# The Role of Teachers' Instructional Moves on Students' Problem-Solving Skills: A Discourse Analysis of Mathematics Lessons in the USA and Tanzania

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**Abstract**

*The role of instructional moves in fostering students' problem-solving skills is well documented. Hence, this study analysed a videotaped interaction of four high school students from one school in the USA solving an ill-structured mathematical problem under teachers' guidance. Furthermore, five students from one school in Tanzania solved the same problem while their teachers were allowed to observe, after which they were interviewed. Findings indicated that non-judgmental teachers' instructional moves that requested for students' explanation, clarification and justification were key to providing scaffolds that helped students during problem solving. Additionally, although Tanzanian teachers perceived several challenges, they had positive opinions regarding ill-structured problems, collaborative problem solving and use of video for reflective practices. Finally, policy and practical implications for mathematics education in Tanzania are discussed.*

***Keywords***: *collaborative problem solving, ill-structured problems, instructional design, mathematics education,*

## Introduction

In a complex world that we live in, we are always encountering problems requiring us to solve them intelligently for our survival. Recognizing this important aspect of human experience, one of the ultimate aims of mathematics education has been to foster problem-solving skills among students (Darling-Hammond, 2011; De Smedt, Holloway & Ansari, 2011; Fasni, Fatimah & Yulanda, 2017; Greene, 2011; Ndlovu, Pournara & Mwakapenda, 2019; Wyndhamn &Saljo, 1997). Moreover, to cope with an ever-changing and technology-driven world, problem-solving skills are increasingly becoming important (Phillips, Clemmer, McCallum &

Zacharia, 2017). Moreover, problem-solving skills have been found to be key if students are to succeed in Science, Technology, Engineering and Mathematics (STEM) (LeFevre, Douglas & Wylie, 2017; Martin, Liem, Mok, & Xu, 2012). Unfortunately, while problem-solving skills are regarded as important among employers, many graduates are said to lack them (Phillips et al., 2017; Topcu & Yilmaz-Tuzan, 2011). It is worth noting that it is very rare that problem-solving skills depend on elements of luck but require skills and knowledge of relevance to the problem at hand. In the context of mathematics education, this implies that, mathematics classrooms should equip students with necessary knowledge and skills to solve real life problems. Likewise, according to Wyndhamn and Saljo (1997), mathematics education should enable students to apply mathematical knowledge to solve new problems in real contexts.

Nonetheless, the complexity surrounding the development of problem-solving skills demands teachers' skills and creativity if they are to guide students in mastery such skills. Moreover, the complexity of developing problem-solving skills is sometimes contributed by the nature of the problems themselves. For instance, in mathematics classrooms problems are, often times, ill-structured and complex (Phillips et al., 2017). According to Phillips et al. (2017), some problems involve uncertainty and unknown pathways, thus solvers should possess the capability to analyse tasks, design plans and execute them. Therefore, teachers should be skilful enough to guide students through a problem solving cycle. While there exists various models of problem solving cycles, a model suggested by Jamaludin and Hung (2017) best summarizes the steps of problem-solving cycle as follows:

> Problem solving explicated as (1) preparation—defining the problem and gathering information relevant to it; (2) incubation—thinking about the problem at a subconscious level; (3) inspiration—having a sudden insight into the solution of the problem; and (4) verification—checking to be certain that the solution was correct. (Jamaludin & Hung, 2017, p.4)

To navigate through a problem-solving cycle pointed out above, teachers must guide students well. For instance, teachers can act as facilitators who guide students to clarify their arguments, provide alternative explanations and relate the problem with their prior experiences.

Apart from the above problem solving cycle, other researchers have described different forms through which problem solving happens. Of interest to this study are the forms described by Lin, Yu, Hsiao, Chu, Chang and Chien (2015) which provide a distinction between Individual Problem Solving (IPS) and Collaborative Problem Solving (CPS). While IPS is common in many mathematics classrooms, CPS is said to be more effective when it comes to helping students develop problem-solving skills (Lin, et al., 2015). According to Lin el at. (2015), CPS offers possibilities for effective collaboration, benefiting from multiple knowledge and has a potential to improve solutions through peer feedback. Furthermore, according to Greene (2011), CPS enhances students 'discipline as it teaches students how to tolerate one another in groups. These potentials partly justify the investigation by this study on the impact of teachers' instructional moves on problem solving in the context of CPS.

## Teachers' instructional moves: what does research say?

Learning as a social process, demands skilful use of language. Thus, a range of verbal and non-verbal discourse processes are needed to foster problem solving in mathematics classrooms. Processes such as reasoning, observation, posing researchable questions, formulating hypotheses, predicting patterns and identifying relevant steps are important parts of a mathematical world. Based from this understanding, the impact of student-teacher interactions in mathematics classrooms has for many years attracted the attention of educators (Darling-Hammond, 2011; Fasni et al., 2017; Springer & Dick, 2006). For instance, it is argued that, instructional discourse greatly influences problem solving (Adamovic & Hidden, 1997; Frey & Fisher, 2010; Krussel, Springer & Edwards, 2004). Additionally, effective instructional discourse is credited for creating classroom environments that enhance meaningful learning and understanding (Bell & Odom, 2012; Harris, Phillips & Penuel, 2012). Adamovic and Hidden (1997) further argues that, for students to solve mathematical problems, teachers must use defined steps to guide students in the process. These defined steps and techniques or student- teacher interactions are referred to as "instructional discourse" (Bell & Odom, 2012, p. 609), "teacher instructional moves" (Harris et al., 2012, p. 769) or "discourse moves" (Bell & Odom, 2012, p. 609).

It is through instructional discourse where teachers provide scaffolds that guide students to ask thoughtful questions, evaluate alternatives and discover patterns. Depending on how it is skilfully carried out, instructional discourse can have both positive and negative consequences on students' learning as well as their abilities to solve problems. Sullivan (2011), for example, found that a less-judgmental discourse in the context of open-ended, goal oriented activity led to improved students' ability to generate creative ideas. Regarding the nature of discourse, Chiu (2008) also demonstrated that, the kind of questions and the politeness of disagreements among group members affected their chances to generate new ideas during science problem solving. As such, that is why teachers are encouraged to conduct action research in order to find out the kind of instructional moves that suit particular classroom needs.

Research on classroom interactions has come out with different ways to describe instructional discourse. The common one describes how teachers and students interact in the classroom in terms of who initiates the move. One of them is the Initiation-Response-Evaluation (IRE) model where the teacher initiates, students respond and then the teacher evaluates students' responses (Clement, 2008; Krussel et al., 2004). As an example, let us say a teacher may ask a student: What is mathematics? (I), a student responds: Mathematics is a study of numbers (R). Then a teacher may evaluate the student's response by saying excellent! (E). It is important to note that the IRE pattern happens mainly in traditional classrooms. In student-cantered classrooms the IRE pattern is usually extended to allow a dialogue to take place (Clement, 2008).

While the IRE pattern is commonly known, other researchers have taken different approaches to describe instructional discourse. Clement (2008), for instance, distinguishes between teacher/students directed and teacher/students generated models. According to Clement (2008), a teacher can dominate in directing the agenda while students dominate in generating ideas. Yet, other studies such as that of Martin-Hansen (2002) have described instructional discourse in terms of teacher-centredness and/or student- centredness while other studies have studied different contexts under which problem solving can be enhanced using instructional discourse/moves. For instance, Liu et al. (2015) investigated how instructional moves enhanced problem solving in the context of technology. Yet, recent studies have tended to be more specific by addressing a specific aspect of problem solving and/or an instructional discourse. For example, Phua and Tan (2018) investigated how students' questioning within groups resulted into productive argumentation, while Laas (2018) studied how certain kinds of instructional moves improved argumentation. More recently, the research has focused on how teachers' skilful use of argumentations lead to improved students' argumentations (Liu & Roehrig, 2019) and how teachers' guidance improved students' questioning skills (Stokhof, Vries, Bastiaens & Martens, 2019).

This study takes a different route in a sense that it investigates how teachers' instructional moves in the context of CPS guided students to solve an ill-structured mathematical problem. Specifically, the study uses a video clip to investigate how teachers' instructional moves helped high school students in the USA to solve a specific problem described in this study as the '*taxi problem*'. Furthermore, this study adopts a comparative approach by investigating how students in another context, in this case Tanzania, solved the same problem as well and how their teachers reacted. More importantly, this study intends to ignite a debate about general issues such as the overall aims of education as well as specific issues such as the trade-off between implementing more student-cantered methods, on one hand, and overemphasis on standardized examinations on the other hand. The study uses Krussel et al. (2004) framework to discern how the purpose and form of an instructional move result in a given consequence in a particular setting by answering three research questions, namely: (1). What are kinds of teachers' moves that characterize the discourse in the video? (2) How did teachers' move impact students' justification and reasoning of their solutions when solving a problem; and (3) What were the reactions from Tanzania mathematics teachers who watched the video and their students solving the same problem?

## High school mathematics curriculum context in Tanzania and the USA

While the curriculum contexts in the USA differ from state to state, they are all guided by the similar national curriculum core standards. For instance, whereas in some states and districts high school education covers three years, others have their students spending four years of high school education. Nonetheless, there are more similarities than difference in a high school curriculum. Such topics as calculus, logic, differential equations and vectors are almost similar across states. For reason that relate to mathematics being a universal subject (Kinyota & Kavenuke, 2018), the curriculum content in the USA is also more similar than it is different with a high school curriculum in Tanzania schools. For instance, the Massachusetts Curriculum Framework for Mathematics lists topics such as *algebra 1 & 2, functions, statistics and probability, geometry and pre-calculus* as part of its standards (MDESE, 2017, p.180). Another similarity is on teachers, whereas teachers in both countries, although they go through different routes of training and accreditation, possess the same qualifications (for example, most of them have at least a bachelor degree related to teaching mathematics).

However, individual studies (Clement, 2008; Kitta & Tilya, 2010) from these two settings seem to suggest a significant difference between these countries in aspects such as class size, levels of mathematics teachers' autonomy to design and provide ill-structured problems to students, level of student-centredness in mathematics classrooms and the overemphasis on standardized tests. Having small class sizes, high level teacher autonomy, long time experience and strong beliefs in student-centred methods and less emphasis on standardized tests make the USA a conducive place for nurturing problem-solving skills through CPS. Nonetheless, through a careful needs assessment, it is possible to develop a mode of CPS that will suit the Tanzania context. In other words, the implementation of CPS in Tanzania does not necessarily demand copying of the whole USA education system, but rather a careful analysis and selection of aspects that will work in the Tanzanian curriculum contexts.

## Conceptual Framework

Krussel et al. (2004) proposed a framework for describing teachers' instructional moves in the classroom as well as how such moves can help students solve mathematical problems. Following a synthesis of various studies in instructional discourse, Krussel et al. (2004) concluded that all teachers' moves have a purpose, setting, form and consequence. Examples of purpose could be to: request an explanation, initiate a discussion, test students' thinking and provide a scaffold. The setting, according to this framework, is used to describe both temporal and physical dimension such as classroom norms, available time and resources and roles that each member play during the lesson. The form of an instructional move refers to the verbal and non-verbal interactions that take place. For instance, teacher's verbal moves may be a probe or challenge (for example, how do you know?) or may be a non-verbal clue of any form. The consequence, according to Krussel et al. (2004), refers to a combination of both intended and unintended outcomes of an instructional discourse. In that regard, teachers must be careful during assessment to check not only students' learning but also how their instructional techniques might result in negative unintended consequences.

In this study, Krussel et al. (2004) framework served as a coding system for video data analysis. To better understand the kind of teachers' moves and how they affected students' problem solving, instructional discourse was coded by analysing its purpose (P), setting (S), form (F) and consequence (C).

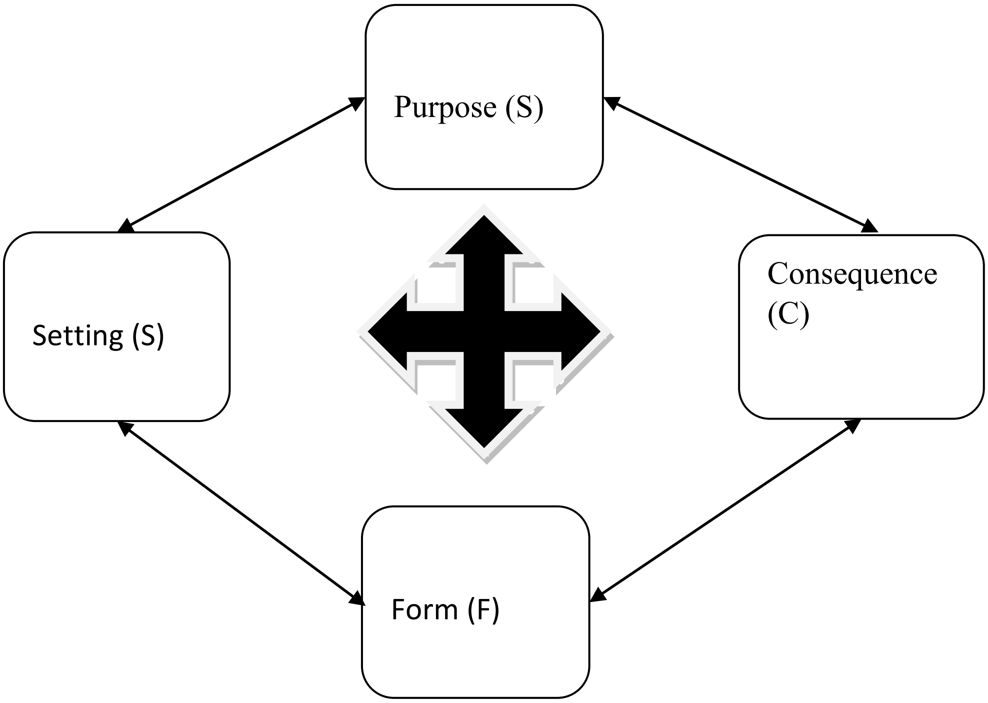


Figure 1*: A modified Krussel et al. (2004) framework for analyzing discourse*

To apply it in the present context under interrogation, the researcher modified it by adding double arrows to indicate elements of interactivity among the four components (See figure 1). Using other words, the researcher thought that the four elements interact in a way that there should be alignment between them. For example, the purpose of a discourse (P) must inform the setting (S) and the form of a discourse (F).

## Methodology

### Research design

The researcher used a case study design to frame the study's methodology. A case study design allows researchers to conduct an in-depth and detailed investigation of a particular case (Charmaz, 2010). By using a comparative approach, the researcher in the present study selected two cases. The first case involved high school students, under the guidance of their teachers, from the USA solving a mathematical problem in a recorded video. The second case involved high school students from one school in Dar es Salaam, Tanzania solving the same problem in a real situation, with their teachers watching.

## Sampling

With a careful analysis, it is argued that teachers and students can learn a lot from videos (Higgins, Moeed, & Eden, 2018). Particularly, videos are powerful tools for helping teachers to evaluate their own as well as other's lessons. This study was carried out in two phases. During the first phase, the researcher analysed a video of high school students solving mathematical problem in one of the high schools in the United States. In this video students in groups of four (1 female, 3 males) were given a problem to figure out the shortest route from the taxi stand to each of the points as show in Figure 2. Students are also required to figure out whether or not there was more than one shortest route. In case they discover more than one route, students must identify the maximum number of shortest routes. In all cases students must justify their responses. Students were mostly left to solve the problem by themselves but at some points the teacher intervened so as to facilitate the discussion. Thus, I hypothesized that during teacher' intervention there would be some special moments that changed students thinking and reasoning about the problem. The video provided an appropriate setting for understanding the kinds of teacher moves and how they helped students to shape their reasoning about the problem.

During the second phase five high school students and three mathematics teachers were purposefully selected from one of the schools in Chang'ombe, Temeke district—Dar es Salaam, Tanzania (see demographics in Table 1). Students were given an opportunity to solve the same problem (referred to as the taxi problem) while their teachers and the researcher were observing and taking notes. Teachers were then allowed to watch the video of other students and teachers working on the same problem. Thereafter, the researcher conducted semi-structured interviews with the teachers to find out their reaction. Specifically, the purpose was to understand teachers' attitudes toward the approach as well as the opportunities and challenges of practising the same.

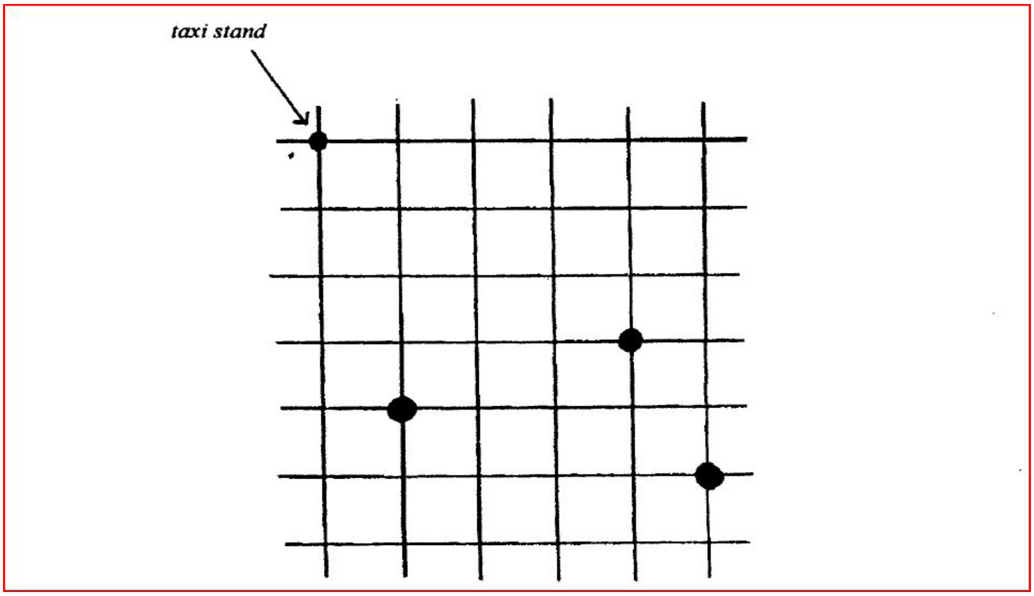


Figure 2: *The taxi problem*

**Data analysis**

The researcher followed four steps to analyse video data. During the first step, the entire video tape of about 100 minutes was watched while taking notes on important issues as it is done during participant observation. Additionally, during the first step an episode that was thought to serve research interest was as well chosen. During the second step attention was paid to areas of interest, playing back and rewinding to record carefully different events as they happened in the group before and after teachers' intervention. During the third step, the discourse was transcribed at the same time relating it to the large context of the entire video. The fourth stage involved relating the transcriptions to the coding system that was developed using Krussel et al. (2004) framework.

The framework provided a lens through which to analyse instructional discourse during teacher-student interactions. Specific attention was on how the four elements (purpose, setting, form and consequence) interacted together during discourse. For example, what did the teacher intend by asking this question? In which form did the teachers use (such as a probe, request for explanation or non-verbal clue.), in what settings as well as identifying the intended and unintended consequences of the discourse? These elements were then used to create a coding system that would indicate the kinds of teachers' instructional moves and their effects during students' problem solving. Since the setting was almost fixed, I paid much attention to purpose, form and consequences. Data analysis of teachers' interviews involved a combination of both content and thematic analysis (Wellington, 2000) where a general question guided the identification of emerging themes. To get categories and subsequent themes, interviews were recorded, transcribed and then coded using line by line coding (Charmaz, 2010). For the purpose of anonymity, for students and two teachers who are featured in the video were given pseudo named as S-1, S-2, S-3, S-4 and T-1, T-2 while those in Tanzania were pseudo named as SS-1, SS-2, SS-3, SS-4, SS-5 and TT-1, TT-2, TT-3 respectively.

**Table 1:** *Teachers' Demographics*

| Teacher (sex) | Average age | Total working experience | Experience teaching high school |
|---|---|---|---|
| T-1(F) | Unknown | — | 11 |
| T-2(F) | Unknown | — | 5 |
| TT-1(M) | 29-32 | 4 | 4 |
| TT-2(F) | 45-48 | 13 | 6 |
| TT-3 (M) | 35-38 | 9 | 4 |

## Findings

### Students working in a group

Students in the video clip had solved the problem by themselves in group without any intervention from the teacher for about an hour. They counted the number of ways across and down for different blocks of the taxi problem such as 2 by 2, 3 by 3, and 2 by 4 blocks. with the goal to discover a pattern that would be used to find out the number of shortest routes from the taxi stand to different points. They worked in groups and sometimes individually to confirm the number of ways for each block. When solving the problem, they used different strategies such as trial and error, use of analogies, and reference to or experiences from previous problems. As they worked on the problem, students discovered that if they flip a paper, the number of shortest routes for each block followed the Pascal's triangle. This was a great moment for them. However, students were not sure of their reasoning, specifically, they were not sure if in the process they had discovered a pattern (Pascal's triangle) and whether it would work for points beyond what they worked on. As a transcript in table indicates, students had successfully solved the problem although they were not sure of their reasoning. While working in groups, in addition to solving the problem, students were articulate enough in posing thoughtful questions as well as generating alternative solutions. In terms of discipline, students maintained a friendly working condition although there were few cases of quarrels.

**Table 2:** *Example of Transcripts of Students Working In a Group*

| Time | Student | Talk | What followed (observation) |
|---|---|---|---|
| 00:55:18 | S-2 | Smiling "Alright, it's, it's Pascal's Triangle | Then all students think for some time and continue trying out |
| 00:55:36 | S-2 | "No it's (Pascal's triangle) not , it doesn't work out" | They continue to count number of steps between points to confirm results |
| 00:56:10 | S-2 | Referring to all, "Do a four-by-two" | |
| 00:56:13 | S-3 | "Yah, we do a four-by-two, it should put us, ehh, in business" | Continue working on a four-by-three figure as suggested, S-1 is working on the three-by-three block |
| 01:07: 12 | S-4 | (lifts a hand) "fifteen for this one" | They record that |
| 01:10: 39 | S-1 | "Yah, I got twenty for that one" ( 3-by-3 block) | The group is happy the answer confirms what they found before. However, they are not sure if the pattern works. |
| 01:10: 51 | S-3 | (Touching head) "The next question is, why, why is it, why is this… The Pascal's triangle… works for this? | |
| 01:11:01 | S-3 | Referring to a 3-by-3 block "First how do you know it's twenty? How do you know it's nothing else? | The group continues to work on the blocks for about 6 minutes and the start off-task businesses while waiting for the teacher to come |

On part of students from Tanzania, data from observation indicate that they all seemed to enjoy the task. They preferred working individually with few occasions of sharing solutions. Also, they were able to identify few shortest routes from the taxi stand to the destinations. Given that the students were not used to solving these kinds of ill-structured problems, as interview data indicated, it was not surprising that their reasoning was not as articulate as their counterpart in the video. Although they were right on the number of routes they discovered, they were not able to figure out how their informal reasoning related to formal mathematics (the Pascal's triangle). Nonetheless one student (SS-4) was critical enough to raise the issue of the time taken when a car is making a sharp corner. This was agreed by teachers and the researcher as a moment of critical reasoning.

### Teachers' instructional moves that characterized the discourse

Most of teachers' moves were questions and requests that demanded students to provide justification to their reasoning. Additionally, teachers provided enough time from question to question so that students have adequate time to explain their reasoning. Furthermore, in the video, teachers' questions tended to be less judgmental. As a consequence, students were encouraged to express their ideas freely. Teachers also tried to use different forms of reinforcements. For instance, teachers recognized students' responses by repeating them (see Table 3, 1:50:19, T-1).

**Table 3:** *Example of Teachers' Transcripts (T- 1 and T-2)*

| Time | Student/ teacher | Teachers' instructional moves, students' responses | Purpose (P)/Consequence (C) |
|---|---|---|---|
| 01:20:13 | T-1 | (Points on students' work) "So you found all those numbers, all of them by counting? | P: request for explanation<br>C: Students recounted all the rows and confirmed |
| 01:20:17 | S-2 | "Yah!" | |
| 01:20:20 | S-3 | (Points on their work) "Yah, up to here what is written we counted through them" | |
| 01:21:37 | T-1 | "You show me that it is Pascal's triangle but I don't see it…Help me see it" | P: How the number of rows related to Pascal's triangle<br>C: Students justified for the blocks they worked on |
| 01:21:41 | S-3 | (Shocked and shout) "You don't see it!!! Here (flips the paper and explains how it relates to the triangle) "1, 1-2-1, 1-3-3-1, 1-4-6-4………..." | |
| 01:42:34 | T-2 | " May be you can help me see how you are relating the number of toppings and the number of….getting to any particular corner" | P: How different students' ideas related to each other and to the problem<br>C: Students used analogies and explained how it related to the problem |
| 01:50: 11 | S-1 | (Referring to T-1) "I mean…. does that convince you?" | |

| Time | Student/ teacher | Teachers' instructional moves, students' responses | Purpose (P)/Consequence (C) |
|---|---|---|---|
| 01:50:19 | T-1 | "I see how you get those numbers…I guess my question still is.. How would you talk about some general numbers"? | P: Does the pattern work for other numbers?<br>C: Students started to think and reason beyond their tested blocks, were more confident |
| 01:50:32 | S-2 | ( Points on a particular point on the diagram) "Alright, we just pick this one" | |
| 01:50:35 | S-1 | (Referring to T-1) "First do you understand how it relates to Pascal's triangle?... So you give us the general number we look at the triangle" | |

## How teachers' instructional moves guided students' justification and reasoning

The Krussel et al. (2004) framework guided the researcher in analysing different episodes and incidents in the video. To find out how teachers' instructional moves guided students' justification and reasoning and consequently solving the problem, the researcher analysed teachers' moves in terms of their purpose as well as how they shaped students' responses (consequences). That is to say, these teachers' moves had purposes which, in different forms and settings, resulted in different consequences. For instance, teachers' request for explanations consequently forced students to connect different ideas that they initially treated separately. An example is when the teachers asked students to relate all the analogies such as pizza toppings and tower problem they had mentioned when solving the taxi problem (Table 3, 01:42:34, T-2). By connecting ideas and analogies that were once separate, students were able to generate other new ideas. Furthermore, teachers' instructional moves that requested for consideration of other aspects (Table 3, 01:21:37, T-1) helped students to start questioning if their discovered pattern would work for other general numbers.

Timing was also helpful. As noted earlier, teachers' waiting time lapse and use of less judgmental discourse helped the students to gain confidence. As a result, their reasoning improved as they interacted with the teachers. It was also noted that teachers tended to avoid the IRE pattern. Instead of accepting or judging students' responses directly, they responded by asking other follow up questions that helped students to test their assumptions. In general, friendly, timely and less judgmental teachers' instructional moves that demanded students' clarification helped students to solve the problem. Additionally, they were able to discover a pattern, a Pascal's triangle and that it could be used to identify the number of routes even for other problems with the same features.

**The reactions from Tanzania teachers who watched the video and their students solving the same problem**

Interview data indicated that all of the three teachers, regardless of their differences in working experiences, held positive recommendation of CPS. Additionally, they enjoyed observing their students working in groups and watching the video. TT-2 and TT-3 acknowledged the power of video as a learning tool as opposed to a research tools. As TT-3 expressed:

> Mhhh…for use in research I don't think much…but for teaching it is possible. You can learn, I learned a lot from this video. If someone also records me during teaching I can use the video later to see how I was teaching and learn the…yaahh

All teachers admitted that their students do not have the opportunity to engage in long-time group works. Even if they involve in collaborative problem solving, the teachers said, students are given problems with known or predictable pathways of solutions. In other words, ill- structured problems, which refer to problems that have no single solutions and they demand students to make connections among concepts from different domains. Such problems are not common in their mathematics classrooms. "Pressure to cover the syllabus" so as to enable students "pass NECTA [National Examination Council of Tanzania]" examination was identified by teachers as a major barrier to the practice productive CPS. While the other two teachers had a moderate stance regarding students' engagement with ill-structured problems, TT-1 opined that it was completely impossible to implement such kind of pedagogy in the context of mathematics classroom in Tanzania. He was of the view that:

> The way I watched the video…I think this method…this kind of method is possible only in Europe and may be China and America. For our students what is important to them is solving problems from past NECTA examinations…you know the past NECTA questions [problems] will…ehhh…have a chance to repeat again [reappear] in the final examination and midterms.

Despite his radical stance regarding the possibility of his mathematics students engaging in solving ill-structured problems, TT-1 acknowledged that the students he watched in a video had have better chances of improving in reasoning and "critical thinking" as compared to his student who lack such opportunities. As with TT-1, other two teachers were of the view that there are skills that the USA students will gain that "our students" are missing.

Although they described it differently, findings from the interviews with the teachers seem to suggest that teachers consider larger class size as a barrier to implementing CPS and other student-cantered approaches. What TT-1 referred as "overcrowded rooms" was not only a problem to teachers but also to students themselves. Nonetheless, TT-3 opined that high school mathematics classrooms are not supposed to be overcrowded. He seemed convinced that if mathematics majors from different combinations were "separated," they would not have faced such a problem of large classes. However, he further added that, separating classes would increase the workload for mathematics teachers.

Regarding teachers' instructional moves, all teachers shared a common agreement with respect to the power of questioning. They considered that, the way teachers frame questions during mathematics classrooms can either enhance or hinder students' understanding of the lesson. If "I get enough time," TT-3 said, I would like to "implement the way she [female teacher in a video] was asking the students." It is important to note that by saying if "I get enough time," TT-3 was expressing the same frustration that all teachers had regarding the lack of enough time for engaging in more student-cantered problems due to the pressure of covering the syllabus.

## Discussion and Conclusions

From the findings of this study it can be concluded that when students solve problems on their own they are likely to come up with claims and conclusions some of which may not be strong. Thus, teachers' instructional moves that are less judgmental and that can provide students with opportunities to explain, justify and reconsider their thinking can help the students to improve their thinking as well as the products of their thinking. These findings appear to replicate Frey and Fisher (2010) who found that non-judgmental teacher instructional moves worked better when the goal is to help students generate constructive mathematical ideas. Teachers' instructional moves were also found to be a powerful tool for scaffolding students during problem solving. Specifically, these findings imply that if teachers are to involve in instructional moves that provide students with opportunities to explain and clarify mathematical concepts, they must work hard in avoiding the common IRE pattern.

Furthermore, findings from this study remind teachers that every kind of instructional move they make will have an intended purpose but the consequence can be both intended and unintended. This implies that teachers should pay attention to both intended and unintended consequences of their instructional moves/discourse whenever they get a change to reflect on their practice. This way, teachers are most likely to improve practice by learning from both the intended and unintended consequences of their instructional moves.s

Interview with teachers seemed to suggest that they neither appreciate nor conduct action research and also they are not involved in reflective practice. On the one hand, their responses reflect the common challenge facing many teachers. This implies that, for these teachers to have more efficacy on CPS and other student-cantered methods, they ought to be supported to change their perceptions. On the other hand, their concern about the barriers is justified. Thus, changing teachers' perceptions should go hand in hand with creating enabling environments for CPS to take place. One way to change teachers' perceptions would be to encourage them to involve more in reflective practices and action research. For instance, teachers can observe each other's classroom session and/or watch videos of other teachers facilitating CPS of ill-structured problems and then discuss the many ways they can improve their practice.

Indeed, by watching the video of other teachers facilitating a CPS class, the teachers who participated in this study seemed inspired and motivated to do the same. In relation to that, teachers could also be encouraged to conduct action research within their school premises and beyond if possible and share the results with other teachers. Collaborative action research among teachers has been found to be a powerful engine that drives teachers' perceptions change and professional growth (Fernandez, 2017; Hairon, 2017). Specifically, action research enables teachers to reflect on their own actions and make important decisions and steps towards change (Teo, Badron & Tan, 2017). Nonetheless, it is important to note that for all these to happen the ministry responsible for education must create policies and structures that permit these to happen. Such as rewarding teacher research, allocating time in the school timetable for students to solve ill-structured problems, enhancing teachers' knowledge and skills through professional development and, of course, reducing class sizes.

Assuming that these teachers' views represent the situation in other mathematics classrooms across Tanzania, the fact is that students are not given the opportunity to solve many complex ill-structured mathematical problems as interview data indicated, presents another problem that policy makers and teachers need to reconsider. This is because, first, ill-structured problems force students to be involved in "informal reasoning" where they have to make connections between different concepts as well as between new knowledge and real life experiences (Gil & Ben-Zvi, 2011, p. 88). According to Karpudewan and Roth (2018), making connections between concepts enables students to gain conceptual understanding. Second, problems in real life are oftentimes ill-structured with unpredictable and/or unknown solution pathways. Thus, exposing students to solving ill-structured problems can be said to be the best way to prepare them for future life. Third, when students engage with ill-structured problems in collaborative groups they are forced to provide explanations or what Gil and Ben-Zvi (2011, p. 89) have described as "answer[s] to the question why". Not only do explanations enhance informal reasoning among students (Gil & Ben-Zvi, 2011; Topcu & Yilmaz-Tuzan, 2011), but also they help teachers to uncover students' misconceptions regarding mathematical concepts (Karpudewan & Roth, 2018).

Fourth, full engagement in all the steps of problem solving and thus a meaningful development of problem-solving skills among students is best achieved when students get more opportunities to solve ill-structured problems (Jamaludin & Hung, 2017; LeFevre et al., 2017; Topcu & Yilmaz-Tuzan, 2011). That is to say, the advantages of being involved in solving ill-structured problems overweigh those of covering too much mathematical content. In other words, a trade-off between covering a mathematical content required to face national examination and the need to allocated time in school timetables for ill-structured mathematical problems so as to develop problem-solving skills and reasoning must be confronted.

## Recommendations

As science and mathematics teachers in Tanzania and elsewhere continue to struggle with the best ways to develop problem-solving skills among students as well as the implementation of more students-cantered methods, the following recommendations could guide that struggle:

i. There is a need for schools to allocate time and resource for students to solve ill-structured problems. Given the advantages associated with solving ill-structured problems, schools could allocate at least one hour per week for students to be involved in CPS.

ii. Encouraging teachers to conduct action research and other reflective practices. This is because formal education and workshops won't help teachers to cope with ever changing reforms, not to talk of learning from their own teaching. For instance, teachers can be encouraged to observe each other's' lessons, video recording of their own lessons and watch in teacher groups with the purpose to improve though feedback from peers. Moreover, teachers can also learn by watching videos of other teachers. Instituting school-based professional development system to enable teachers to reflect on their practice on daily bases. One possibility would be to institute compulsory weekly meetings where mathematics teachers of the same and/or different class levels meet to discuss students' problems, curriculum challenges etc.

iii. Working on other enabling environment for students to engage in CPS. Such as reducing teachers' workloads by reducing class sizes, providing teaching and learning resources, working on the challenge of power dynamics in the classroom. Developing model teachers' instructional moves that will provide clear guidance for teachers as they help students gain problem-solving skills in the context of CPS. This could be done first by studying the nature and patterns of instructional moves that dominate mathematics classrooms in Tanzania. Second, the information gathered will then be used to inform the development of a research-based model of instructional moves that will help teachers in the context of Tanzania.

## Limitations

Teachers and the researcher did not intervene when students were discussing in a group because of reasons beyond the scope of this study. Therefore, future studies are needed to investigate how teachers' instructional moves can be used to enhance students' problem-solving skills. To make students comfortable in a group, the researcher decided to invite only three teachers. Also, because of unavailability of large screen display, video watching was done using a laptop. Therefore, four individuals, the researcher included, was the maximum number the context could hold. Thus, further studies might tape on this limitation by increasing the sample size. Besides, while a video provided a good learning environment, it is not possible to consult the participants in case where teachers and the researcher wanted get clarification.

Finally, given that video data is always dense and with a lot of information, selecting a specific conceptual framework as a tool for analysis might have limited the discovery of other important aspects of teacher instructional moves and students' reasoning. Nonetheless, a specific conceptual framework helped the researcher to focus there by making data analysis easier and practical. Thus, other studies might study the impact of instructional moves on students' problem solving using other frameworks.

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