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Exploring the Recontextualisation of Biotechnological Knowledge in the Plant Biotechnology Course: A Bernsteinian Analysis

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Abstract
The purpose of this study was to explore the recontextualisation of knowledge in a Plant biotechnology course. The goal of the analysis was to understand the structure of the pedagogic discourse which the biology education students were to experience during their training. The aim of any training is to prepare the students for their future profession. In this case the training is aimed at preparing the students for teaching biology in secondary schools in Zambia. Studies have indicated that, to effectively prepare the students to teach biology in secondary schools, the students need to experience a pedagogic practice characterized with both weak and strong framing and a weak classification between the discourses. The analysis will also inform the practitioners of the knowledge to be taught and how the knowledge is to be taught. The research question which guided the study was: How is knowledge recontextualised in a plant biotechnology course? Bernstein's classification, framing, recognition and realization rules were used to analyze and interpret the findings in relation to the training of the teachers. Indicators were developed to guide the analysis. An inductive approach was used to analyse the document. Atlas ti 8 was used to analyse the document. The findings indicated that the document is strongly framed in the selection and evaluation criteria, weakly classified in the relations between discourses. There was no indication of sequencing, pacing and the hierarchical rules in the document. The findings indicate a weak recognition and realisation of the text.

Keywords: Recontextualisation, Classification, Framing, Recognition, Realization, Pedagogic Discourse, Biology Education Students

1. Background to the study

The article is focused on exploring the recontextualisation of knowledge in a plant biotechnology course (BT 440 course) as one of the courses taken in the biology education programme. The plant biotechnology course is prepared for the students enrolled in the Department of Biological Sciences, yet it is also included in the biology education programme. Bernstein's sociological theory of pedagogic discourse was used to analyze the BT 440 document to understand the instructional discourse (selection, sequencing, pacing, evaluation criteria and the relations between the discourses) and the regulative discourse (hierarchical rules) embed in the pedagogic discourse. Classification and framing concepts were used to analyse the document, while recognition and

realization rules of Bernstein were used to interpret the findings in relation to the training of the biology education students.

The desire of schools is to provide equal access to school knowledge, science inclusive to all the learners. Science education is well known to have a positive impact on the development of the individual, nations and the world at large (Young, 2007). It is the desire of every nation to provide quality and relevant science education to all its learners in schools at all levels of the education. Despite this desire of nations to provide equal access to science education to all the learners in schools, not all the learners have access to school knowledge being provided.

The differential access to school knowledge by the learners has been attributed to a number of reasons. Some scholars have attributed this situation to a lack of laboratories in schools, insufficient teaching and learning resources in schools, large number of pupils in one class, lack of knowledgeable and skilled teachers in teaching sciences (Reeves, 2006). The differential access to school knowledge has been a concern for nations, Zambia inclusive. Scholars such as Ensor (2004) and Morais (2002) have attributed the differential access to school knowledge to the characteristics of the pedagogic discourse being transmitted. They have also indicated that, successful teacher training is a necessary condition for teachers to successfully teach in schools. Prospective teachers need to experience a pedagogic discourse which enables all the learners to have access to the school knowledge during their training. Therefore, a need that educators be knowledgeable of the characteristics of the pedagogic practice which support the acquisition of school knowledge by all the learners. Educators also need to be aware of the characteristics of the pedagogic discourse which they are teaching.

In this article I have focused on analysing the BT 440 course as one of the courses taught to the prospective biology education students to understand the pedagogic discourse intended for the prospective biology teachers. Bernstein's classification and framing concepts were used to analyze the BT 440 course.

2. Problem statement

This study was focused on the Plant biotechnology course taken by the biology teacher education students enrolled in the Department of Mathematics and Science Education. The biology education students take some of the courses developed in the Department of Biological Sciences. One of the courses is plant biotechnology (BT 440). The plant biotechnology course developed in the Department of Biological Sciences context has to be recontextualised for relevance to biology teacher education students who are being prepared to teach the 5090 biology syllabus developed by the Curriculum Development Centre (CDC).

The plant biotechnology course is designed for the students enrolled in the Department of Biological Sciences to meet the objectives of the programmes in the Department of Biological Sciences. The plant biotechnology course is not designed for the students enrolled in the Department of Mathematics and Science Education. The lecturers in the Department of Mathematics and Science Education are not involved in designing the plant biotechnology course. The lecturers in the Department of Biological Sciences are not involved when developing a programme for the biology education students. Yet the plant biotechnology course designed for the students in the Department of Biological Sciences is included in the programme for the biology education students who are enrolled in the Department of Mathematics and Science Education. In this situation it is likely that the plant biotechnology course may not help to meet the objectives, which is to teach the 5090 biology syllabus to all the learners regardless of their social background.

3. Purpose of the study

The purpose of the present study was to explore the recontextualisation of biotechnological knowledge in a plant biotechnology course using the classification and the framing concepts of Bernstein. The aim of the analysis is to understand the characteristics of the plant biotechnology course being taught to the biology education students who are training to teach biology in secondary schools in Zambia. This analysis will inform the content to be transmitted (instructional discourse) and how the content is to be transmitted (regulative discourse).

4. Research question

The research question which guided the study was:
How is knowledge recontextualised in a plant biotechnology course?

5. Literature review

The concepts in this study are pedagogic device, pedagogic discourse, recontextualisation, classification and framing, vertical and horizontal knowledge structure of Bernstein.

The pedagogic device is a theory by which knowledge is produced and converted for pedagogic communication. It has three fields which are the production field, recontextualisation field and the reproduction field. Knowledge production takes place in the production field. The produced knowledge is them selected, delocated, that is taking a discourse from its original site and moving it to a new different site (a pedagogic site) in which a gap is created and this lead to the transformation of knowledge. The knowledge is transformed through the recontextualisation process.

The Pedagogic discourse embeds two discourses which are the: Instruction Discourse (ID) and the Regulative Discourse (RD). Bernstein's work enables one to track the knowledge from the disciplinary field to the curriculum and the pedagogic practices.

At the Copperbelt University, the biotechnology knowledge which gets recontextualised into the biology curriculum is produced in the production field. The curriculum developers who are the lecturers in the Department of Biological Sciences select and relocate the biotechnology knowledge into a new context which is the plant biotechnology course in this case. The development of the plant biotechnology course takes place in the Pedagogic Recontextualisation Field (PRF).

The developed course is implemented both in the Department of the Biological Sciences and in the Department of the Mathematics and Science Education. The curriculum implementation takes place in the reproduction field. At the Copperbelt University, the pedagogic recontextualisation takes place in the Department of Biological Sciences and in the Department of Mathematics and Science Education. In the Department of Biological Sciences, the BT 440 was developed and taught, and in the Department of Mathematics and Science Education the BT 440 course was taught to prepare the biology education students to teach the 5090 biology syllabus.

The 5090 biology syllabus is an official text produced by the Curriculum Development Centre (CDC). A number of agents were involved in the production of the 5090 biology syllabus. The productions of the 5090 biology syllabus involve the recontextualising processes. The production of the 5090 biology syllabus takes place in the Official Recontextualisation Field (ORF). Figure 1 show the conceptual framework which guided the study.

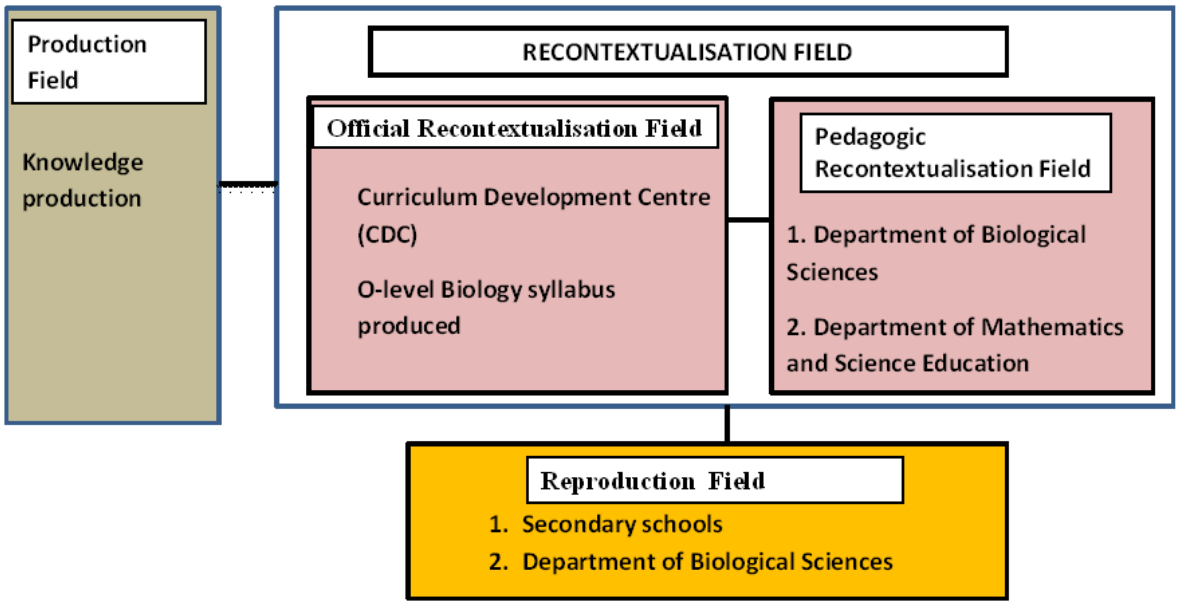

Figure 1: Conceptual Framework for the study

As shown in Figure 1, in this study, I mainly, drew on the pedagogic recontextualisation field which is concerned with the plant biotechnology course produced in the Department of Biological Sciences.

Recontextualisation is a process which involves the selection, sequencing, pacing and evaluation of the knowledge/discourse to produce a new discourse now called a pedagogic discourse. The production and the implementation of the pedagogic discourse involve a number of agents and agencies working at the different levels of the education system. Bernstein has called these levels as the fields of the pedagogic device which are: production field, recontextualisation field and the reproduction field. In each of the fields, there are agents working in the production, recontextualisation and reproduction of the knowledge. When Knowledge is produced in the production field, the knowledge produced is recontextualised in the recontextualisation field to become school knowledge. The three fields of the pedagogic device are hierarchically related in that recontextualisation can only take place if there has been knowledge production, and reproduction can only take place if there has been the production.

Each of the field has a number of agents working to produce the desired knowledge. Agents working in the production field are the intellectuals in universities and in research centres. It is from the field of the production that knowledge is selected to be recontextualised in the recontextualisation field (Hoadley, 2006; Luckett, 2009). In the context of this research this would mean that the production fields include the departments in the university in which knowledge is produced such as the Department of Biological Sciences (DoBS), Department of Chemistry (DoC) and the Department of Physics (DoP) and the other departments from which knowledge is selected to make a biotechnology course such as the plant biotechnology at Copperbelt University and the University of Zambia. Knowledge is also produced at the research centres such as the National Institute of Scientific Research (NISIR) and mount makulu research centre as some of the sites from which biotechnological knowledge is produced in Zambia. The knowledge produced in the production field is self-explanatory and gets transformed as it gets recontextualised. The agents involved in the production of knowledge do not have time or resources to convert or translate the new knowledge into a form accessible to the non-specialists. Hence the translation of the produced knowledge into a form accessible by non-specialists is done in the recontextualisation field of the pedagogic device. It is in the recontextualisation field that this study is positioned.

The recontextualisation field is mainly concerned with the production of the pedagogic discourse. It is the recontextualisation field which link the field of research (production field) to the field of practice (reproduction field). Hence an understanding of the recontextualisation will inform how the field of research relates with the field of practice (Luckett, 2009). The agents in the recontextualisation field are able to pedagogies the knowledge

produced in the production field (Singh, 2002). Recontextualisation rules play a major role in having the specialist knowledge accessible to the learners.

The selection of the knowledge from the production field is guided by the rules of recontextualisation. It is through the recontextualisation rules that a discourse is moved from its production context/site to another context. When the discourse has been moved from the original context to new different sites where it gets recontextuslised it will no longer resemble the original discourse because it has been converted or pedagogised into a pedagogic discourse/pedagogic communication (Diehl, Lindgren, & Leffler, 2015; Wheelahan, 2005; Wheeler, 2009). This clearly tells that as knowledge is recontextualised, it is transformed and no longer looks like the original knowledge.

Recontextualisation (the making of school knowledge, for example, the curriculum knowledge) is a key element of Bernstein's theory of pedagogic device (Weelie & Boersma, 2017; Hewllet, 2013; Wierdsma, 2012). Recontextualisation produces power relations in the process of selecting, de-locating and re-locating a discourse. It is through recontextualisation that a discourse or part of a discourse is selected, de-located and re-located in a new different context with other discourses. Therefore, recontextualisation refers to how knowledge produced at one site is recontextualised by curriculum designers at an educational institution such as Copperbelt University and reproduced by teachers/ trainers when they interact with learners. During this process of recontexualisation, knowledge is transformed (Bertram, 2008; Bibila, 2016; Reeves, 2006). Recontextualisation is more concerned with the transformation of knowledge when it is moved from one context to a new different context.

The way knowledge has been recontextualised, determine the recognition and realisation rules of the school knowledge/formal knowledge as a vertical discourse (Singh, 2002; Singh, Thomas, & Harris, 2013). It is important that educators understand how the curriculum knowledge is sequenced and organized which could be achieved by analyzing the pedagogic discourse. Analysis of the curriculum, in this case a course will inform the pedagogic practices and the content to be transmitted and acquired. The focus of this study is to understand the pedagogic practices and the content of the biotechnology course.

A number of scholars such as Morais, Neves and Afonso, (2005), Ensor, (2004), Morais, (2002); Jónsdóttir and Macdonald (2008) and Bertram, (2012), have used Bernstein's classification and framing concepts to characterise the pedagogic discourse and to show the variations in the pedagogic discourses.

Morais and Mirrinda (1996) wanted to understand the framing of the evaluation criteria as a condition for success in science classes. Studies have indicated that one of the ways in which students could be helped to succeed in learning the sciences is to explicate the evaluation criteria. The evaluation criteria is one of the characteristics of the instructional discourse (ID) embedded in the regulative discourse (RD) which always dominates over the instructional discourse. In most cases, the regulative discourse is not explicated. The regulative discourse is always transmitted through the instructional discourse. The data in this study was collected through the questionnaire, interviews and marked answer scripts of the learners.

The findings indicated a weak framing in the evaluation criteria (instructional discourse) and a strong framing in the hierarchical rules (regulative discourse). This finding does not support the acquisition of the text in the teaching and learning. For successful teaching and learning the evaluation criteria need to be explicated. The evaluation criteria were also focused on in a study carried out by Morais, Neves and Afonso (2005).

In their study, Morais, et al., (2005), they were focused on understanding teacher training processes and teacher's competencies in primary schools. The study was aimed at understanding how teachers were trained to effectively teach sciences in primary schools. The training was focused on explicating the evaluation criteria in the training of the teachers. The study used an action research methodology. The data was collected using the interview method, and observation method. The findings indicated that the teachers were effectively prepared to teach sciences in primary schools as they gained both the realisation and the recognition rules. Therefor explicating the evaluation criteria is a necessary condition in both teacher training programmes and in the teaching and learning context. Therefore, it is important that educators are aware of the characteristics of the pedagogic discourse being

implemented and be aware of the characteristics of the pedagogic practices which support the learning of all the learners. An example is the study carried out by Morais, (2002).

In the case of Moaris (2002), he wanted to understand the characteristics of pedagogic practices which support the acquisition of scientific knowledge by all the learners. Document analysis and observation method were used to collect the data. The findings indicated that for successful learning, the pedagogic discourse must be characterised by a weak framing in the pacing and hierarchical rules and the framing has to be strong in the selection, sequencing and in the evaluation criteria of the knowledge. The classification between discourses (inter-disciplinary, intra-disciplinary and inter-discursive relations) and between spaces has to be weak. Morais (2002) also notes that, though a weak pacing is a necessary condition for successful learning, governments have not easily accepted this due to a high cost which would be experienced if the teaching and learning time is increased. He therefore advised that, if the cost of the education is to be reduced, there is a need to weaken the classification between discourses and between spaces as these are some of the ways of explicating the evaluation criteria. He further notes that, the evaluation criteria can also be explicated through correcting the answers of the learners.

A similar study was carried out by Jónsdóttir and Macdonald (2008) to understand the instructional discourse and the regulative discourse in the teaching and learning of innovative education in Iceland. The study was carried out at Ingunnarskali school in Iceland. The study involved four teachers who were teaching innovative education at the time of the study. The data was collected using field observation and interviews. The findings indicated that the framing and the classification were a mixed of weak and strong framing (F+-) and weak and strong classification (C+-) in the teaching and learning of innovative education. Such a study helped to understand the characteristics of the pedagogic discourse being implemented.

Classification and framing have also been used by Ensor (2004) to characterize the pedagogic discourse being transmitted in a mathematics teacher training programme to effectively prepare the students for their profession as teachers. The data was collected through the interview method, document analysis and observation method. The analysis of the mathematics course revealed that the hierarchical rules, pacing, and sequencing were weakly framed and that the framing was strong in the evaluation criteria and in the selection of knowledge.

Ensor (2004) concluded that when the framing is weak in the selection and in the evaluation criteria, the realization and recognition of the text are going to be weak. For the recognition and realization to be strong, the framing of the evaluation criteria, selection and sequencing needs to be strong.

Therefore, this study aims to understand the strength of the realisation and the recognition rules indicated in the plant biotechnology course.

6. Methodology

A qualitative approach was used in this study. Document analysis was used as a method to collect the data. Ethical clearance was not necessary since the study did not involves human beings. Permission to analyze the document was got through the head of the Department of Biological Sciences. This course was analyzed because it is one of the courses taken by the biology education students in the Department of Biological Sciences. Indicators were first developed to guide the analysis. See Appendix 1. The document was inductively coded using Atlas ti 8.

The BT 440 document was analysed to characterise the pedagogic practices indicated in the document. As earlier indicated, the pedagogic practice embeds the instructional and the regulative discourse. Classification and framing concepts of Basil Bernstein have been used to characterise the pedagogic practices indicated in the BT 440 course. The instructional discourse was analysed in terms of the control relations between agents which are the discursive rules (selection, sequencing, pacing and evaluation criteria) and in terms of the relation between discourses (inter-disciplinary, intra-disciplinary and inter-discourse). Framing was analysed in terms of the extent to which the transmitter, in this case the lecturer and the learner had the control in the teaching and learning process in the document. The analysis was focused on understanding the degree of control given to the lecturer and the learner in terms of what should be learnt, how it should be learnt, how long it should be learnt and how it should be

assessed. The relations between discourses were analysed in terms of the strength of insulation between the discourses. Classification was used to analyse the relations between the discourses. Classification analysis helped to determine the integration of knowledge between discourses. That is between the topics, between disciplines and between everyday knowledge and school knowledge.

A sentence was analysed for the extent to which the teacher or the learner had the control in the teaching and learning process.

The codes, categories and the theme which emerged from the analysis of the BT 440 are shown in Table 1. The categories which emerged from the analysis of the codes are: BT 440 content, evaluation criteria, pacing of knowledge, reading materials and relations between discourses.

7. Findings

Table 1 has presented the findings of the analysis of the plant biotechnology course

Table 1: Codes, Categories and theme on the analysis of the Plant biotechnology course

CODES	CATEGORIES	THEME
○ Analysis of plastid genomes		INSTRUCTIONAL DISCOURSE
○ Biodiversity and conservation.		
○ Bioinformatics		
○ Bioinformatics:		
○ Biosafety		
○ Cloning		
○ Crop improvement		
○ DNA extraction methods;		
○ Final examination 60%		
○ Gene silencing and micro RNAs;		
○ Generation of mutants;		
○ Intellectual property rights;		
○ Legal aspects of GMOs;		
○ Molecular biology software		
○ monitoring systems for GMOs;		
○ Mutant screening;		
○ Patenting of biological material		
○ Physiology and pathology		
○ Plant culture		
○ Plant data bases		
○ Plant molecular biology:		
○ Plant viral vectors.		
○ Production of therapeutics in plants; reporter genes; g		
○ Proteins systems		
○ Public perception of plant biotechnology,		
○ Reporter genes		
○ RNA extraction methods;		

○ Swiss-prot; clustal Programs.		
○ Test 20%	EVALUATION CRITERIA	
○ Assignments 5%		
○ Lab course 15%		
○ Lab work time	PACING	
○ Lecture time		
○ Journals	READING MATERIAL	
○ Text books		
○ Characteristics of plant biotechnology	RELATIONS BETWEEN DISCOURSES	
○ Interactions between disciplines		

7.1. Evaluation criteria

In terms of the evaluation criteria, the BT 440 course is explicit in the assessments to be done as indicated in the course. The continuous assessments weigh 40% to the final examination grade. Continuous assessment was based on Lab course 15%, Tests 20% and Assignments 5%, the sessional examination weighted 60%. In addition the BT 440 course has indicated the course objectives to be achieved in the teaching and learning. An explicit indication of the assessments to be done and the course objectives to be achieved indicate a strong framing (F+) in the evaluation criteria.

7.2. Reading materials

The reading materials are the materials to be used by the lecturers and the learners in the teaching and learning of the course.

Analysis of the BT 440 documents revealed that, journals and text books were used as the sources of information in the teaching and learning process. The analysis revealed that text books and journals were indicated as some of the materials to be used in the teaching and learning of the course. The specific text books indicated in the BT 440 course are:

> Slater, A., Scott, N.W., & Fowler, M.R. (2008). *Plant Biotechnology: the genetic manipulation of plants*. Oxford University Press
> Halford, N.G. (2006). *Plant Biotechnology: current and future applications of genetically modified crop Wiley*.

The journals indicated in the BT 440 course are:

> Plant Biotechnology Journal: aims at publishing original research and reviews in the fields of applied plant science with an emphasis on molecular plant sciences and their application through plant biotechnology, published by Wiley- Blackwell.
> Plant Biotechnology Reports: Peer-reviewed journal covering aspects of plant biochemistry, biotechnology and plant science; published by Springer.

7.3. Pacing of knowledge

Analysis of the BT 440 course document revealed that, the course has indicated the number of lectures to be done in a week as the course indicate that, ‘’Time allocation: 4 hours of lectures per week; 1-week lab course at the end of each term.’’ There was no indication of how long should be taken to teach a topic and how long should be taken to teach all the topics in the course. Therefore, framing of the pacing is not indicated (F0).

7.4. Relations between discourses

The relations between discourses or the integration of knowledge in the BT 440 course was analysed using the classification concept of Bernstein. An external language of description was developed to help to read the data. Indicators were developed to guide the coding of the document.

Analysis of the relations in the discourses found that, discourses are related in terms of the Inter-disciplinary relation (relations between the disciplines), Intra-disciplinary relation (relation between the topics) and Inter-discursive relation (the relationship between school knowledge and everyday knowledge). Hence classification was weak (C-) in inter-disciplinary relations, intra-disciplinary relations and in the inter-discursive relations.

In terms of knowledge selection and sequencing of the knowledge, the course clearly indicated the knowledge to be taught, but does not indicate the order in which the topics are to be taught. This is an indication of strong framing (F+) in terms of knowledge selection.

7.5. Instructional discourse as the main theme

The instructional discourse emerged as the main theme in the analysis of the BT 440 document. The categories which are included in the theme are: BT 440, evaluation criteria, pacing of knowledge and relations between discourses. There was no indication of the regulative discourse in the analysis of the BT 440 course.

7.6. Summary on the analysis of BT 440 course

In summary, the findings on the analysis of the BT 440 course document has shown that, framing was strong (F+) in the selection of knowledge and in the evaluation criteria of the knowledge. There was no indication of the sequence, pacing and the hierarchical rules in the document and no sentence or statement was coded for the hierarchical rules. The classification was weak (C-) in the inter-disciplinary relation, intra-discipline relation, inter-discursive relation. The document also indicated that journals and text books were the sources of knowledge which were indicated as sources of knowledge in the teaching and learning of the course.

8. Discussion

The findings were discussed in relation to teacher training. For the prospective biology student teachers to be effectively prepared to teach secondary school biology in Zambia, a number of studies (Ensor, 2015; Larsen, 2013; Bertram, 2008; Hoadley, 2005b; Morais et al., 1992; Morais et al., 2005) have indicated that, they must experience a pedagogic practice with a weak framing in the pacing and hierarchical rules. The weak framing in the pacing and in the hierarchical rules should be accompanied by a strong framing in the selection, sequencing and evaluation criteria of the knowledge and that the classification between the discourses (inter-disciplinary, intra-disciplinary and inter-discursive) must be weak.

The analysis of the BT 440 course indicated a strong framing in the and in the evaluation criteria. Though there was no explicit indication of the sequencing, pacing, and the hierarchical rules in the document, it is most likely that the sequencing and pacing is likely to be done by the lecturers who are knowledgeable of the content to be taught and therefore have an understanding of what was to be taught and how it is to be taught. Bernstein himself indicated that the regulative discourse dominates over the hierarchical rules, therefore the hierarchical rules though not explicitly indicated in the document, they are strongly framed since they dominate over the instructional discourse.

The focus on the instructional discourse in the BT 440 indicates that the course is more focused on teaching the content to the prospective biology teachers. The goal of teaching biotechnology to the prospective teachers was to provide students with the relevant knowledge required by the prospective biology teachers. If the students are to be prepared for their teaching profession, they need to acquire a vertical discourse which is context independent (Millar, 2014; Player-Koro, 2011).

The classification is weak in the inter-disciplinary relationships, intra-disciplinary relationship is strong, indicating that there is a strong relationship between the topics, hence the topics are weakly classified (C-), inter-discursive relationship is weak, indicating that, there is a relationship. A classification is one way in which the pacing is weakened, hence a condition for successful learning of all the learners. There is also a need for explicating the evaluation criteria for successful learning (Ensor, 2004).

From the discussion, a strong framing in the hierarchical rule and in the pacing is likely going to lead to the students to acquire a weak recognition and realization rules in the teaching and learning. This will lead to students not being effectively prepared to teach biology to all the learners in secondary schools. Therefore, a need that the BT 440 course is revised so that it will be framed and classified in line with the conditions which enable a successful training of the biology education students.

8.1. Summary and conclusion

The analysis revealed that, framing was strong (F+) in the selection, sequencing, hierarchical rule and in the evaluation criteria. The framing was weak (F-) in the pacing of the knowledge. In the relations between the discourses, the classifications were weak (C-) in the inter-disciplinary, intra-disciplinary and in the inter-discursive relations. The review of the related literature showed that, if teachers are to be prepared to teach all the learners regardless of the children coming from the different social class families, there is a need for a pedagogic practice which is strongly framed in the selection, sequencing and evaluation criteria and that the framing should be weak in the pacing and in the hierarchical rule and that there is need for a weak classification (C-) between the discourses .

Hence the practices indicated in the BT 440 has shown that while the selection, sequencing, evaluation criteria have the required framing to learn the content and be able to teach all the learners, a weak framing in the hierarchical rule and pacing is required if the teachers are to be successfully trained to teach biology to all the learners in secondary schools in Zambia. This is not the case in the BT 440 course. Studies have further indicated that, a weak framing (F-) in the hierarchical rule could be attained by using the teaching and learning approaches in which the learners are active.

Hence for the prospective teachers to be successfully trained to teach biology to all the learners in secondary schools, the framing should be strong in the selection, sequencing, and evaluation criteria and should be weak in the hierarchical rule and in the pacing.

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Appendix 1: Indicators for analysing the Plant biotechnology course

Grading scales used to analyse the Plant biotechnology course (BT 440) The document was analysed for the discursive rules (Selection, sequencing, pacing and criteria) and for the discursive relations (Inter-disciplinary, intra-disciplinary and inter-discursive).
Indicators for the discursive rules and discursive relations were developed to guide the analysis of the document. The indicators developed to guide the analysis are shown in the tables.

Discursive rule SELECTION

To what extent does the teacher and the learner have control in the selection of instructional knowledge? The extent to which the teacher and the learner have the control in the selection of knowledge was determined by the extent to which a sentence or a statement indicated the content or the knowledge to be taught.

F++	F+	F-	F--
Teachers have the control in the selection of the knowledge taught, learners don't decided on what to learn.	**Teachers have the control in the selection of the knowledge taught, though in some instances, learners decide on the knowledge to learn.**	**Learners have control in the selection of the knowledge taught, though in some instances, teachers decide on the knowledge taught and learnt.**	**Learners have more control in the selection of the knowledge taught. Teachers don't decide on the knowledge to be taught.**
The sentence/statement clearly indicate the knowledge to be taught and learnt	The sentence/statement indicate the knowledge to be taught, but leaves room for learners to make additions	The sentence/statement make suggestions of the knowledge to be taught,	The sentence/statement does not indicate the knowledge to be taught

Discursive rule SEQUENCING

To what extent does the teacher and the learner have control in the sequencing of the instructional knowledge? The extent to which the teacher and the learner have the control in the sequencing of the knowledge was determined by the extent to which a sentence or a statement indicated the sequence in which the topics were to be taught.

F++	F+	F-	F--
Teachers have the control in the sequencing of the knowledge.	**Teachers have the control in the sequencing of the topics, thought learners sometimes also control the sequencing of the knowledge.**	**Learners have control in the sequencing of the knowledge though the teachers sometimes control the sequencing of the knowledge/topics**	**Learners have more control in the sequencing of the knowledge/topics.**
The sentence/statement clearly indicate the sequence in which the topics are to be taught	The sentence/statement suggests the sequence in which the topics are to be taught, but leaves room for learners to make additions	The sentence/statement does not indicate the sequence in which the topics are to be taught, but gives a suggestion.	The sentence/statement does not indicate the sequence in which the topics are to be taught.

Discursive rule PACING

To what extent does the teacher and the learner have control in the pacing of the learning? The extent to which the teacher and the learner have the control in the pacing of the learning was determined by the extent to which a sentence or a statement indicated the time required to teach and learn the topic.

F++	F+	F-	F--
Teachers have the control in the pacing of the learning.	**Teachers have the control in the pacing of the learning, thought learners sometimes also controlled the pace at which the knowledge was taught.**	**Learners have the control in the pacing of the learning, thought teachers sometimes also controlled the pace at which the knowledge was taught.**	**Learners have the control in the pacing of the learning.**
The sentence/statement clearly indicate the time at which the topics are to be taught	The sentence/statement suggests the time at which the topics are to be taught, but leaves room for learners to decide on the time required for learning	The sentence/statement suggests the time at which a topic has to be taught.	The sentence/statement does not indicate the time required for teaching and learning.

Discursive rule EVALUATION CRITERIA

To what extent does the document explicate the criteria? The extent to which the document explicate the criteria is determined by the extent to which a sentence or a statement explicitly indicate the concepts to be learnt and assessed.

F++	F+	F-	F--
Evaluative criteria very clear and explicit	**Evaluative criteria clear and explicit**	**Evaluative criteria mostly not explicit**	**Evaluative criteria not explicit**
The sentence/statement clearly indicates the evaluative rules by clearly indicating the concepts to be taught and learnt.	The sentence/statement indicates the evaluative rules by clearly indicating the concepts to be taught and learnt.	The sentence/statement mostly does not indicate the evaluative rules. The concepts to be learnt are suggested.	The sentence/statement does not indicate the evaluative rules. The concepts to be learnt are not indicated in the sentence.

Discursive relations
Inter-discipline relations (Between disciplines)

The extent to which a sentence/statement indicates an integration of knowledge from other disciplines

C++	C+	C-	C--
No indication of the knowledge from other disciplines	**Very little indication of the knowledge from other disciplines**	**little indication of the knowledge from other disciplines**	**A very clear indication of the knowledge from other disciplines**
There is no indication of the knowledge from other disciplines in the sentence/statement	There is little indication of the knowledge from other disciplines in the sentence/statement	There is clear indication of the knowledge from other disciplines in the sentence/statement	There is a very clear indication of the knowledge from other disciplines in the sentence/statement

Inter-discursive relations (Between school knowledge and everyday knowledge)
The extent to which a sentence/statement indicates everyday knowledge

C++	C+	C-	C--
No indication of everyday knowledge in a sentence/statement	**Very little indication of everyday knowledge in a sentence/statement**	**little indication of everyday knowledge in a sentence/statement**	**Very clear indication of everyday knowledge in a sentence/statement**
There is no indication of everyday knowledge in the sentence/statement	There is little indication of everyday knowledge in the sentence/statement	There is clear indication of everyday knowledge in the sentence/statement	There is a very clear indication of everyday knowledge in the sentence/statement

Intra-disciplinary relations (Between the topics)
The extent to which a topic/sentence/statement indicate a relation in knowledge between the topics

C++	C+	C-	C--
No relationship indicated	**Very weak relationship indicated**	**Weak relationship indicated**	**Very strong relationship indicated**
There is no indication of a relationship in knowledge in the topics in a sentence/statement	There is a very weak indication of a relationship in knowledge in the topics in a sentence/statement	There is a weak indication of a relationship in knowledge in the topics in a sentence/statement	There is a very strong indication of a relationship in knowledge in the topics in a sentence/statement