petersen *et al.*, 2019, p. 157).

#### Positive interdependence

According to Petersen *et al* (2019), positive interdependence is thought to be the most crucial component of CL and is referred to as its beating heart (Petersen *et al.*, 2019, p. 156). The interdependence of a group must be managed in such a way that makes learners understand that they won't succeed until all the members of the group succeed (Mentz & Goosen, 2013, p.129). One of the key elements in bringing the group members together in a cooperative effort should be having the project's completion as a shared goal (Mentz & Goosen, 2013, p. 129). A cooperative group's members have two primary responsibilities: to achieve the goal individually and to make sure that the goal is achieved by every member of the group (Mentz & Goosen, 2013, p. 129). According to Goosen (2013), a teacher can promote effective group interdependence by implementing at least two of the following:

- Setting explicit group goals in a way that makes everyone in the group understand that they can only succeed if the group as a whole does;
- cooperatively rewarding productive group efforts;
- Provide different resources to various group members, which the group must combine to accomplish their goal;
- allocating varying responsibilities among the group's participants; and

• giving different members of the group different duties to perform for the whole group to realize they need one another to attain the shared objective.

#### Individual Accountability

Individual accountability is another key part of cooperative learning. Individual accountability refers to the expectation that each group member is responsible for contributing to the group's success and achieving the shared learning goals (Mentz & Goosen, 2013, p. 133). This means that each member of the group must take responsibility for their own learning and actively participate in the group's activities. Individual accountability is an essential element of cooperative learning because it helps to ensure that each group member is engaged in the learning process and equity, as each group member is expected to contribute equally to the group's success (Bosch & Laubscher, 2022a, p. 139). By promoting individual accountability, cooperative learning can help learners develop important skills such as self-reflection, self-regulation, and self-evaluation, which are important for lifelong learning (Loksa *et al.*, 2022, p. 2).

#### Face-to-face promotive interaction

Face-to-face promotive interaction occurs when group members encourage and motivate one other while they work to accomplish the group's shared objectives (Petersen *et al.*, 2019, p. 157). By meeting in their assigned teams, learners create efficient means of cooperation and communication that enable them to move toward the goals they have established (Mentz & Goosen, 2013, p. 134).

#### Interpersonal and small-group skills

Learners should be introduced to and guided on how to properly engage in small group interactions at the start of a cooperative learning task or assignment by engaging in a variety of activities and games (Mentz & Goosen, 2013, p. 133). Believing in one another, communicating properly, accepting and supporting one another, and amicably resolving disagreements are all social skills need to participate in a CL activity successfully (Petersen *et al.*, 2019, p. 158).

#### Group processing

Group processing refers to the process of reflecting on and evaluating the group's interactions and performance (Mentz & Goosen, 2013, p. 134). This means that group members take time to discuss how well they are working together, what is working well, and what could be improved. Group processing is an essential element of cooperative learning because it helps to ensure that group members are learning not only from the content being studied but also from the process of working together (Petersen *et al.*, 2019, p. 158). It helps to promote a positive group dynamic, where group members are aware of each other's strengths and weaknesses and can provide constructive feedback to each other (Bosch & Laubscher, 2022, p. 140).

The teacher facilitates a CL activity by organizing the learning experience, ensuring sufficient resources are available, and implementing effective scaffolds (Petersen *et al.*, 2019, p. 158).

## CL as a strategy to enhance SDL

The primary goal of both CL and SDL is to enable learners to be actively involved in their own education. The shared characteristics of 21<sup>st</sup> century skills, CL and SDL underscore the symbiotic relationship between these three concepts (Mentz & van Zyl, 2016, p. 85). The collaborative and interactive nature of CL complements the principles of SDL by fostering autonomy, self-motivation, and self-regulation (Mentz & van Zyl, 2016, p. 79). Moreover, CL and SDL share a common goal of equipping students with the 21<sup>st</sup> century skills necessary for continued learning and knowledge construction even beyond formal learning institutions (Mentz & van Zyl, 2016, p. 80). Bosch and Loubser, (2022), identified 5 elements of cooperative learning that enhanced SDL (Bosch & Laubscher, 2022b, p. 30). These included the capacity for social knowledge construction, enhanced resource management, critical reflection, critical thinking, and time management abilities (Boch & Laubscher, 2022b, p. 30).

## The implementation of CL in the IT classroom

For successful implementation of CL in the IT class, teachers have to instruct learners on the five elements of CL as previously mentioned. This can be done by having a class discussion about what responsibilities and behavior are needed for the successful implementation of CL (Mentz &

Goosen, 2013, p. 133). Furthermore, the teacher has to plan the activity based on the specific needs of a particular group, clarifying the roles and responsibilities of every group member.

The teacher must continue to keep an eye on the activity and remain available to provide support and direction at all times (Mentz & Goosen, 2013, p. 135). The size of the group also plays a critical role in the eventual success of CL. It seems the ideal size of a CL group should not exceed 4 members where possible; fewer may still be better (Mentz & Goosen, 2013, p. 133). For pairprogramming activities in the IT class, a group of only two members will be sufficient. Mentz and Goosen mentioned that Highschool learners prefer to choose their own group members, but this might not be advantageous to reaching the group goals, what is suggested is that learners be placed randomly in groups by the teacher (Mentz & Goosen, 2013, p. 133).

Assigning the different roles amongst the group member are also a task the teacher has to pay special attention to divide the duties of the learners so that one learner does not take over and do everything themselves or other members "free-loading" on the group and not participating (Mentz & Goosen, 2013, p. 133).

During pair-programming CL activities in the IT class, the teacher has to carefully pick the "driver" and the "navigator" and it is important to rotate the roles frequently. Other CL activities like Jigsaw, De Bono's Thinking Hats, Group-Individual-Group (GIG), Cooperative Graffiti, Think-pair-share, Student Teams Achievement Divisions, Group investigations, or Teams-Games-Tournament (TGT), can be implemented during theory and practical lessons in the IT class (Mentz & Goosen, 2013, p. 136) (Petersen *et al.*, 2019, p. 158). For these activities, the different roles might be group leader, scribe, recorder, secretary, speaker, and planner (Mentz & Goosen, 2013, p. 133).

While bearing in mind that the goal of CL is for learners to learn together but accomplish alone, teachers must assess the individual learners, and when the marks are returned to the group the group should reflect on their own achievements (Mentz & Goosen, 2013, p. 137). The learners can grade each group member on the CL group abilities, such as communication and cooperation, in the final cumulative peer assessment and be used by the teacher to adjust the individual assessment of each member in the group based on their level of participation (Mentz & Goosen, 2013, p. 137).

Pair programming, in my opinion, is the best approach for doing collaborative practical work in the subject Information Technology, whereas the Jigsaw method is best for doing theoretical work. Learners can actively participate in collaborative learning by assigning their roles deliberately and switching them around in pair programming. Additionally, Jigsaw as a Cooperative Learning (CL) exercise helps learners develop the essential CL and SDL skills as previously mentioned.

## Practical examples of teaching strategies: Pair programming in the IT Class

Several strategies have been established in CL to promote collaborative learning experiences. However, two techniques hold particular significance and efficacy in the context of Information Technology.

#### Pair programming in the IT class

Pair programming is a collaborative approach where two programmers work together on the same task using a single computer. They work on the same design, algorithm, code, and test simultaneously (Mentz & Goosen, 2013, p. 138). Research has shown that pair programming is highly beneficial in educational contexts, especially in acquiring programming skills and improving program quality (Breed *et al.*, 2013, p. 207). The driver, one of the members of the pair, is responsible for typing or coding, while the other member, the navigator, observes the driver's work, identifies problems, and suggests improvements to the program design or code (Breed *et al.*, 2013, p. 207).

Pair programming must be supervised for both individuals to learn from the experience, with the weaker party receiving individual instruction, and the stronger individual learning by explaining and reconsidering their approach. To ensure equal participation, it is important to pair everyone, switch roles regularly, and prevent a dominant personality from taking over the session (Brown & Wilson, 2018, p. 3).

During pair programming, it is essential that the teacher provides clear instructions to the learners and ensures that they understand each step of the activity. Learners should be given the opportunity to ask questions beforehand to clarify their roles (Mentz & Goosen, 2013, p. 146). The

teacher should act as a timekeeper and clearly communicate this role to the learners (Mentz & Goosen, 2013, p. 146). In addition, the teacher should move around the class and be available to provide guidance, feedback, and redirection to learners who stray from their specific roles.

Mentz and Goosen believe that communication is the one skill that is the foundation of pair programming, including the other CL skills (Mentz & Goosen, 2013, p. 141). There is no one-size-fit-all solution to choosing pairs for pair programming. It is suggested that learners learn better when paired with a learner with the same level of abilities (Williams and Kessler (2003) and Chaparro *et al* (2005) as Cited by Mentz & Goosen, 2013), while other recommendations include that programmers that are just starting out should be paired according to different personality types (Katira (2004) as Cited by Mentz & Goosen, 2013) (Mentz & Goosen, 2013, p. 141). Jensen suggests pairing group members with different levels of programming ability (Jensen (2005) as Cited by Mentz & Goosen, 2013). What does seem to be important is switching group members regularly so that it is always different groups completing a pair programming task. This way each member of the class will interact with all the personalities and different levels of skills available in the class (Mentz & Goosen, 2013, p. 142).

Furthermore, the teacher should provide feedback and assistance on each learner's groupwork skills. However, it is not the teacher's role to fix general errors during the exercise. These errors can be addressed after the assessment (Breed *et al.*, 2013, p. 207). The teacher should also schedule a time during this activity so that learners can reflect on their own programming skills, as well as their collaboration skills with their teammates. This can be achieved through several assessments. These assessments should include teacher, peer, class and self-assessments (Mentz & Goosen, 2013, p. 146). This will help learners to identify their strengths and areas for improvement, ultimately enhancing their overall learning experience (Mentz & Goosen, 2013, p. 146).

#### Jigsaw method in the IT class

The Jigsaw method of CL involves synthesizing individual informational puzzle pieces to produce an in-depth knowledge of the studied topic. In this method, learners are initially placed in a home group where they get specialized academic information and materials. Each learner is then required to become an authority on the topic that they were given (Bosch & Laubscher, 2022a, p. Chapter :6 Learning tasks and strategies for teaching and learning in CAT and IT

143). Experts from various topics then get together to debate their particular topics in new groups made up of others who have studied the same topic. After the group discussion, learners re-join their original home groups to impart what they've learned to the members of those groups. Each home group gains from having an expert on the individual topics in this manner (Bosch & Laubscher, 2022a, p. 143). Each topic is assessed individually, providing for a thorough assessment of each learner's comprehension and competency (Bosch & Laubscher, 2022a, p. 143).

The teacher should also schedule a time during this for both methods of CL (pair programming and Jigsaw method). After a pair programming activity, learners can reflect on their own programming skills, as well as their collaboration skills with their teammates (Mentz & Goosen, 2013, p. 147). For both activities learners and the teacher can assess each group member on the principles of CL such as "active listening, effective interpersonal communication, all-around cooperation, and fulfilment of respective roles" (Mentz & Goosen, 2013, p. 147).

This can be achieved through several assessments. These assessments should include teacher, peer, class and self-assessments (Mentz & Goosen, 2013, p. 146). This will help learners to identify their strengths and areas for improvement, ultimately enhancing their overall learning experience during both types of activities (Mentz & Goosen, 2013, p. 146).

## Conclusion

A famous quote by Socrates states: "*I cannot teach anybody anything, I can only make them think*" (Ahmed, 2023). This is aligned with the idea of SDL, by emphasizing that learners take responsibility of their own learning. Meaningful learning takes place when learners actively engage in critical thinking and reflection. By employing CL activities teachers assist learners in their self-directed learning journeys by acting as mentors and facilitators. Teachers offer guidance, resources, and feedback, assisting learners in acquiring the knowledge, metacognition, and self-regulation needed to become successful self-directed learners. Pair programming and Jigsaw methods as CL activities enable learners to think independently and take charge of their learning by creating an environment that promotes inquiry, investigation, and critical thinking.

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