Enhancing Semantic Gravity through Practical Work: A Case on Semiconductors in Grade 12

Literature has revealed that linking abstract concepts to real life experiences helps students in recognising the link between theory and practice, which in turn strengthens their conceptual understanding. However, it is unclear how the connection between these two forms of knowledge is made explicit in practice. This paper seeks to bring insight on how the links between theory and practice can be explicitly enacted and made visible in practice using the semantic gravity code of the Legitimation Code theory (LCT). A lesson on the topic of semiconductors was explored to illustrate how the teacher transitions between between abstract and concrete forms of knowledge and vice versa. To visualise these shifts over time, the lesson episodes were mapped using semantic profiles. An analysis of the semantic profiles revealed a wider semantic range when practical work was introduced in the lesson. The findings indicate that practical work plays a significant role in enhancing the connection between abstract and concrete ways of understanding. By adopting pedagogies that seek to explicitly link theory and practice, science educators may inform their practices. The study concludes that science instruction ought to be centred around practices that enable teachers to visualise how they connect theory and practice.

Keywords: Practical work, semantic gravity, Legitimation Code theory, science education

Introduction

The teaching and learning process is dynamic and involves many different elements that contribute to its effectiveness. Science learning and teaching often involve grappling with difficult concepts (Balla et al., 2024; Department of Basic Education, 2019; Sarabi & Gafoor, 2018), and this difficulty is often attributed to the complex and abstract nature of scientific concepts. The National Academies of Sciences, Engineering, and Medicine (2015) identified engaging students in doing science rather than simply learning about science as the primary vision for science education. Millar (2004) argues that when abstract concepts are involved in teaching and learning processes, then mere transmission of knowledge does not work. Thus, in fulfilling the vision for science education, a conscious design of methods of teaching to assist students in moving beyond abstractions is required, and practical work emerges as a viable option. To support the viability of practical work, (Shana & Abulibdeh, 2020) explored the importance of combining theory and practical work in science education. The findings indicated that including practical work in instruction improves academic performance. Additionally, Osborne (2015) specified several reasons for adopting practical work in science education, including its value in offering practical representations of phenomena.

Several studies have shown that relating abstract concepts to real-life experiences helps students see the connection between theory and practice and consequently impacts their understanding of concepts being taught (Newton &

Miah, 2021; Sumeracki, 2019). According to the National Academies of Sciences, Engineering, and Medicine (2015), practical work helps students see science as relevant to their everyday lives. This suggests that only practical activities that draws on the students' real experiences produces these results. This insight is consistent with other studies that contend that practical work provides numerous benefits, including but not limited to understanding the theories and concepts of science (Kibirige and Maponya, 2021; Godwin et al., 2015; Shana & Abulibdeh, 2020).

When talks about linking theory and practice emerge, quite often studies focus on using practical work as a means to an end; this implies that the role of practical work is understood at surface level. For example, using practical work only serves to connect theory and practice; yet it is not entirely clear how this connection is made. Abraham and Millar (2008) explored the effectiveness of practical work in 25 science lessons. The findings demonstrated that practical work was effective in enabling learners to be hands on with the objects. However, the practical tasks designed by the teachers did not integrate practices that helped students see links between the tasks and the theory. This paper attempts to provide insight into how this link making can be clearly enacted and made visible in practice. The study aims to demonstrate how the teacher accomplishes the necessary transitions between abstractions and real-world examples or experiences to build an understanding that is cumulative. Cumulative knowledge building is a form of learning in which new knowledge builds on and incorporates previous knowledge (Maton, 2009). The links made between abstract and concrete forms of understanding need to be a series of interconnected or variations of abstract and concrete forms of understanding throughout the lesson. This connection allows students to gain a deeper and more integrated understanding of the concept being taught. Walton and Ruszynyak (2019) underscore the idea that without this cumulative approach, learning might become segmented, thus hindering student’s ability to form a coherent understanding.

In this paper, segmental learning refers to the practice of introducing practical work without clearly and explicitly linking it to the abstract concepts that the practical work aims to address. The paper suggests that abstract and concrete forms of understanding should not be viewed as separate entities. There is a need for science teachers to view science ideas and practices as progressive, capable of building knowledge over time in a lesson. While simply integrating practical work into teaching can be viewed as a viable strategy for dismantling abstract and complex ideas associated with science learning, it is also significant to ensure that instruction is not segmented. For example, teaching a concept in purely abstract terms may make it difficult for students to fully comprehend it. On the other hand, teaching a new concept in only concrete terms may limit a student's ability to understand how to apply the concepts in other situations (Clarence, 2013). Using the Legitimation code theory (LCT) dimension of semantic gravity (SG), this study attempts to explicitly show how shifts between abstract and concrete or contextualised experiences occur during the teaching of the concept of semiconductors for grade 12 in Technical Sciences.

Semantic gravity (SG) describes the degree to which teachers take abstract concepts and bring them closer to the learner's everyday lives or real –world situations (Walton & Rusznyak, 2019). The main aim of this paper is to show how practical work enhanced semantic gravity (SG) in a lesson taught on the topic of semiconductors. The practical work component of the lesson is not separate from the observed general lesson, so the study focuses on how the teacher generally shifts between abstract and concrete forms of understanding in the overall lesson, later revealing how practical work strengthened the overall lesson's semantic gravity. To achieve this, the research questions that follow guided the study:

I. What transitions does the teacher make between abstract and concrete forms of understanding when teaching the concept of semiconductors?
II. How does practical work strengthen the semantic gravity of the lesson?

Literature Review

Practical Work in Science Instruction

Science teaching is primarily about science knowledge building (Scott et al., 2011). For this task, science teachers use various teaching strategies, including practical work, to initiate learners to science discourse —scientific ways of doing and seeing the world. Practical work and its important role in meaningful teaching and learning are largely advocated for in science education (Abrahams & Millar, 2008; Di Fuccia et al., 2012; Millar, 2004). Millar (2004) described practical work as a form of teaching and learning activity where students are involved in observing and/or manipulating real objects and materials. For Millar, classroom demonstrations are one form of practical and learners' hands-on manipulation of equipment and chemicals is another form of practical work. This study was interested in exploring links between abstract and concrete forms of knowledge through demonstrations in a science classroom teaching of semiconductors concepts. For effective knowledge building, practical work must engage students in thinking processes (Jokiranta, 2014). As such, practical work is essential in science because it provides the practical experiences for understanding scientific processes and ideas. As Millar (2004) posits that a typical practical activity will be followed by a period of discussion of the observations and measurements made, patterns in them and how they might be interpreted and explained, such is required and doable for both demonstrations and hands-on practical work forms.

The Topic of Semiconductors in Technical Science Education

The topic of semiconductors for Grade 10 is introduced as materials whose conductivity rises with increased temperature (Rollnick et al., 2012). Although this topic is largely located in the discipline of engineering, there are basic physics and chemistry concepts underlying how the topic works. The link between the topic and engineering is what makes the topic important in technical science classrooms.

The topic must be taught practically for effective meaning-making. According to Yu et al. (2022), students are encouraged to actively participate in class to apply the knowledge they have gained about the topic of semiconductors. Bakhibaeya et al. (2016) justified the use of ICT to integrate the model and full experiment scale in semiconductors instruction. This study is concerned with showing how the abstract concepts are then linked with practical concepts for mean making on the topic of semiconductors or vice versa. Given the difficulties experienced by learners in understanding the topic of semiconductors (Garcia-Carmona & Criado, 2009), it is important to understand how teachers pedagogically approach the topic. Though Rollnick (2017) developed teachers' content knowledge (CK) and pedagogical content knowledge (PCK) for the semiconductor topic, it remains unclear how teachers teach this practical topic after their CK and PCK has been strengthened, especially in the context of technical science education. Technical science, by nature, requires to be taught through the infusion of practical activities (DoE, 2014) aimed at helping learners grasp the abstract concepts. Limited research on the topic has been done, according to a literature search. In summary, the limited studies on teaching semiconductors point to a need to examine how teachers build scientific knowledge of the topic in science classrooms.

Conceptual Framework

Semantic gravity, a concept from Karl Maton's (2014) Legitimation Code Theory (LCT) was used to understand how cumulative knowledge building occurs in the semiconductors lesson. Maton's LCT stems from Basil Bernstein's Code Theory (2000) and Bourdieu's Field Theory (1999). LCT is a multidisciplinary framework used to understand social practice by researchers and practitioners alike (Maton & Doran, 2019), thus allowing researchers to study knowledge as a focal point. There are five dimensions under LCT that researchers and practitioners can choose from to understand research and practice alike. Of the five dimensions, three have been extensively used, namely specialization, semantics and autonomy. The other two dimensions are temporality and density are less common in research. Science, a complex field of study with complex relations, requires teaching strategies that enable learners to access knowledge (Maton & Doran, 2021). Thus, we used semantic gravity (SG), from the semantics dimension to understand how links between abstract and concrete forms of understanding are achieved in a lesson on semiconductors to enable learners to access knowledge meaningfully. Additionally, semantics allowed us to clearly highlight how practical work can strengthen the overall links made in the lesson.

Semantic gravity is the degree to which teachers work with abstract concepts, unpacking them to bring their meanings closer to the learners' everyday contexts (Walton & Rusznyak, 2019). Semantic gravity can be relatively stronger (SG+) or weaker (SG-) with unlimited variations (Maton, 2014). When meaning remains too abstract, learners may fail to apply knowledge in other contexts (SG-), also when meaning remains in learners' everyday experiences, no learning takes place. Thus, knowledge is accumulated when teaching and learning shift between weaker

(-) and stronger semantic gravity (+), (Hugo, 2014). According to Martin, Maton, and Doran (2020), weakening semantic gravity (SG↓) refers to a teacher's shift from specific case details to generalisations and abstractions, while strengthening gravity (SG↑) refers to a shift from generalized or abstract ideas to concrete and delimited cases. The constant shifts in semantic gravity over time during the lesson can be represented in a semantic profile, which is necessary for comprehending and analysing cumulative knowledge building (Maton, 2014). Abstract understandings in this study are characterised by SG-, whereas concrete understandings have varying degrees listed from weaker to stronger (SG+, SG++, SG+++). Furthermore, SG+ has varying levels of strength. For example, using a hypothetical example is a lower level of SG+ denoted as SG+ (one), whereas using diagrams is slightly higher (SG+, two). The associated meanings of these semantic codes are outlined clearly on the translation device highlighted in the methodology.

Methodology

The methodology section explains and illustrates how the Legitimation Code Theory's dimension of semantic gravity informed the research methods used in this study. The LCT framework was used in this study because of its relevance as an analytical and organising framework for data (Clarence, 2013). Data was collected through classroom observations, in which the teacher was video recorded during instruction. One lesson taught by an experienced and qualified technical sciences teacher was observed, transcribed, and analysed. The transcribed lesson was a fifty-minute session on the topic of semiconductors for students in grade 12. To adhere to ethical considerations anonymity was exercised by blurring the faces of students and the teacher. The topic targeted intrinsic and extrinsic semiconductors, n-type, p-type and p-n junctions, conductivity, resistivity, depletion region, as well as forward and reverse bias. To be able to see how the teacher shifts between abstract and concrete knowledge forms, or vice versa, the overall lesson was divided into five episodes which were then analysed and labelled as such on the discussion section; each episode lasted approximately ten minutes. The first four episodes offered general instruction, while the fifth episode focused on the practical activity, in which the teacher provided resources and tasks to engage students in the practical work. These episodes were then coded using the associated semantic gravity codes.

Data Analysis

Four semantic gravity codes were identified (SG-, SG+, SG++, and SG+++), and their specific meanings in this study are described in the table below. The semantic gravity codes were then organised using a semantic gravity translational device, and specific examples from the lesson were presented. This organisation clearly reveals how and why the specific segments of the lesson were coded in a specific manner. According to Cowsley-Haselden (2020), the translation device allows for constant interaction between theory and data. The semantic gravity codes identified were then represented using semantic profiles, as seen in the findings and discussion section. Semantic profiles are a useful tool for visualising how the teacher makes shifts between the semantic gravity codes over time in a lesson (Xie, 2020), thus explicitly revealing the transitions between abstract and concrete ways of understanding and vice versa.

Table 1. Semantic gravity (SG) translational device (shows how abstract or concrete meaning is)

Strength	**Code**	**Indicator**	**Examples from the analysed lesson transcription**
Weaker Stronger	SG-	The teacher explains statements in an abstract manner	Conductivity is inversely proportional to resistivity, if the resistance is high, the conduction will be low
	SG+ (one)	Teacher refers to a hypothetical example	We bring in the foreign element. You still remember the alien element? Silicon crystals if you still remember
	SG +(two)	Teacher also uses diagrams to illustrate concepts	But there is something you need to know. Now, if you look at this electron (referring to the diagram), it's far from the hole. So, chances are that because of this gap (referring to the diagram), it's almost impossible for electrons to neutralise with the hole.
	SG++	The teacher focuses on real world example/direct experience	Remember when I asked Kutlwano to move and I said, take those electrons. There was the first electron being removed, and then she left an empty space, and I said France must come too, and he left space, so remember that the actual things that are moving are electrons. Kutlwano and France represent electrons in this case.
	SG+++	Teacher focus on personal experiences	Now, using these materials (diodes, multimeters, etc.), let us observe reverse and forward bias. Here, the teacher directs learners into conducting an experiment.

Findings and Discussions

This section begins by addressing the first question, and then some of the findings from the first question are used to address the second question. To provide a clear indication of how the teacher transitions between abstract and concrete forms of understanding, each episode's findings are discussed separately.

Research Question 1: What transitions does the teacher make between abstract and concrete forms of understanding when teaching the concept of semiconductors?

Shifts in Semantic Gravity in Episode 1

The lesson begins with the teacher introducing the concept of semiconductors using an abstract statement. This suggests that the lesson begins with a high level of abstraction, indicating weaker semantic gravity (SG-) as seen in the extract below.

> ***Teacher****: The last lesson was about extrinsic semiconductors where we introduced doping as a method of increasing conductivity in semiconductors. Can you tell me exactly what is doping from the previous lesson? What did I say about doping? Yes?*

Introducing the lesson with a weaker degree of semantic gravity is deemed necessary as it allows learners to grasp the key elements of the disciplinary knowledge targeted in the lesson (Jaakkola & Veermans, 2015). The concept of doping as a method of increasing conductivity in semiconductors is an abstract concept that requires being unpacked using illustrations so that learners can comprehend it. While this statement appears to be simple, at least three abstract questions must be addressed to understand the concept. The abstract questions related to this statement are: What is doping? What is conductivity? How can doping improve conductivity in semiconductors? The statement is framed within the framework of prior knowledge, suggesting that the concept is not new for the learners. Even so, it is worth noting that the teacher introduces it to develop an abstract understanding of the targeted concepts in this new lesson. Following the abstract statement, the teacher makes a shift from SG- (abstract) to SG+ (hypothetical example). In doing so, the teacher strengthens the semantic gravity of the lesson. A shift from abstract to concrete examples enables an entry point for learners to build mental images of the abstract concept that is introduced. Further, the teacher offers learners an added advantage by making it easier for them to conceptualise the abstract concepts (Lindsay, 2011).

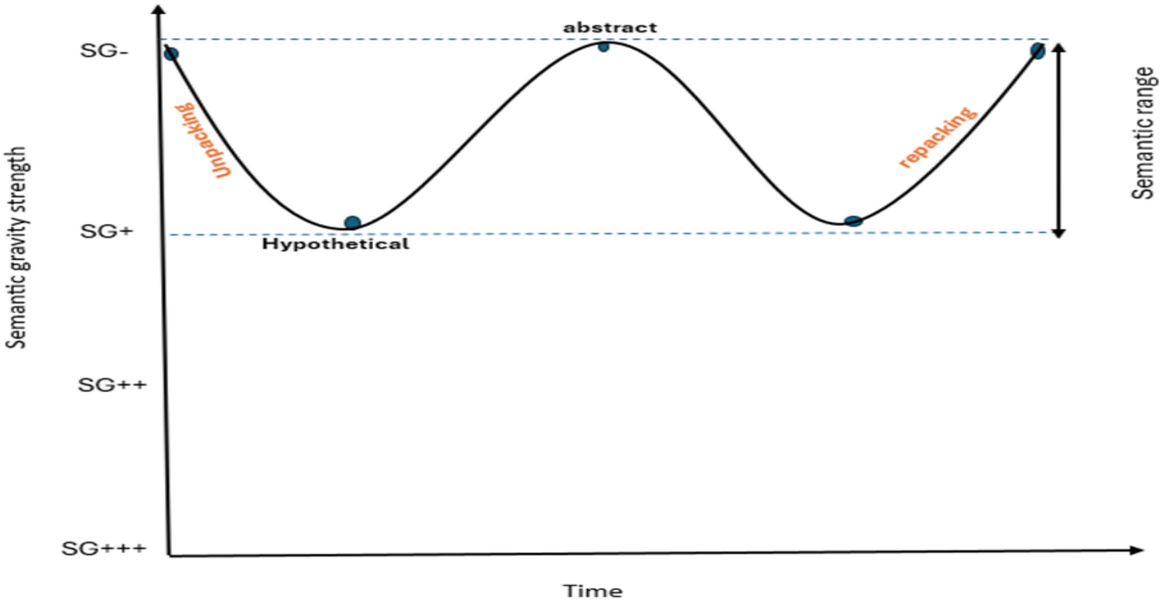
> **Teacher**: *When we speak of doping, we bring in a foreign element. Do you still remember the alien element? Silicon crystals if you still remember. So, we had some silicon crystal with electrons around it and we introduced a certain element. Which element can you remember? There was an alien—- a foreign element that we used.*
> **Learners**: *As*
> **Teacher**: *As which is what? Arsenic…and in which group is Arsenic if you look in your period table right now? It is in group?*
> **Learners:** *15*

At this point in the lesson, the teacher is unpacking meaning by attempting to explain how doping occurs in semiconductors. This strengthens the semantic gravity as the teacher moves from abstractions to forms of knowledge that learners can easily understand. The element arsenic is used as an illustration in this process, and learners are immediately redirected to their periodic tables to identify the group to which arsenic belongs. The teacher is gradually preparing to repack meaning by shifting from SG+ back to SG-, thus weakening the semantic gravity. This transition is required because leaving the meaning too context-based or concrete may hinder learning. When learning is grounded in illustrations that are not linked back to disciplinary knowledge, then learning becomes segmented (Hassan, 2017). The extract below shows this significant shift between SG+ and SG-.

> ***Teacher:*** *Group 15, meaning it has how many electrons outside, the valence electrons?*
> ***Learners****: 5*
> ***Teacher:*** *So, if we pair the four electrons around the arsenic, what we end up having is one free electron, and because of this free electron that is able to move around, we say it forms a certain type of semiconductor, which we call an n-type. What did we say about this n? What does n stand for?*
> ***Learners:*** *Negative*
> ***Teacher:*** *It means there is an extra electron, so it forms an n-type.*

The extract above is characterised as weakening semantic gravity since the teacher introduces concepts such valence electrons, n-type and free electrons that require further unpacking. If these concepts are not unpacked properly, understanding may be hindered. Singh, Hugo, and Essack (2013) describe unpacking as a downward curve, indicating a transition from decontextualized meaning to familiar examples. Thus, throughout this episode, the teacher makes shifts between SG- to SG+(one) and then back to SG-. The transition from SG+ (one) to SG- is referred to as repacking, and it is represented by an upward case, indicating shifts from familiar understandings to abstract forms of knowledge. The weakening and strengthening of semantic gravity over time in this lesson enabled the teacher to make shifts between abstract and concrete forms of understanding, which were limited to hypothetical illustrations in this episode. These shifts were necessary as they allowed learners to comprehend the targeted concept, thus building cumulative knowledge (Byers, 2018). To visualise how the teacher shifts between SG- and SG+ (one) in this episode, a semantic profile indicating a semantic wave with a low semantic range is identified.

Figure 1. Semantic gravity wave visualised in episode 1 of the lesson



Shifts in Semantic Gravity in Episode 2

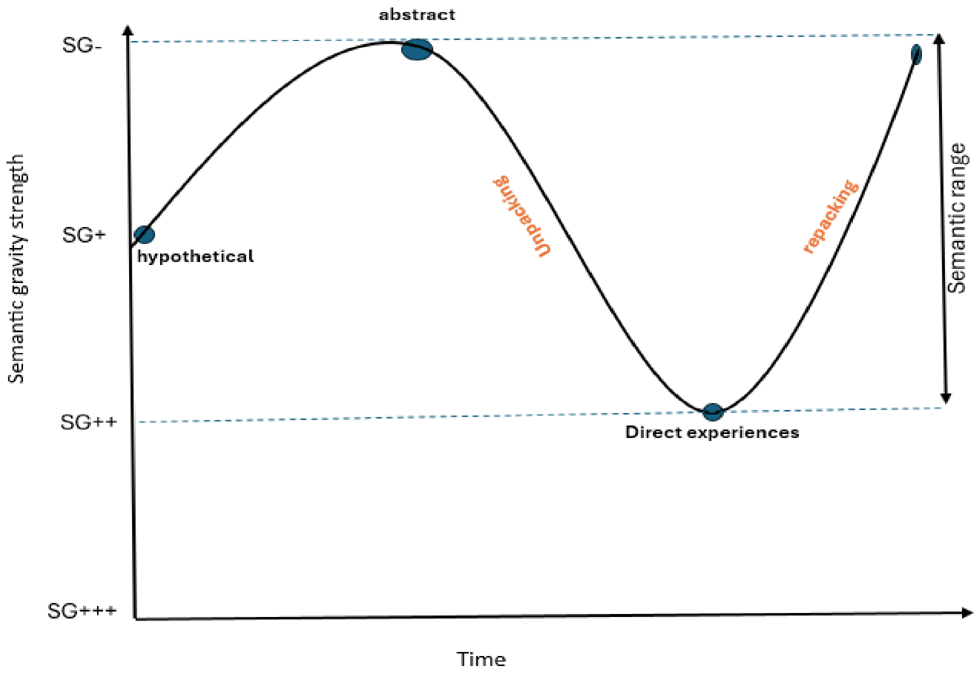
Episode 2 is characterised by shifts between SG+, SG-, SG++, and then SG-. This episode is an extension of the first episode, in which the teacher transitioned to SG-. This episode then begins with the teacher introducing a hypothetical example (SG+). The key aspect is that explanations do not remain in these hypothetical terms; instead, the teacher repacks understanding. This leads to an upward curve (as visualised in the semantic profile below), illustrating a significant shift from concrete (SG+) to abstract forms of understanding (SG-). Now that understanding has been condensed to its standard abstract terms, meaning needs to be contextualized once more so that learning becomes a process of weakening and strengthening semantic gravity over time throughout the lesson. Blackie (2014) points out that teachers can help learners reach abstractions, but it is important to draw on their experience to help them develop mental associations.

Interestingly, in this episode, the teacher introduces direct experiences (SG++) to help learners better connect with the abstract concepts that are being taught, thus further strengthening the semantic gravity of the lesson. SG++ denotes that the lesson uses a slightly higher degree of concrete understanding. At this point in the lesson, meaning and understanding are excessively contextualized or too closely linked to learners' direct experiences, hence, it is imperative for the teacher to repack understanding by connecting the experiences to the targeted abstract science concept being taught. This requires a shift from SG++ back to SG- thus weakening the semantic gravity of the lesson. Maton (2014) argues that the answer to academic success is not having a stronger or weaker semantic gravity (SG), but rather having a wider range of movement between them. Based on this statement, it can be concluded that this episode offered greater opportunities for cumulative learning than episode 1. The excerpt below demonstrates a scenario in which the teacher weakened semantic gravity by transitioning from SG++ to SG-. The first part of the extract is denoted as SG++ (direct experiences), whereas the second is SG - (abstract; mainly because the teacher introduces a new concept of conductivity).

> **Teacher**: *Remember when I asked Kutlwano to move, and I said, take those electrons. There was the first electron being removed, and then she left an empty space, and I said France must come, and he left space, so remember that the actual things that are moving are electrons (the teacher was talking about a demonstration that the class previously did).*
>
> **Teacher***: Electrons now move due to the repulsion coming from the negative terminal of the battery, and even the holes will look as if they are moving. So, it means electrons are being pushed fast by the negative terminal of the battery. This movement results in a term called conduction.*

The semantic profile below indicates how the teacher transitioned from hypothetical meanings (SG+) to abstract understandings (SG-), then SG++ (direct experiences), and finally back to SG- (abstract).

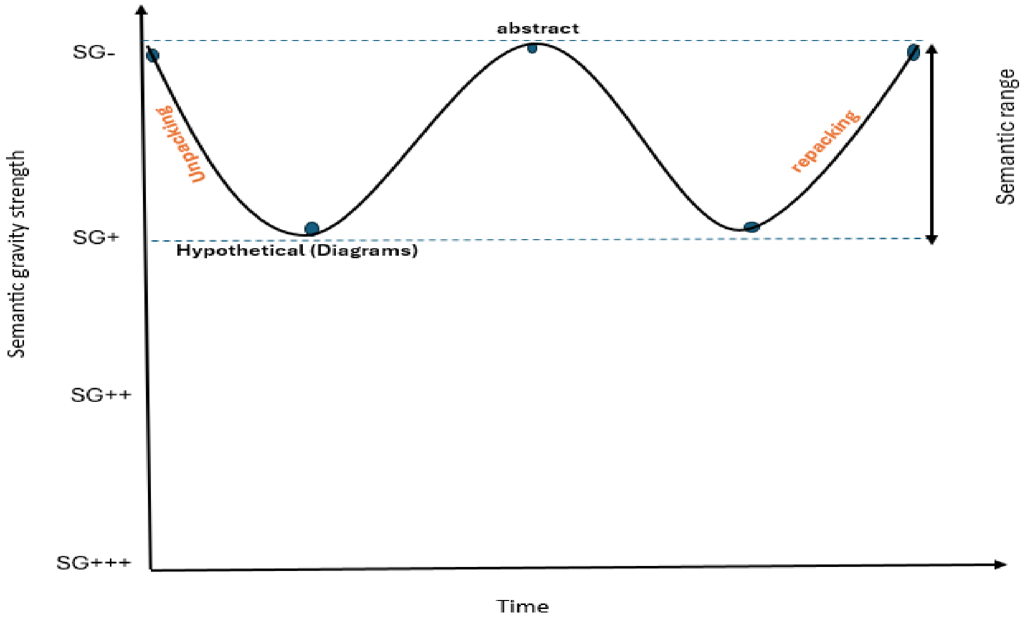
Figure 2. Semantic gravity wave in episode 2 of the lesson



Shifts in Semantic Gravity in Episode 3

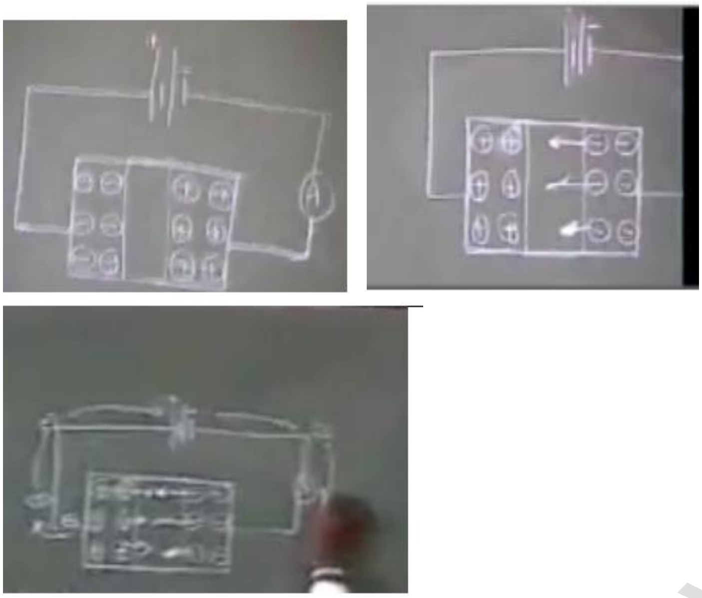
The semantic profile below depicts how abstract (SG-) and concrete (SG+) forms of knowledge shift over time in a lesson. The teacher weakens and slightly strengthens semantic gravity, as evidenced by shifts from SG- to SG+, then SG+ back to SG-.

Figure 3. Semantic gravity wave in episode 2 of the lesson



The semantic profile for this episode is like episode 1. What sets these two episodes apart is the kind of hypothetical examples (SG+, two) used in the lesson. SG+ in episode 1 is characterised by hypothetical statements, whereas SG+ in episode 2 is denoted by representations in the form of diagrams. The presented diagrams are anchored with detailed information relating to the content as the teacher explains the concepts. Diagrams offer a visual representation of the connections between concrete and abstract knowledge forms (Harris, 2000). Furthermore, Raiyn (2016) contends that visual learning helps learners develop visual thinking, which means they can better link ideas, words, and concepts with diagrams. In this episode, the teacher explains the concept of conduction and uses a diagram anchored with explanations to help learners build mental images of how electrons move in a circuit. See the diagrams below:

Figure 4. Diagrams used to explain abstract concepts

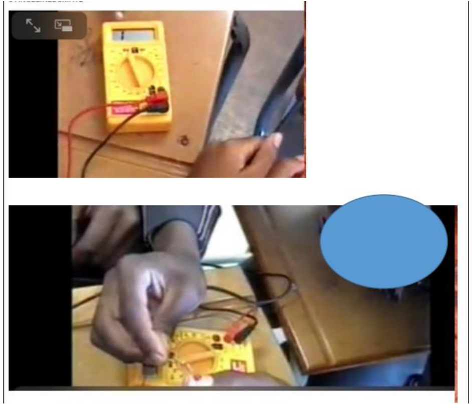


Semantic gravity is strengthened using diagrams, but meaning is not limited to these diagrams; the teacher further weakens semantic gravity by shifting to SG-. According to Maton (2014) and Maton (2013), semantic gravity is weakened when meaning shifts from the concrete particulars of a case to generalizations and abstractions where meaning is not closely related to its context. To provide the opportunity for cumulative learning, SG must be weakened (Maton, 2009).

Shifts in Semantic Gravity in Episode 4

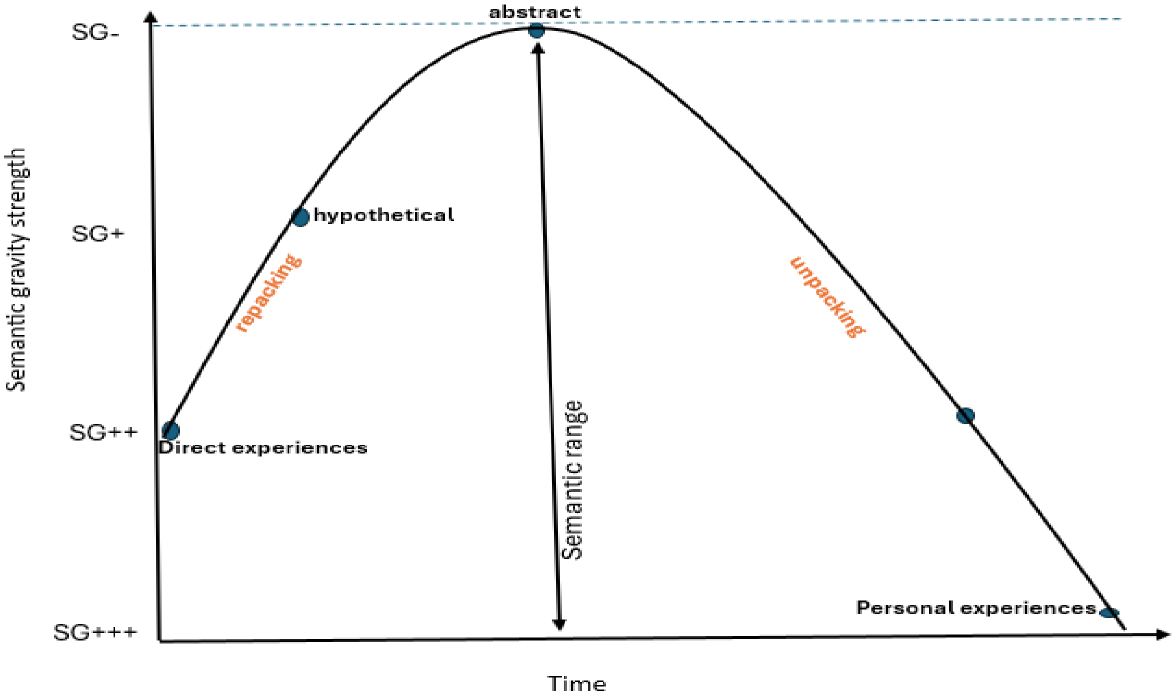
Episode four is possibly the most crucial episode identified in this lesson. In this episode, the teacher manages to transition between four codes: SG++, SG+++, SG+ and SG- while in other episodes, the weakening and strengthening of semantic gravity remained at these three levels (SG-, SG+, SG++). The episode opens with a relatively stronger semantic gravity (SG++), which touches on learners' direct experiences, semantic gravity is slightly weakened as the teacher transitions from SG++ to SG+, indicating a shift between direct experiences and hypothetical examples. Based on the degrees of concrete forms of knowledge identified in this study, the teacher transitions from a higher degree (SG++) to a lower degree involving diagrams (SG+). The weakening of semantic gravity slowly presents a setting in which direct experiences are linked to diagrams that are tied to the content. Meaning and explanations are not limited to a hypothetical level (SG+); the teacher takes meaning all the way to its abstract form by shifting to SG-. This is a necessary shift that links various concrete forms of understanding to the abstract concept being taught. Following that, the teacher strengthens the semantic gravity to its maximum form by introducing a practical activity denoting SG+++. SG+++ in this instance links abstract concepts to learners' personal experiences. Learning is contextualised as learners work with the required materials, as seen below.

Figure 5. Learners manipulating materials during the practical work



By tapping into learners’ experiences the teacher makes links between abstract and concrete forms of knowledge. The observed high semantic gravity range indicates greater opportunities for cumulative knowledge building. As argued by Maton (2014) the wider the knowledge range, greater the potential for cumulative knowledge building. The semantic profile below indicates how the teacher made transitions between all the four codes.

Figure 6. Shows shifts in semantic gravity in episode 4



Shifts in Semantic Gravity in Episode 5

Episode 5 can be viewed as a summary of the overall lesson following the introduction of the practical activity. The teacher further taps into learners' personal experiences by stimulating a dialogue about the practical activity.

Learners share their personal experiences, while others re-do the practical; during this dialogue, learners are drawn back to the abstract concept that the practical was intended to address. Shifts from SG+++ (personal experiences) to SG- (abstract) are observed, this transition is surprisingly facilitated by the learners. The fact that learners are involved in this dialogue helps them see the relevancy of the practical activity. See extract below:

Teacher: *How was your experience using the diodes and observing the reverse and forward biases?*

Learner 1*: It was interesting to see the current flow.*

Teacher*: Good Teacher: Can someone from the next group share their experience?*

Learner 2: *Sometimes it is scary because you are thinking, what if I break these things.*

Teacher: *Okay. That is the only problem. Can anyone from this group tell us about their experience?*

Learner 3: *We had a fault with our LED because it did not light up, we think the problem could have been the battery. We are hoping that we redo and see how it works out.*

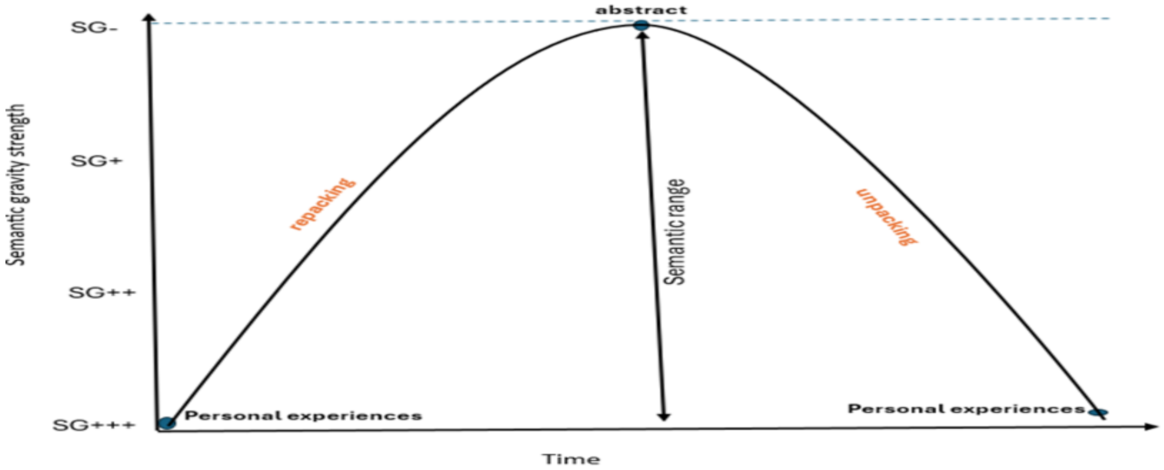
Teacher: *Can another group send their materials so that this group can quickly observe the forward bias and reverse bias using the LED. Let us give them a chance before we move on.*

The group is given a chance to re-do the practical, and their LED lights up.

Learners in the group*: That is the forward bias!! The other way around, it means the LED won't light up, so that will be the reverse bias.*

This episode can be visualised using the semantic profile below.

Figure 7. Shows shifts in semantic gravity in episode 5



Research Question 2:
How Does Practical Work Enhance or Strengthen Semantic Gravity?

To answer research Question 2 above, the semantic ranges observed across all episodes served as a primary indicator. Episodes 4 and 5 clearly demonstrate how the teacher was able to transition between SG- and SG+++, giving those episodes the highest semantic gravity range as underscored by Maton (2014). The introduction of the practical activity allowed the teacher to tap into learners' personal experiences, thereby creating a direct link between theory and practice. Maton (2013) contends that lessons should have a greater range rather than small semantic ranges, as a greater semantic range offers more opportunities for cumulative knowledge building. The inclusion of the practical segment in the lesson meant that understanding was grounded in learners' personal experiences as they interacted directly with the materials used in the task, this strengthened the semantic gravity of the overall lesson. Furthermore, the practical activity enabled meaningful dialogue between the teacher and learners. Encouraging learners to ask experience-related questions, further personalised learning, and ultimately enhanced semantic gravity. Blackie (2014) noted that asking questions allows for semantic gravity to be strengthened. According to Summer (2009), a science teacher improves the learning environment by incorporating learners' ideas into science classrooms and assisting learners in connecting science to their daily lives. In a similar vein, Hassan (2017) suggests that probing questions increase learners' engagement with the content. "Is this a forward bias? "How do you know? Is there any light from the LED?" asked the teacher. To answer the questions, learners would draw on the practical and theoretical understanding offered throughout the lesson.

Additionally, when learners were performing the practical task, the teacher shaped their knower gaze by specifically showing them that practical work is a form of trial and error and that when the results contradict the theory, they must redo the practical to verify the results. See the extract below:

> ***Teacher:*** *Can others share their experiences? What can you say about the multi-meter? Is there forward bias in the multi-meter?*
> ***Learner:*** *There was a reading for the reverse bias.*
> ***Teacher:*** *Let's redo the practical to see if you are telling us the truth.*

Learners redo the practical and later realize that there is no reading for the reverse bias only in the forward bias.

> ***Teacher:*** *See, it means your group didn't do it right. Now listen, class, the next activity is coming, and we are moving back to our positions. This will be a small activity for about ten minutes on your own. Okay?*
> *In reverse bias, our LED will not glow up, and the multi-meter will not show any readings because there is no conduction. Remember, conduction is the movement of electrons, this means that in reverse bias, electrons are not able to move, as I explained earlier. But in forward bias, our LED glows up, and the multi-meter shows a reading because there is conduction.*

Clarence and Mckenna (2017) underline the necessity of learners being aware of the various kinds of knowledge and skills required when learning a subject. Accordingly, science teachers ought to make explicit the ways in which they shape learners into scientific tasks. Science learners ought to be clearly shown the skills relating to the content to build connections between theory and practice and later apply the knowledge in different situations. This instance, as shown during the practical component of the lesson, enhanced the semantic gravity.

Conclusions

The teacher could make transitions between abstract and concrete forms of understanding, or vice versa, during the lesson which was evident from a series of weakening and strengthening of semantic gravity over time in the lesson. Varying degrees of concrete understanding (SG+, SG++, and SG+++) are noted during the lesson and linked directly to the targeted abstract concept of semiconductors. One of the key elements noted in the overall lesson is that as the lesson progressed, the teacher introduced more contextualised examples such as direct experiences (SG++) and personalised experiences (SG+++). Analysing the semantic ranges of all episodes revealed that as the lesson progressed, wider semantic ranges were observed, indicating wider opportunities for cumulative learning.

A focus on practical work, shows that it has the ability to contextualize and personalize learning, when the practical activity is linked directly to the abstract concept being taught. It is thus crucial for science teachers to recognize the added significance that practical work can play in bringing together theory and practice in science classrooms, rather than simply introducing practical work to meet curriculum demands. The practical activity offered personalised knowledge, allowing learners to comprehend the overall content of the lesson. This personalisation further exemplifies the value of practical experience in science education. The study concludes that practices that help visualise how teachers combine theory and practice ought to be at the centre of science teaching. Such practices make explicit the forms of knowledge that are hidden within practices and allow them to be clearly seen. Findings from the study can help teachers inform their practices by intentionally adopting pedagogies that are aimed at explicitly linking theory and practice. Semantic profiles are a significant contribution to the Legitimation code theory because they provide a visual representation of how teachers can actively develop learning that explicitly connects theory and practice.

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