

EXAMINING QUESTIONING AND DISCOURSE PATTERNS IN STEM CLASSROOMS DURING TEACHER PREPARATION PROGRAMME: A GROUNDED THEORY APPROACH

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ABSTRACT

The study examined pre-service teachers' questioning and discourse patterns in STEM classrooms and how their perceived agency influence their classroom instruction. A grounded theory approach was employed as the research design. Participants involved 30 pre-service teachers from Sokoto State University who enrolled in teacher training programme in the 2019/2020 academic session. In consistent with grounded theory, participants were selected using purposive and theoretical sampling techniques. Data sources include 40 video-taped classroom sessions, field notes, lesson plans and interview protocol. Four research questions guided the study, resulting to four theoretical propositions: (1) two interrelated interaction patterns (IRF_E and IRF_D) characterized STEM classrooms, and these patterns were determined by specific activities involved in the classroom; (2) few elicitation techniques were utilized by pre-service teachers; the prevalence of these techniques depends on students' level and objectives to be achieved; (3) pre-service teachers are more selective in the use feedback strategies to drive STEM classroom, depending on classroom culture; (4) pre-service teachers are more concerned with classroom management and behavior control than teaching method; they also display more personal qualities than teaching skills; and their classroom culture is more of teacher-directed and discipline-defined. The study recommends among other things the need to engage pre-service teachers in intensive micro teaching programme before they are sent to schools.

Keywords: *Classroom Discourse; Questioning; Patterns; Pre-service Teachers; STEM*

INTRODUCTION

Nigeria's hope to achieve sustainable development goals (SDGs) largely depends on her education sector. However, the recent population growth in the country has placed new demands on the already challenged education system, resulting to poor access to education by millions of Nigerian children (The Business Year, 2018). Despite this, Nigeria has witnessed slight increase in enrollment, and baseline statistics such as adult literacy rates (age 15 and above) have increased from 51.1% in 2008 to 62% in 2018 (UNESCO, 2020). In effort to improve quality education, policies have been made to install rigorous curriculum to increase knowledge transfer. To achieve this, the potentials of STEM education have been acknowledged as many international investors have been invited to initiate a number of collaborative programs aimed at revitalizing STEM learning opportunities (The Business Year, 2018). These opportunities came into reality when the U.S in 2017 declared her intention to create an education academy that will serve as robotics-training institute for students as well as general STEM education center for teachers (CcHUB, 2019). The Chinese government also announced her plan to establish a chemical technology University in the country and also plan to widen her exchange programs with Nigerian public Universities to help meet the growing demand of STEM education in Nigeria (DailyTrust, 2016).

In addition to these international efforts, the Nigerian government in attempt to expand STEM opportunities has also increased budgetary allocation to education from N398bn in 2017, N605.8bn in 2018 to N620.5bn in 2019. This increase in budgetary allocations is still below UNESCO standard (Punch, 2019). From these budgets, STEM activities across the country have received a massive boost, including improved scientific workforce, procurement of STEM facilities, and scholarship grants to STEM research. Despite huge funding by governments and international partners to improve STEM education in many countries, there is still paucity of research examining school STEM practices, differentiating features, and their effectiveness (Tofel-Grehl & Callahan, 2016). However, studies have been conducted to explore classroom discourse in anticipation of revealing STEM implementation practices among teachers (Chin, 2007; Erdogan & Campbell, 2008; Reinsvold & Cochran, 2012; Maftoon & Rezaie, 2013; Kaya, Kablan & Rice, 2014; Tofel-Grehl & Callahn, 2016). These anticipations were drawn from the

benefits of classroom discourse, particularly those that deal with teacher and student questions.

Classroom discourse is defined as mechanism of teacher-student interaction in classrooms (Nystrand, Wu, Gamoran, Zeiser & Long, 2003). It is the re-construction of language beyond individual's sentence level and speaking turn, where meaning is constructed in the process of interaction (Carter & Nunan, 2001: p.201). According to Jocuns (2013), it refers to "all forms of talk that one may find within a classroom or other educational setting" (p. 1). History of classroom discourse research can be categorized in two research domains. The first domain examined communicativeness of the classroom in comparison to the real world (Nunan, 1987). The second domain focused on classroom as a variety of institutional discourse (Seedhouse, 1996). These domains of studies focused on the extent to which classroom discourse shared features with real-world communication, and revealed that classroom and real-world communications follow different communication patterns when measured in terms of authenticity. These studies further held that teacher communication time prevent learners the opportunities of making genuine communication (Cullen, 1998).

Despite the comprehensiveness of these domains of studies, Cullen (1998) criticized their notion as been simplistic, and that it ignored the social and independent nature of classroom discourse. Additionally, Walsh (2002) argued that classroom discourse is legitimate, authentic and real, and it is constructed by teachers and learners. From sociocultural perspectives, classroom discourse is a kind of classroom interaction in which learning goals are not separate from conversational interactions (Markee & Kasper, 2004; Walsh, 2002). The learner and the teacher construct meaning in a scaffolded environment, with the teacher guiding the discourse to support student learning (Vygotsky, 1986). Classroom discourse falls under two major categories: authoritative and dialogic. The authoritative discourse refers to a relational power structure where one participant retains overall power over the exchange, and the power is based on position within the social structure alongside the knowledge differences between the participants (Tofel-Grehl & Callahan, 2016). In this category, the teacher dominates the authoritative role, and the centrality and authority of the teacher drive classroom discussion (Scott, Mortimer & Aguiar, 2006). Dialogic discourse on the other hand refers to

a classroom setting where opportunities are provided to explore differing perspectives (Tofel-Grehl & Callahan, 2016).

In dialogic interaction, participants engage in the process of initiating their own explanation and meaning, with no single authority over others (Scott, Mortimer & Aguiar, 2006). Within this classroom setting, the teacher often plays the role of a moderator and facilitator, rather than a knowledge giver (Driver, Newton & Osborne, 2000). The types of questions framed by the teachers and students facilitate classroom interaction (Erduran & Osborne, 2005). These interactions serve as essential tools for evaluating emerging learners' understandings and their attainment of overall learning objectives (Cazden, 2001; Chin, 2007; Tofel-Grehl & Callahan, 2016). Low prevalence of dialogic discourse has been observed in different classroom setting, with research evidence indicating that only 14% of all classroom lessons entailed rigorous intellectual discussion (Banilower, Smith, Weiss & Pasley, 2006; Scott et al., 2006; Tofel-Grehl & Callahan, 2016). Within the authoritative and dialogic classroom settings, different sub-categories have been identified, with three major sub-categories emphasized by a number of studies to include: *interaction pattern, elicitation technique, and feedback strategies* (Mehan, 1979; Chaudron, 1988; Cullen, 1998; Ellis, 1994; Walsh, 2006). The basic assumption of these sub-categories lies in the notion that analyzing classroom discourse is essential to facilitating learning and communicative interaction (Maftoon & Rezaie, 2013; Kaya et al., 2014).

Interaction Pattern

As noted by Cullen (2002), the underlying feature of classroom discourse is measured in terms of *interaction pattern* which consists of three moves: *initiation, response, and follow-up* (IRF). Studies have indicated that the IRF pattern could take different formats; the pattern may be used to initiate sequences, facilitate varieties of perspectives, or stimulate learners' abilities (Molinari, Mameli & Gnisci, 2012; Maftoon & Rezaie, 2013). The first move, *initiation*, is facilitated by the teacher mostly through a question (Behnam & Pouriran, 2009). Teacher questioning formats are framed up in different ways as 'closed-ended', 'open-ended' and 'task-oriented' (Erdogan & Campbell, 2008; Reinsvold & Cochran, 2012), and these formats influence how students construct meaning during classroom interaction (Chin, 2007). Open-ended questions are used in the classroom to provide opportunities for students to construct scientific knowledge, and they serve as avenue to maintain students' interest and

engagement (Erdogan & Campbell, 2008; Nystrand & Gamoran, 1991). Closed-ended questions, which are commonly used by teachers (Maftoon & Rezaie, 2013), help in recalling basic facts but they limit students' learning (Nassaji & Wells, 2000). The second move, *response*, is extended to encourage the construction of meaning and understanding within authoritative or dialogic classroom (Myhill, 2006). Studies have indicated a more complex IRFRF chain, where elaborative feedback is followed by further response repeatedly until meaningful learning occur (Scott et al., 2006). Sometimes a more extended pattern of IR₁R₂R_nF occurs during teacher questioning where multiple students are involved in the response move (Mayer & Patricia, 2007). These interactive approaches help the teacher to explore students' ideas and allow the students to construct meaning (Scott et al., 2006).

The third move in the IRF pattern is the *feedback* move. This move is used to provide follow-up where the teacher accepts or reject a response, or provides elaborate discourse to justify a response (Kaya & Ceviz, 2017). As argued by Cullen (2002), the F-move has two functions: evaluative and discursal. It plays the evaluative role when the feedback focused on whether a response is correct or not. The discursal function occurs when learners' contribution is incorporated into the flow of classroom discourse. This role is seen as a form of scaffolding where students' responses are reformulated, extended, and integrated into the final discourse (Tofel-Grehl & Callahan, 2016). The IRF interaction pattern has been widely criticized despite its prevalence in the classroom, with previous research evidence suggesting that they are non-communicative and failed to provide opportunities for students to ask questions, construct meaning and engage in the learning process (Nunan, 1987; Wolf, Crosson & Resnick, 2005). However, Seedhouse (1996) argued that IRF cycle is quite common in parent-child interaction and that "critics of the IRF cycle have failed to notice the significant role it plays in language learning" (p. 20).

Elicitation Technique

Studies have shown that teacher questions are the most frequent activity in classroom discourse, often employed to elicit response (Cullen, 1998; Ellis, 1994; Walsh, 2006; Yu, 2010). Elicitation of response through questioning takes different techniques, including factual, reasoning, open, and social questions (Cullen, 1998). These techniques were later modified by Long and Sato (1983) to include two major techniques:

echoic and epistemic (see table 1). Echoic questions focus on repetition of utterances or confirmation of facts, while epistemic questions focus on acquisition of information (Maftoon & Rezaie, 2013). Studies have indicated that *epistemic* techniques are frequently used in classroom discourse compared to echoic, with *display questions* the predominant sub-category (Nunan, 1987; Chaudron, 1988; Cullen, 1998; Walsh, 2006; Yu, 2010; Maftoon & Rezaie, 2013).

Table 1: Taxonomy of Teachers' Questions

Type	Sub-category	Example
Echoic	Comprehension checks	All right? OK? Does everyone understand 'polite'?
	Clarification requests	What do you mean?; I don't understand; What?
	Confirmation checks	S: carefully T: carefully?; Did you say 'he'?
Epistemic	Display	What's the opposite of 'up' in English? Will you come to school tomorrow?
	Referential	Why didn't you do your homework? How did you spend your holiday? How did you arrive at that?
	Expressive	It's interesting the different pronunciations we have now, but isn't it?
	Rhetorical	Why did I do that? Because..... And by doing this, I mean.....

Ellis (1994: p. 588; cited in Maftoon & Rezaie, 2013: p. 113)

Feedback Strategies

Feedback is one of the essential features of classroom discourse, although there are conflicting views on its roles among researchers (Maftoon & Rezaie, 2013). For example, earlier study by Truscott (1996) indicates that corrective feedback is counterproductive and harmful to meaningful learning and therefore should be avoided. On the contrary, Seedhouse (1996) argued that learners expect correction from their teachers as a

form of feedback, and therefore employment of different feedback strategies to meet their needs is welcomed. However, Walsh (2002) warns that persistent correction may result to learners' inability to express their ideas, and therefore emphasized the need for simultaneous reflection between corrective feedback and teachers' pedagogy goals. Studies have shown that teachers employ a number of feedback strategies in their classroom interaction, although these strategies are not explicitly stated in school curriculum (Lyster & Mori, 2006; Maftoon & Rezaie, 2013). Based on previous studies, Lyster and Mori (2006) classified these strategies into six categories on the basis of their corrective measures as presented in table 2 below.

Table 2: Corrective Feedback Strategies

Sub-category	Description	Example
Explicit correction	The teacher gives the correct answer and explicitly indicates that student's answer was incorrect	T: what is the plural of Sheep? S: Sheeps T: that's wrong, the correct answer is sheep.
Recast	The teacher paraphrases all or part of student's response.	S: a verb is a telling word or a doing word in a sentence T: we can simply say: it is an action word
Elicitation	The teacher allow student to complete teacher's response and sometimes asks students for word translation	T: a verb is..... S:an action word T: Alright, how do you say that in your language?
Meta-linguistic clues	The teacher provides comment in relation to student's response	T: we don't say like that in Japanese
Clarification request	The teacher requests for clarification of student's response especially when the response is ill-formed	Pardon?, what do you mean by that? I don't understand.
Repetition	The teacher repeats the student's ill-formed response, adjusting	T: The moon revolves round the sun ?

intonation to highlight the
error

Lyster and Mori (2006, p. 271; cited in Maftoon & Rezaie, 2013)

From the foregoing literature, it appears that studies examining classroom discourse are overwhelming. However, gaps still exist in the literature. First, pre-service teachers were mostly neglected in many studies concerning classroom discourse. Kaya and Ceviz (2017) emphasized that “examining pre-service teachers’ classroom discourse might help them to develop consciousness about classroom interactions and improve their questioning skills when they start their teaching career” (p. 84). Second, majority of studies on classroom discourse largely rely on observational method and deductive approach to test existing theories (e.g. Hardman, Abd-Kadir & Smith, 2008; Behnam & Pouriran, 2009; Maftoon & Rezaie, 2013; Kaya, Kablan & Rice, 2014; Kaya & Ceviz, 2017). Consequently, there are limited theories developed to explain the current classroom practices of teachers (Ab-Rashid, Yunus, Omar, Halim & Rouyan, 2017).

The problem of limited theories in the field of classroom discourse can be solved using Grounded Theory. The advantage of grounded theory has been explained by many authors, including its ability to provide “relevant predictions, explanations, interpretations and applications” (Glaser & Strauss, 1967: p.1). In view of this, it is anticipated that the use of grounded theory will enrich literature on classroom discourse and also provide insights to students and teachers in understanding trends and patterns of classroom interactions. It is with this premise that the present study examined pre-service teachers’ questioning and discourse patterns in STEM classrooms using a Grounded Theory approach. The study addressed four major research questions:

1. What interaction pattern do pre-service STEM teachers follow during classroom interaction?
2. What forms of elicitation technique are prevalent in pre-service teachers’ STEM classrooms?
3. How do pre-service teachers drive STEM classroom discourse through the feedback strategies they employ?
4. How do pre-service teachers’ perceptions of their own agency influence their classroom discourse and questioning patterns in STEM classrooms?

METHODOLOGY

Participant recruitment

Using a grounded theory, we examined questioning and discourse patterns of pre-service teachers in STEM classrooms and how their perceived agency influence their discourse patterns. Unlike other research designs, grounded theory is an inductive approach that supplies systematic guidelines for collecting, synthesizing, analyzing and conceptualizing qualitative data for the purpose of theory construction (Charmaz, 2006; Creswell, 2014; Corbin & Strauss, 2007). The strengths of grounded theory have been documented in many research studies, including the fact that investigator bias is less likely to affect the findings and that it can produce a detailed, more diverse set of findings than traditional research (Corbin & Strauss, 2007; Milliken, 2010; Creswell, 2014). Participants involved pre-service science education teachers from Sokoto State University who enrolled into compulsory six weeks teacher training programme in 2019/2020 academic session. The participants were selected from 10 secondary schools out of 59 schools the where pre-service teachers were posted. Initially, five participants were selected as cases using purposive sampling, and for every selected case, data was collected and analyzed concurrently to generate categories. Thereafter, theoretical sampling technique was employed to select and analyze more sampled cases iteratively until *theoretical saturation* was reached. Theoretical saturation was achieved when no new data seem to contribute new categories to existing categories that has been developed (Strauss & Corbin, 1990; Charmaz, 2006; Corbin & Strauss, 2007). Overall, a total of 40 cases were collated from 30 participants to achieve theoretical saturation.

Out of the 30 selected pre-service teachers, a smaller sample size of informants was recruited for in-depth interview (IDI), with 3 informants selected in the initial recruitment process using purposive sampling. Data collected from these 3 informants was analyzed concurrently before embarking on theoretical sampling as already discussed above. Overall, 10 interview informants were selected to achieve saturation.

Research Context

The pre-service teacher training programme is a mandatory six weeks programme offered by all education students every academic session. During the programme, students are posted to their schools of choice to teach their respective teaching subjects. In the 2019/2020 programme, a

total of 770 students (science education: 334; Educational foundations: 446) were posted to 59 schools. Subjects taught by science education students include: Basic Science and Technology (BST), Biology, Chemistry, Computer, Mathematics and Physics. Of the 40 collated cases, 6 were from BST classrooms, 5 from Biology; 6 from Chemistry; 6 from Computer; 8 from Mathematics; and 9 from Physics classrooms. Classroom interaction ranges from 40 to 80 minutes, with a total of 1,720 minutes observed.

Data Collection

As noted above, a total of 40 classroom interactions were observed. Each classroom interaction was video-recorded to examine questioning and discourse patterns. Field notes were taken alongside teachers' lesson plans. In order to avoid information bias and anxiety, the teachers were not informed of the researchers' plan to record their classroom interactions. However, their permission was obtained to use the video after classroom activities. In this case, the researchers played the role of non-participant observers who disguised as instructional supervisors and could not participate in the actual teaching activities. In order to examine how the pre-service teachers' perceptions of their own agency influence their discourse patterns, few were asked their willingness to join interview sessions. Upon their agreement, each of the 10 pre-service teachers was engaged in 20 minutes in-depth interview. Four key interview questions were asked to elicit response (see table 3). However, the interview questions were frequently modified depending on the emerged categories during data analysis. This is to say that data collection and analysis were done concurrently to build categories and these categories determined how subsequent interview questions were modified (Corbin & Strauss, 2007). For every interview session, we detached ourselves from personal assumptions and biases to keep already known facts away from the informants. Perceptions of the informants were recorded while facial expressions were noted down at every occurrence.

Table 3: Key Informant Questions with Prompts

Key question stem	Prompts
What actions worked or didn't work for you as a teacher?	[e.g. methodology; discipline strategy; classroom management technique]
What personal qualities/skills enabled you to work successfully with students?	[e.g. self-belief; optimism; self-awareness and insight; openness to new ideas; ability to maintain positive relationship with students; teaching skills]
What belief system do you have that helped you engage with learning and/or behavioral challenges?	[belief that teachers' behavior impact learning; belief that every classroom is made up of students with different innate abilities; belief that one method cannot work for all]
What aspects of your classroom culture helped you in your journey with students?	[Open-sharing; student-directed; teacher-directed; discipline-defined; discovery and inquiry]

Adapted from Schon (2018: p. 9)

Analysis

In consistent with grounded theory, emerging discursive themes were identified from the data (Corbin & Strauss, 2007). Video recordings of classroom interaction, lesson plans, field notes and in-depth interview transcript were used as data sources. To address the first research question, classroom interaction pattern was analyzed holistically within the conceptual framework of IRF_E and IRF_D, with letter E and D denoting Evaluative and Discoursal functions respectively (Cullen, 2002). The second research question focused on the forms of elicitation technique that are prevalent in pre-service teachers' STEM classroom. To address this question, teachers' elicitation techniques were analyzed within the conceptual framework of echoic versus epistemic (Ellis, 1994). To address the third research question, feedback strategies employed by pre-service teachers to drive classroom interaction were thoroughly analyzed on the basis of: explicit correction, recast, elicitation, meta-linguistic clues, clarification request, and repletion. Analysis addressing the fourth

research question employed data collected from in-depth interview to explore how pre-service teachers' perceptions of their own agency influence their classroom discourse patterns. Data sources used to address these research questions were transcribed and analyzed using thematic framework. In consistent with grounded theory, thematic categories were generated using three coding techniques: initial, intermediate and advanced coding.

In initial coding, we inductively generated as many codes as possible from the datasets. Important words or group of words were identified and labeled (Charmaz, 2006). In the intermediate coding, we improved the initial codes to transform basic data into abstract concepts, allowing the theory to emerge from the data. Core categories became evident as they were developed from core concepts (Moghaddam, 2006). Relationships between core categories were identified and the analysis was refined. We closely interacted with the data to reassess conceptual meaning of the core categories (Strauss & Corbin, 1998). In the advanced coding, we integrated the core categories into final theoretical categories. In doing this, we reduced the core categories to more abstract and highly conceptualized terms, with constant comparison of different categories as they emerged (Charmaz, 2006). Memos were developed in connection with the theoretical categories to produce a set of theoretical propositions (Strauss & Corbin, 1998). In order to enhance theoretical sensitivity of the study, we employed our analytic temperament and competency. In analytic temperament, we distanced ourselves from presumptions, tolerate confusion, and facilitate a trust in the power of preconscious processing for conceptual emergence (Glaser, 1992). To maintain analytic competency, we developed theoretical insights and conceptual ideas from various studies (e.g. Engward, 2013; Tofel-Grehl & Callahan, 2016; Vollstedt & Rezat, 2019).

RESULTS AND DISCUSSION

Consistent themes emerged from pre-service teachers' STEM classrooms in accordance with the following discursive areas: interaction patterns used by pre-service teachers; elicitation techniques prevalent in STEM classrooms; pre-service teachers' use of feedback strategies to drive STEM classrooms; and influence of pre-service teachers' perceived agency on classroom discourse. Results were analyzed regarding the broad trends observed in these four discursive areas.

Interaction Patterns used by Teachers

Common classroom interaction patterns were observed across wide range of disciplines. With few exceptions, teachers assumed the role of classroom leaders who initiate and control classroom discourse. While many discourse patterns were noticed, they generally fall under IRF_E and IRF_D patterns, with common difference noticed in their feedback move. In interaction patterns coded as IRF_E, pre-service teachers initiate questions, forcefully persuade students to respond, and evaluate students' response as either "correct" or "wrong". This pattern was dominant across wide range of STEM classrooms, with little exceptions where IRF_D pattern was noticed. In this interaction pattern, little feedback loop was observed, with implicit acceptance of the teachers' evaluative feedback by the students without further question. This means that pre-service teachers highly adopted one evaluative feedback at a time without further clarification (see Table 4). Evaluative feedbacks were in form of rigid, closed-answer patterns using question-answer linguistic format (Lemke, 1990). In this interaction pattern, pre-service teachers spend less time evaluating students' response as multiple responses were not allowed. Students on the other hand were allowed to talk less as one evaluative feedback is ascribed to one response at a time. Rather than participating in multiple responses, many students were observed copying notes from the board or discussing with their colleagues on matters not related to classroom activities. One key advantage of this classroom pattern was that pre-service teachers covered wide range of contents within classroom instructional time as opposed to classrooms coded as IRF_D. However, classroom interactions ended without significant number of students understanding major concepts treated in the class, with research evidence associating this to high authoritative approach of the teacher (Tofel-Grehl & Callahan, 2016).

Table 4: IRF_E Interaction Pattern

Extract 1	Extract 2
T: who can list the types of environmental pollution?	T: How many outermost shell electrons do group two elements have?
S: air, wind, noise, water	S: 3
T: correct	T: No
T: Define environmental Hazard	S: 2
S:a process of causing harm to the environment	T: Correct
T: A process? No!	

Source: Field Data

In interaction patterns coded as IRF_D, pre-service teachers initiate questions as usual, dialogically persuade students to respond, and then follow their response with more discourse moves. This interaction pattern started with thought provoking questions and proceeded with activities that require learners' active response such as think/pair/share. While classroom discourse was still predominantly initiated by pre-service teachers, students possessed greater autonomy in answering questions as opposed to classrooms that follow IRF_E pattern. In this interaction pattern, a more complex pattern of IRF_DRF_DRF_D was observed, although this was limited. This means that elaborative feedback was given to students' response continuously until meaningful learning occurred. One of the essential features of this interaction pattern was the positive value placed on students' response. For example, students' responses were valued and respected, while their engagements were brought into social context of the classroom (see Table 5). Although this interaction pattern helped students in the understanding of classroom concepts and clarification of abstract ideas, its major weaknesses is the disruption of communication flow alongside time wasting without covering relevant concepts in record time. To cater for these challenges, Maftoon and Rezaie (2013) recommended that teachers should maintain balance between evaluative and discursive feedback.

Table 5: IRF_D Interaction Pattern

Extract 1	Extract 2
T: What can you say about input devices?	T: What do you know about projectile motions
S: They are computer hardware	S: Is a motion that follows a parabolic path
T: Yes, what are they used for?	T: Parabolic path! What kind of path is that?
S: To enter data in computer system	S: Like a curve
T: What kind of data?	T: Yes! Just like when you hit a tennis ball against a wall.
S: Numbers and characters	
T: Yes, they are used to enter numeric or alpha-numeric data	

Source: Field Data

Although the two interaction patterns were observed across wide range of STEM disciplines, their occurrence was largely determined by specific activities involved in the classroom. Based on observed classroom activities and field notes, activities that required recalling factual ideas were mostly evaluated using IRF_E interaction pattern (see Table 4). These are concepts that called for evaluative feedback rather than discussion. On the other hand, activities that required detailed explanation were mostly discussed using IRF_D interaction pattern (see Table 5). These are concepts that called for elaboration and intensive feedback so that students can clearly understand information that were abstract and confusing.

Elicitation Techniques Prevalent in STEM Classroom

Predominant elicitation techniques employed by pre-service teachers were observed across wide range of STEM classrooms. In general, the pre-service teachers used three distinct elicitation techniques to elicit response from the students. First, clarification requests was often used when students' response are not clear and precise (see Table 6; extract 1). This technique usually involved the following clause: "what do you mean", "I don't get you right". They were also used to enforce repetition particularly in situation where students used ambiguous words or wrong pronunciation. Second, display questions were often used to elicit response by pre-service teachers when the focus is on measuring factual knowledge. This elicitation technique requires only one acceptable answer (See Table 6; extract 2). In few cases, they were used to ascertain the correctness of information given by another student or to arose students' interest, particularly those with emotional detachment.

Although clarification requests and display questions cannot be used to elicit in-depth information, they are content-based and therefore give students direction to follow. Furthermore, these questions are simple and short and were answered without much time wasting. The prevalence of display questions suggests that students' factual knowledge is more important to pre-service teachers than deep insights and understanding. Referential questions were the third category of elicitation technique often employed by pre-service teachers. These questions were often used to get detailed information from the students and for ascertaining that students have wide range of information on a given concept (see Table 6; extract 3). Despite their ability to stretch responses, teachers sometimes interrupted students even when their information is accurate. This

therefore stretched classroom activities to longer time without covering many concepts (Maftoon & Rezaie, 2013).

Table 6: Extract of Elicitation techniques used by Pre-service teachers

Extract 1	Extract 2	Extract 3
T: Give one property of an atom	T: Biology is the study of? S: Life T: correct	T: Which methods can we use to solve simultaneous equation?
S: They are invincible	T: What is the atomic number of Calcium	S: Substitution method and elimination method
T: What do you mean by "invincible"	S: 20 T: correct	T: good, how can you use substitution method?
S: I mean indivisible; they cannot be further divided into smaller parts	T: Which element has atomic number of 8?	S: By making one of the variables the subject of the equation in one of the equations and then substituting its value in the other equation
T: ok, good	S: Oxygen	T: perfect

Source: Field Data

Despite observing the three elicitation techniques across wide range of STEM discipline, an investigation of the teachers' lesson plans indicates that display and referential questions are determined by students' level and pre-defined objectives in the lesson plan. For example, it was observed that students in lower level were frequently asked display questions because of their presumed inability to address complex situations. Students in higher classes were frequently asked referential questions on the assumption that they can answer complex questions and can be able to apply knowledge in different situation. These questions were also in accordance with stated objectives from teachers' lesson plan.

Feedback Strategies Employed by Pre-service Teachers to Drive STEM Classrooms

Common feedback strategies used by pre-service teachers to drive STEM classroom discourse were identified. In general, pre-service teachers employed three major feedback strategies, which are: explicit correction, recast, and elicitation. These strategies cut across almost all STEM

classrooms, with few exceptions where no form of feedback was given. Explicit correction was frequently used by the teachers to rule out students' ill-formed response on the assumption that the mistake will not occur again (see Table 7; extract 1). This strategy also helped the teachers to explicitly punish wrong utterances and reinforce right response. However, one major observed weakness of this strategy was that it instilled fear and anxiety in the students and therefore reduced their participation in classroom discourse. With few exceptions, students whose responses were corrected with this feedback strategy were laughed and mocked by their peers and consequently lose their classroom autonomy.

Recast strategy was employed by pre-service teachers to paraphrase students' responses particularly those that contain few incorrect wordings (see Table 7; extract 2). Although not frequently used, some teachers put much emphasis on recasting students' response and fixed incorrect parts in their utterances. This involved replacing wrong utterances with correct ones and then forming a new whole sentence. This strategy was considered the best as many students pose greater classroom autonomy. Students felt respected and consequently increased their participation. In consistent with Lyster's (2007) position, recast were more noticed by high ability learners and sometimes failed to draw students' attention in recognition of the parts of their responses that were corrected. However, this recognition depends on the number of wrong utterances replaced by the teachers. Elicitation strategy was one of the feedback strategies used by pre-service teachers to drive STEM classroom discourse. This strategy was used to guide students' cue in response to questions (see Table 7; extract 3). Although not frequently used, elicitation strategy was used to actively engage students in classroom activities as well as enforcing word or sentence translation, providing opportunity for language learning.

We observed one important occurrence from the database containing the three feedback strategies employed by the pre-service teachers; the teachers were more selective in the use of these strategies, depending largely on classroom culture. For example, teachers employed more explicit correction in teacher-directed classrooms (see Table 7; extract 1). Recast and elicitation were more employed in classrooms that accommodate discovery and inquiry and self-direction (see Table 7; extract 2 & 3).

Table 7: Feedback Strategies Employed by Pre-service Teachers

Extract 1	Extract 2	Extract 3
T: What is reversible reaction?	T: What is the meaning of half life of a radioactive element?	T: ICT means Information and....?
S: Reaction that gives out heat	S: Is the amount required for half of all elements to evaporate	S: Communication Technology
T: That is wrong; it means chemical reaction that proceeds in both direction	T: Yes, it is the amount of time required for half of radioactive element to decay	T: Apart from mouse, what other input device do we have?
T: What is the oxidation state of Hydrogen in H_2SO_4	T: How can we convert 30 minutes to seconds	S1: Keyboard S2: Scanner S3: Light pen
S: 5	S: By multiplying 30 by 60	T: How do you call this in your language? (pointing at light pen)
T: Wrong, the answer is 6	T: Exactly, by multiplying the 30 minutes by 60 seconds	S: Alkalami (meaning pen)

Source: Field Data

Influence of Pre-service Teachers' Perceived Agency on Questioning and Discourse Patterns

Pre-service teachers' perceived agency was identified alongside its influence on questioning and discourse patterns in STEM classroom. Pre-service teachers acknowledged their ability to control their classrooms using different actions, including those that have to do with democratic and autocratic, throughout their teacher training programme. They perceived these strategies as their strongest weapon to drive classroom discourse. They however, acknowledged that they gave less emphasis on their perceived methodological strengths and weaknesses, with research evidence indicating that the effectiveness of teaching method is determined by classroom management and discipline strategies (Obi & Ezemba, 2019). To buttress this point, one of the pre-service teachers commented that "...at the first minute of my classroom interaction, I ensured that my classroom is properly organized and that discipline is maintained....this has really worked for me....without it my classroom would always be in a rowdy session and my instruction would never be

effective no matter what teaching method I employed". This indicates that pre-service teachers were more concerned about classroom management on account that it enhance learning. However, Oliver and Reschly (2007) earlier argued that "sound behavior management does not guarantee effective instruction; it establishes the environmental context that makes good instruction possible" (p.1).

Apart from behavior and classroom control, pre-service teachers also perceived their personal qualities as their agency that influenced classroom discourse. They were adamant that "optimism" and "ability to maintain positive relationship with students" influenced their classroom interaction. One of the teachers remarked "...before my classroom period, I am always optimistic that my lesson would be a successful one....although I was challenged by fear and anxiety during my first week, I remained optimistic that I can make a differenceI was able to achieve this through my rapport with students". In consistent with these comments, it became apparent that pre-service teachers possessed some personal qualities that enhanced their classroom discourse. However they were negative about their teaching skills on the account that they lack prior teaching experience, suggesting the need to engage pre-service teachers in intensive micro teaching before sending them to schools (Choudhary, Choudhary & Malik, 2013; Remesh, 2013). In another perspective pre-service teachers held the belief that teachers' behavior impact learning, and this belief system has enabled them to act as role models towards ensuring that discipline is maintained for effective classroom instruction. One pre-service teacher responded that "I believe that teachers' behavior impact learning....I always act as role model...I always dress properly and behave well in the class....this has helped me to control my students and draw their attention towards classroom instruction". The teachers also acknowledged the presence of diversity in classrooms, but were of the belief that holistic classroom instruction can cater for students' learning, as to what follows: "...classrooms are made up of students from different background....to cater for this difference, I always believe that a general approach can influence learning....it has always enhanced my classroom instruction with the help of classroom management strategy".

This belief system was contrary to studies advocating for differentiated instruction, with evidence suggesting that adopting single teaching approach for all learners does not automatically guarantee effective

instruction (Tomlison, 2001; Ford, 2013; Yusuf, Bello, Faruk & Mani, 2019). Teachers' classroom culture was more of "teacher-directed" and "discipline-defined", with few exceptions where discovery and inquiry and self-direction were accommodated. The teachers perceived these cultures as being helpful towards effective classroom discourse. One of the teachers responded that "my classroom atmosphere was always conducive because I avoid rowdy session and 'chorus answers'....I determined who speaks in the class and what activity needs to be done....I adopt this approach to maintain discipline otherwise I won't achieve my lesson objectives". Although this approach could enhance obedience and decrease disruption, it would instill a belief in the mind of the students that learning cannot or should not be self-directed. Furthermore, learners are likely to lose autonomy resulting to less participation (Tofel-Grehl & Callahan, 2016).

Theoretical Propositions

In consistent with findings of the study, many propositions were generated:

1. Two interrelated interaction patterns (IRF_E and IRF_D) characterize STEM classrooms, and these patterns were determined by specific activities involved in the classroom.
2. Few elicitation techniques were utilized by pre-service teachers; the prevalence of these techniques depends on students' level and objectives to be achieved.
3. Pre-service teachers were more selective in the use of feedback strategies to drive STEM classroom, depending on classroom culture.
4. Pre-service teachers were more concerned with classroom management and behavior control than teaching method; they also display more personal qualities than teaching skills; and their classroom culture is more of teacher-directed and discipline-defined.

A more general theoretical framework can be generated from the above propositions: Pre-service teachers' interaction patterns, elicitation techniques, and feedback strategies are influenced by their own agency, including actions, qualities, belief system, and classroom culture. This theoretical framework is fallible and should be subjected to improvement by further studies.

CONCLUSION AND RECOMMENDATIONS

STEM classroom consist of complex classroom events with diverse features. In order to understand these features, it is essential to explore classroom discourse and questioning patterns present in a typical STEM classroom. We adopted a grounded theory to explore these patterns, and also provide insights on how teachers' perceived agency influence classroom interaction. The findings are illuminating as they provide us with an understanding of pre-service teachers' STEM school practices. Four major findings were revealed to characterize pre-service teachers' classroom discourse. First, two interrelated interaction patterns dominated pre-service teachers' STEM classroom. These interaction patterns are the IRF_E and IRF_D, with the former more prevalent. The occurrence of these interaction patterns was observed to be determined by specific activities involved in STEM classroom.

Few elicitation techniques were utilized by pre-service teachers, and the prevalent of these techniques depends on students' level and objectives to be attained. These were evidently observed as most pre-service teachers used display questions on low level students based on the assumptions that they could not address complex questions. Students in higher classes were frequently asked referential questions on the assumption that they can answer complex questions and can be able to apply their knowledge in different situation. These questions were also in accordance with stated objectives from teachers' lesson plan. Pre-service teachers were more selective in the use of feedback strategies to drive STEM classroom, depending on classroom culture. Pre-service teachers employed more explicit correction in teacher-directed classrooms; recast and elicitation were more employed in classrooms that accommodate discovery and inquiry and self-direction. Pre-service teachers were more concerned about classroom management and behavior control than teaching method; they also posses more personal qualities than teaching skills; and their classroom culture is more of teacher-directed and discipline-defined.

Although questioning and discourse patterns employed by pre-service teachers are valid and relevant, their classroom practices need to be pre-guided through intensive micro teaching programme before they are sent to schools. In addition, their actions, qualities, and belief systems need to be modified to promote effective classroom culture. Furthermore, their overall philosophy about teaching needs to be identified and discussed before the actual training. Doing these would expose them to different

assumptions about teaching, and would correct their views about teaching methods and discourse patterns.

Limitations

Due to the nature of qualitative studies, it would be inappropriate to draw causal conclusions or make generalizations to other settings. Although theoretical propositions and framework were developed in this study in consistent with grounded theory, they are fallible and should be subjected to further investigation. This study serves as an exploration of pre-service teachers' STEM classroom discourse and questioning patterns in relation to how their perceived agency influence their classroom interaction. Findings from the study could be proved to build more diverse trends of classroom discourse.

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