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LIFE SCIENCES TEACHERS' PLANNING OF LESSONS FOR FORMATIVE ASSESSMENT IN INQUIRY-BASED TEACHING

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Abstract

Formative assessment (FA) is considered one of the most powerful tools to enhance learning and influences the development of inquiry skills. However, few studies have addressed how Life Sciences teachers plan for formative assessment in inquiry-based teaching. A lesson plan is one of the crucial tasks for any science teacher since it assists in the presentation of a lesson. Lesson plans show how students will be moved toward obtaining specific objectives. This paper reports on five grade 10 Life Sciences teachers' planning for formative assessment in inquiry-based teaching. The ESRU framework guided this study. The ESRU cycle consists of four elements; the teacher elicits (**E**) questions to check students' ideas, the student (**S**) response, the teacher recognises (**R**) the students' response, and then uses (**U**) the student's response to promote learning. The ESRU comprises complete and incomplete cycles. A complete cycle is when all four elements are visible and incomplete if Elicit, Student response, and Recognize; or only Elicit and Student response. The lesson plan analysis looked at the ESRU cycles' elements in the questions planned to see if the questions were focused on the epistemic or conceptual dimensions. It also looked at how the entire lesson was planned. This research is a part of a more extensive qualitative study where data was collected through lesson observations, interviews, and lesson plans. The study was conducted to describe teachers' formative assessment practices in inquiry-based pedagogy. This paper reports only on lesson plans. One lesson plan was requested per teacher. Participants were purposively selected based on their teaching of the subject and conveniently sampled according to their proximity to the researcher's residence. Findings from all five teachers are as follows; when planning a lesson, it was evident that the five teachers planned for FA. In terms of ESRU, Eliciting and Using strategies were evident in the planned questions. The **S**tudent's response was not included when planning since it is the students' responses during the lesson and can only be captured when the teaching is happening. The **R**ecognising strategies were also not included in the lesson plans since they depend on learners' responses. Four teachers planned more questions focused on epistemic than conceptual structures. The findings signal that there is still a need to train teachers to plan lessons that focus equally on conceptual and epistemic dimensions.

Keywords: *ESRU, formative assessment, lesson plan, inquiry-based.*

1. Introduction

There has been a call globally for science education to include 'inquiry' in science education (NRC, 2000). This has led to many countries reviewing their curricula and including inquiry-based teaching and learning. In the South African context, a lot is being done to amend policies to align with the 21st century, including inquiry-based teaching and learning (DBE, 2011). Scientific inquiry refers to "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (NRC, 1996, p. 23). Inquiry Science-Based Education (IBSE) has been promoted as an inspiring way of learning science by engaging pupils in designing and conducting scientific investigations (van Uum, Verhoeff, & Peeters, 2016). Inquiry-based science teaching (IBST) is one of the strategies that can be used to teach science. IBST and formative assessment (FA) support the construction and development of knowledge through continuous assessment (Harlen, 2013). FA is defined as a continuous and cyclical process of gathering evidence about student learning and using that evidence to guide students' learning process through clear and detailed instruction and feedback (Black & Wiliam, 1998). FA is a pedagogical vehicle that skilled teachers commonly use to support their students in learning scientific practices and content (Dini, Sevian, Caushi, & Picón, 2020). Teachers cannot practice inquiry-based approaches in the classroom without using FA practices. FA is essential in

inquiry-based teaching since it allows teachers to ask learners questions when doing experiments or learning about specific content (Harlen, 2004). However, the value of inquiry-based teaching and learning and implementing such a pedagogical practice continue to be challenging for many South African teachers (Ramnarain & Hlatswayo, 2018). Therefore, there is a need to research how teachers plan lessons for formative assessment in inquiry-based teaching.

The framework that guided this study is the ESRU framework. Ruiz-Primo and Furtak (2007) developed the ESRU cycle of FA where a teacher elicits (E) questions to check students' ideas, then student (S) response, the teacher recognises (R) the students' response and then uses (U) the students' response to promote learning. The ESRU cycle can be considered a 'complete' cycle if all four elements of ESRU features are visible (Elicit, Student response, Recognize and Use) and 'incomplete' if not all the features of the ESRU are included (Elicit, Student response, and Recognize; or only Elicit and Student response in a single dialogue. This Framework was applied in the lesson plans; the focus was to see how the teacher prepares questions for Elicits and Uses when planning a lesson. Questions to **E**licit and **U**se are essential to be included in the planning of lessons, because when the teacher **E**licits a question, this allows learners to share information about what they are thinking or their understanding of a concept (Ruiz-Primo & Furtak, 2007). The **S**tudent's response is not included when planning since the students' responses can only be captured when the teaching is happening. The **R**ecognising strategies are also not included in the lesson plans since they depend on learners' responses. The framework was also applied to the study to see if the planned questions focused on the epistemic or conceptual dimensions.

Ruiz-Primo and Furtak (2007) analysed the type of inquiry promoted during the ESRU cycles. Their model involves three main inquiry dimensions: epistemological, conceptual, and social. Regarding **E**liciting questions, the eliciting strategies were analysed according to the epistemic and conceptual dimensions (See Table 1). Strategies for ESRU cycles by dimension. Epistemic structures are the knowledge frameworks that involve science rules and criteria of what counts as science: experiment, hypothesis, or explanations (Duschl, 2000, 2003). Epistemic structure focuses on developing and evaluating scientific reasoning. Conceptual structures are used when reasoning scientifically and focus on a deep understanding of concepts and principles, while *social processes* focus on how knowledge is communicated. According to Ruiz-Primo and Furtak (2007), both epistemic and conceptual structures are essential in helping learners to use the knowledge comprehended effectively in appropriate situations.

Table 1. Strategies for ESRU cycles by dimension (Ruiz-Primo & Furtak, 2007).

Eliciting	**Recognising**	**Using**
Epistemic frameworks Teacher asks students to: • Compare/contrast observations, data, or procedures. • Use and apply known procedures. • Make predictions/provide hypotheses • Interpret information, data, patterns • Provide evidence and examples • Relate evidence and explanations • Formulate scientific explanations • Suggest hypothetical procedures or experimental plans • Compare/contrast others' ideas **Conceptual framework** • Check students' comprehension Conceptual structures Teacher asks students to: Provide	Teacher: • Clarifies/Elaborates based on students' responses • Promotes students' thinking by asking • Takes votes to acknowledge different students' ideas. • Repeats/paraphrases students' words • Revoices students' words (incorporates students' contributions into the class conversation, summarises what student said, acknowledge student contribution) • Captures/displays students' responses/explanations • Respond with yes/no or fill-in-the-blank-answer question.	Teacher: • Promotes students' thinking by asking them to elaborate their responses (why, how) • Asks students to elaborate based on their previous response. • Compares/contrasts students' responses to acknowledges and discuss alternative explanations conceptions Promotes debating and discussion among students' ideas/conceptions. • Helps students to achieve consensus. • Helps relate evidence to explanations • Provides descriptive or helpful feedback • Promotes making sense • Promotes exploration of students' own ideas • Refers explicitly to the nature of science

Eliciting	Recognising	Using
potential or actual definitions apply, relate, compare, contrast concepts • Compare/contrasts others' definitions or ideas • Check their comprehension		• Makes connections to previous learning

2. Research question

How do Life Sciences teachers plan lessons for formative assessment in inquiry-based teaching?

3. Research design and methodology

The qualitative research design method was used for this study (Creswell, 2014). A case study approach was applied to understand teachers' planning of formative assessment in inquiry-based teaching. Five grade 10 Life Sciences teachers were purposefully sampled based on their teaching of the subject and conveniently sampled due to their proximity to the researcher's location (Merriam, 2009).

4. Data collection

One Lesson plan was requested from all five grade 10 Life Sciences teachers; before lessons were conducted. The teachers gave the researcher their lesson plans together with questions planned and worksheets related to their lesson. The lesson plan is a written description of this process, where the materials, the method, the time, the place of education, and the methods for evaluating the students are described in detail (Nesari & Heidari, 2014). Lesson plans are usually planned before the lessons since they guide the teacher throughout the study, and there must be lesson objectives/outcomes (Kiviet & du Toit, 2010). Kiviet and du Toit (2010) further explain that lesson plans show how students will be moved toward obtaining specific objectives. These lesson plans were analysed to examine how the ESRU framework and the ESRU strategies were applied to the questions. The questions were also analysed to see if the planning focused on epistemic or conceptual dimensions. See table 1, showing the ESRU strategies.

5. Findings

From teachers' lesson plans, it was evident that the five teachers do plan for FA. It was also evident that all five teachers did plan for **E**liciting and Using, but only one did not plan for **U**sing; he planned for Eliciting only. The **R**ecognise element was not evident in the lesson plans since it requires actual teaching. The teacher needs to recognise students' responses, and is generally used based on the student's responses (Ruiz-Primo & Furtak, 2007). Four of five teachers planned more questions focused on epistemic than conceptual structures. This means they repeatedly focused more on 'procedures that involve inquiry rather than the process of developing scientific explanation' (Ruiz-Primo & Furtak, 2007, p. 78) when planning. The excepts below are for Ms. Kubeka, and Ms. Thwala, whose lesson plans had similar topics both prepared lesson plans on Classification. Both lessons had evidence of planning that focused on **E**liciting and **U**sing questions, but Ms. Kubekas's lesson focused more on epistemic questions, and Ms. Thwala focused more on conceptual questions.

6. Ms. Kubeka's Lesson plan analysis

In Ms. Kubeka's topic was on Classification. When analysing the lesson, it was evident that she planned to elicit responses. The questions below are an excerpt from her lesson plan and are part of the eliciting strategy according to the ESRU framework. All the questions planned by Ms. Kubeka focused on the epistemic rather than the conceptual dimension. See Table 1 showing Strategies for ESRU cycles by dimension. The questions below are other examples of the questions attached to the lesson plan which were planned to ask learners.

1. How did you group the shapes for the first time?
2. Explain the process until the end.
3. Write down the characteristics of the shapes in each according to the way you have grouped them.
4. How are these shapes different?
5. How are these shapes similar?

In all the above questions, the teacher plans to request learners to *interpret information or data* according to the eliciting strategy (See Table 1).

When it comes to **U**sing strategy, more questions were evident, and the teacher also planned to use her learners' responses to ask them how they have grouped the shapes. See an excerpt below from her lesson plan.

1. Give reasons why you separated them this way.
2. Why did you separate them this way?

In both the above questions, she plans that when learners explain how they have separated their shapes, he will *promote student thinking by asking them to elaborate on their responses.* These questions show that when planning a lesson, Ms. Kubeka prepared questions requiring her to use her learners' responses. Her planning was not limited to asking questions but also using students' responses to move them toward the learning goal (Harlen, 2013). Ms. Kubeka's questions focused on the epistemic rather than the conceptual dimension.

7. Ms. Thwala's lesson plan analysis

An excerpt from Ms.Thwala's lesson is extracted below. Her lesson was also on Classification. Even though Ms. Thwala's lesson also had evidence of eliciting and recognising. Unlike Ms. Kubeka, her lesson focused more on conceptual than epistemic structures.

1. What are nostrils?
2. On the binomial key, find the characteristics that belong to both mammals and birds.
3. Find one characteristic that is different from both mammals and birds.

When it comes to Eliciting strategy, in the lesson plan, there were questions prepared. The first question is an example of a question that *checks student comprehension*. This shows that in her planning, she knew learners' comprehension was necessary and should be checked. The second question is another **E**liciting strategy where the teacher wants students to *interpret information or data* given to them. The last question shows that she prepares to elicit questions that require learners to *compare/ contrast observations, which* is another eliciting strategy. In the lesson plan, there was also evidence of questions planned for **U**sing learners' answers to promote learning. See an excerpt of her questions below.

1. What are nostrils?
2. Why is it important to first classify by nostrils?
3. Do you think the taxonomy key/ biological key helps us to classify organisms?
4. How?

In the First question, the teacher plans to **U**se her learners' answers by *asking students to elaborate on the previous response,* which is *what are nostrils?* Then learners will elaborate on *why it is important to first classify by nostril.* The second question is a fill-in-the-blank-answer question, whereby a learner will answer with a yes or no. The teacher has also prepared to use the learners' responses by asking *why, to probe learners to elaborate on their previous responses.* Even though the *fill-in-the-blank answer question* is not an excellent eliciting strategy since it leads to learners responding with one-word answers (Shirley, 2009). However, she plans to use their answers by asking them to elaborate. Most of Ms. Thwala's questions focused on the conceptual dimension more than the epistemic dimension, unlike the other four teachers.

8. Discussion and conclusions

During the analysis of the lesson plans, there was evidence of **E**liciting and **U**sing strategy, the **R**ecognising strategy was not evident in the lesson plans since it requires real-time, and teachers can only recognise students' responses in class when teaching. Lesson plans proved that teachers are aware that they should **E**licit and **U**se learners' answers in class to promote learning or to move learners toward the learning goal (Harlen, 2013). According to the ESRU framework, their planning consists of complete

cycles (Ruiz-Primo &Furtak, 2007). Out of the five teachers, one teacher did not plan questions focused on Using learner's responses which made his learners miss out on the 'Use' aspect of the discussion, where the teacher provides "students with specific information on actions they can take to accomplish the learning goals (e.g., ask another question that challenges the students' thinking, 'Compares/contrasts the students' responses', 'Promotes debating/discussion', 'Promotes idea exploration' and 'Promotes thinking' (asking 'Why/how?)' etc.) (Rached & Grangeat, 2021).

Four of the five lesson plans focused more on the epistemic than the conceptual dimension. The teachers' planning focused on the epistemic in the lesson plans. This caused learners to miss the skill and process of developing scientific explanations (Ruiz-Primo & Furtak, 2007). A study by Rached and Grangeat (2021) attests that most science teachers' lessons focus more on the epistemic than the conceptual dimension. This makes learners miss out on learning the conceptual structures of the content. Similarly, another study by Black and Wiliam (2004) discovered that teachers rarely engage learners in discussions that will reveal their conceptual understanding in classroom discussions. Conceptual structures are important because they help students understand concepts and principles as parts of larger scientific conceptual schemes (Ruiz-Primo & Furtak, 2007).

With proper planning of lessons, teaching and learning can take place smoothly. Inquiry-based teaching can also be promoted if the planned questions focus equally on the epistemic and conceptual structure so that learners can understand concepts and scientific knowledge deeply.

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