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ORIGINAL PAPER

In-service mathematics teachers' conception and perceptions of metacognition in their teaching experience

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Abstract

The present study investigated the in-service mathematics teachers' conception and perceptions of metacognitive awareness in their teaching experience. The study sample consisted of 213 Kenyan secondary school teachers. The study adopted a descriptive cross-sectional survey design that utilized both questionnaires and personal interviews. Thematic content analysis was used to analyze the interview data, whereas both descriptive and inferential statistics were employed for the questionnaire data. Results from descriptive statistics showed that teachers had high perceptions of their levels of metacognitive awareness although the mean for metacognitive knowledge was higher than the mean for metacognitive skills. The results of the T test and ANOVA analysis revealed a non-significant effect of the teachers' perceptions on gender, academic qualification, and years of teaching experience. This study revealed the need for teachers to understand the role of metacognition in learning and how they can model metacognitive strategies to the learners. There is a need for the curriculum developers to in-cooperate the concept of metacognition in the in-service and pre-service teacher training programs to enhance students' performance.

Keywords Mathematics teachers · Metacognition · Metacognitive knowledge · Metacognitive skills

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Introduction

Metacognition refers to being aware of one's thought processes (Merriam-Webster 2012). According to Flavell (1979), metacognition is the knowledge that helps one to regulate his/her cognitive activities in the learning processes. Metacognition has been regarded as consisting of two major parts namely, metacognitive knowledge and metacognitive skills (Lai and Viering 2012; Veenman 2011; Veenman et al. 2006; Williams and Atkins 2009). Over the past four decades, research on metacognition and its implications to teaching and learning is increasingly becoming an area of focus among educational researchers. This is due to the proven benefits of metacognition in children's learning (e.g., Csíkos and Steklács 2010; Naseri et al. 2017; Roll et al. 2011).

Metacognitive knowledge has widely been categorized into declarative, procedural, and conditional knowledge (Harris et al. 2010). Metacognitive skills or regulation of cognition have also been conceptualized under three components: planning, monitoring, and evaluating (Harris et al. 2010). Metacognitive skills generally encompass the acquired repertoire of strategic knowledge necessary for monitoring, directing, and managing learning activities (Veenman 2011). Self-monitoring, planning, and self-evaluation are, therefore, part of the metacognitive skills that can be practiced in a learning situation. According to Veenman (2011), the indicators of metacognitive skillfulness include planning, monitoring, note-taking, and time and resource management.

Various studies have shown that the training of students in metacognitive skills greatly enhances their performance (e.g., Donker et al. 2014; Kramarski and Mevarech 2003). A study by Veenman and Spaans (2005) on solving mathematical word problems by secondary school students revealed that students perform better when learning is supported by a series of metacognitive cues. Other studies have also shown the need for metacognitive skills training in schools (e.g., Mevarech and Fridkin 2006; Muijs et al. 2014).

Teachers' metacognition and academic achievement

Teachers are expected to prepare learners to construct knowledge. This implies that teachers must model their teaching to the extent that learners can engage in monitoring and self-regulating learning behaviors. Significant research on how metacognitive skills training impacts learners' academic achievement has been done (e.g., Baas et al. 2014; Hattie 2013; Stel and Veenman 2010). Some studies have also focused on how metacognition impacts pre-service teachers' academic achievement (Abdellah 2015; Hashmi et al. 2019; Young and Fry 2008a, b).

While Hashmi et al. (2019) found a negative correlation between metacognition and academic achievement among the prospective teachers, other studies yielded a positive correlation (Abdellah 2015; Young and Fry 2008a, b). Studies related to teachers' metacognition have mostly focused on pre-service teachers' metacognition. However, little is known about in-service teachers' metacognition. It is necessary to

also assess how practicing teachers are utilizing their metacognitive knowledge and skills in the process of teaching and learning.

Metacognition and background factors (gender, teaching experience, and qualification)

Gender, teaching experience, and teacher qualification are among the most cited background factors influencing mathematics learning. Research reveals that female teachers have a higher likelihood of using student-centered approaches in teaching as compared to male teachers. Likewise, experienced and more qualified teachers are likely to use a wider range of teaching approaches as compared to the less experienced and less qualified teachers (OECD 2009). Little is, however, known regarding how these three background factors impact teachers' metacognition. The foregoing literature has shown that metacognition has an influence on students' learning and that teachers play a great role in enhancing students' metacognition. It is, therefore, important to investigate whether teachers' background factors like gender, experience, and qualification can influence teachers' metacognition.

Although teacher's metacognition has not been widely studied, some studies have suggested that experience, academic qualification, and gender can influence teachers' metacognition. According to Young and Fry (2008a, b), the more experienced (graduate) education students had higher scores of their metacognitive skills as compared to the less experienced (undergraduate) education students. There was, however, no difference regarding their scores on knowledge of cognition. A recent study by Kallio et al. (2020) revealed that more experienced teachers (more than 10 years) had a higher perception of support of their learners' metacognitive awareness more than the less experienced teachers. Other studies also found similar results (Jiang and Gao 2016; Stewart et al. 2007).

Regarding gender and teachers' qualifications, Kallio et al. (2020) observed that women's perception of the support of their learners' metacognition was higher than men's, and teachers with masters' degrees were seen to provide more assistance to their learners as compared to Bachelors' degree holders. However, no significant gender differences among the pre-service teachers were found by Usher (2019). Likewise in the study carried out by Ekici et al. (2019), the pre-service male and female teachers had similar perceptions of their metacognition. Ibrahim and Watts (2016) too observed that males and females had similar perceptions of their metacognitive skills. These studies, however, mainly focused on prospective teachers.

The current study

Research on metacognition has mainly focused on the learners and pre-service teachers. Few recent studies on in-service teachers' metacognition have focused on preschool, primary, and special education teachers (Kallio et al. 2020; Sulaiman et al. 2021; Thienngam et al., 2020). The results on the effect of gender, experience, and qualification in these studies are, however, not consistent. Furthermore, none of these studies focused on mathematics teachers' metacognition. Studies have

generally shown the need for training the learners in metacognition. The implication is that teachers must be metacognitive in their teaching so that they teach or model the same to their learners (Martinez 2006; Tanner 2012; Wilson and Bai 2010). Teachers' understanding of their levels of metacognition can be a head start in the training of learners' metacognitive skills. In-service teachers' metacognition is, however, one of the under-researched areas.

The current study explored the levels of metacognitive awareness among practicing mathematics teachers in Kenya. The motivation behind this study is the fact that no study has been done in Kenya regarding teachers' metacognition despite the role it plays in students' achievement. This study will, therefore, form a basis for further research on metacognitive awareness among teachers in Kenya and how it can be utilized for the benefit of students' learning. The present study responded to the following research questions:

1. To what extent do secondary school mathematics teachers in Kenya perceive their use of metacognitive knowledge and skills in teaching mathematics?
2. Is there any effect of gender, teaching experience, and level of education on the metacognitive awareness of secondary school mathematics teachers in Kenya?
3. What conception of metacognition do Kenyan secondary school mathematics teachers report?

Methodology

Sample

The sample consisted of 213 (157 males) secondary school mathematics teachers from 50 selected public secondary schools in Kenya. The 50 schools were obtained through a stratified random sampling technique to include the different categories of schools (National, County, or Sub-county) and different school types (boys, girls, or mixed). The sample of 213 teachers was then purposefully obtained by considering all mathematics teachers in the selected schools who taught a grade 11 class. Out of 213 participants, 166(77.9%) had a Bachelor of Education (BEd) degree; 19(8.9%) had either a Bachelor of Arts or Bachelor of Science (BA/BSc) degree; and 25(11.7%) had a Diploma in Education, while 3(1.4%) had a Master's degree in Education (MEd). Regarding teaching experience, 125(58.7%) had an experience of up to 5 years; 41(17.2%) an experience of between 6 to 10 years; 27(12.7%) an experience between 11 to 15 years and 20(9.4%) with an experience above 15 years.

Design

The study adopted a descriptive cross-sectional survey design that utilized both questionnaires and personal interviews (Creswell 2009). This method was deemed viable for the current study since the aim was to relate the quantitative and the qualitative findings and, hence, gain more insight into the mathematics teachers'

perception and conception of metacognition. The questionnaire was used to collect the quantitative data whereas structured interviews acquired qualitative data.

Instruments

Questionnaire

The self-report paper and pencil questionnaire comprised two parts. The first part contained questions related to demographic characteristics and the second part consisted of 24 items (questions) adopted from Balcikanli (2011). The 24 items were used to rate the mathematics teachers' metacognitive awareness (Table 1). The Metacognitive Awareness Inventory for Teachers (MAIT) scale (Balcikanli 2011, P. 1323) was developed for measuring teachers' metacognitive awareness. In the current study, the scale was adopted for mathematics teachers. The teachers were clearly instructed to relate the responses to their mathematics classes since some mathematics teachers also taught a different second subject.

The MAIT scale is composed of two dimensions each with 12 items. The metacognitive knowledge dimension has three subscales each with four items: declarative knowledge (DK), procedural knowledge (PK), and conditional knowledge (CK). The metacognitive regulation dimension included planning (P), monitoring (M), and evaluating (E) subscales each with four items (Balcikanli 2011, p. 1323). Items were rated on a 5-point Likert scale ranging from 'Not at All' (NA = 0) to 'Always' (A = 4).

Interview schedule

Eight interview questions were developed by the researchers to get more insight into the themes covered by the subscales on the MAIT scale. The interview sample consisted of 10 teachers (male = 7) who were chosen from ten randomly selected schools. The structured questions focused on the teachers' understanding and use of metacognitive knowledge and skills in their teaching. The interview questions were as follows:

1. What would you consider as your strengths and weaknesses in teaching mathematics?
2. What do you consider before deciding on a particular method to use in your teaching?
3. How do you make use of your strengths and weaknesses?
4. How often do you prepare your lesson plans?
5. How often do you evaluate your teaching goals at the end of each lesson?
6. How often do you question whether you are meeting your teaching objectives while teaching?
7. To what extent did your teaching approach predict students' achievement at the end of term one exams?
8. Do you consider yourself a metacognitive teacher? Briefly explain?

Table 1 A 24-item questionnaire and the subscales

Scale	Items	Questions
Declarative Knowledge (DK)	Item 1	I am aware of the strengths and weaknesses in my teaching
	Item 2	I know what skills are most important to be a good teacher
	Item 3	I know what I am expected to teach
	Item 4	I have control over how well I teach
Procedural Knowledge (PK)	Item 5	I try to use teaching techniques that worked in the past
	Item 6	I have a specific reason for choosing each teaching technique I use in the class
	Item 7	I am aware of what teaching techniques I use while I am teaching
	Item 8	I use helpful teaching techniques automatically
Conditional Knowledge (CK)	Item 9	I use my strengths to compensate for my weaknesses in my teaching
	Item 10	I can motivate myself to teach when I need to teach
	Item 11	I use different teaching techniques depending on the situation
	Item 12	I know when each teaching technique I use will be most effective
Planning (P)	Item 13	I pace myself while I am teaching to have enough time
	Item 14	I teach my specific goals before I start teaching
	Item 15	I ask myself questions about the teaching materials I am going to use
	Item 16	I organize my time to best accomplish my teaching goals
Monitoring (M)	Item 17	I ask myself periodically if I meet my teaching goals while I am teaching
	Item 18	I find myself assessing how useful my teaching techniques are while I am teaching
	Item 19	I check regularly to what extent my students comprehend the topic while I am teaching
	Item 20	I ask myself questions about how well I am doing while I am teaching
Evaluating (E)	Item 21	I ask myself how well I have accomplished my teaching goals once I have finished
	Item 22	I ask myself if I could have used different techniques after each teaching experience
	Item 23	After teaching a point, I ask myself if I would use it more effectively next time
	Item 24	I ask myself if I have considered all possible techniques after teaching a point

Adopted from "Metacognitive awareness inventory for teachers (MAIT)," by C. Balcikanli 2011, *Electronic Journal of Research in Educational Psychology, 9* (3), 1309–1332, adopted with permission

Data collection procedure

The research was conducted in 2019 after obtaining ethical approval from Pwani University of Kenya and getting a license from the Nation Commission for Science, Technology, and Innovation. The lead researcher and research assistants visited the schools and administered the questionnaires to the mathematics teachers with the assistance of the heads of mathematics departments. The filling of each questionnaire took approximately 20 min to complete. The interview was conducted on different dates after seeking the teachers' consent. Teachers were interviewed separately by the lead researcher after assuring them of the confidentiality of the recorded scripts. The interview took between 30 to 35 min for every teacher.

Data analysis

Questionnaire analysis

The adopted MAIT scale had already been validated by performing a confirmatory factor analysis on a separate sample of 180 mathematics teachers. The validation was necessary since the instrument had not been used in Kenya before. Different fit indices which included Minimum discrepancy per Degree of Freedom(CMIN/DF), Root-Mean-Square Error of Approximation (RMSEA), Standardized Root-Mean-Square Residual (SRMR), Tucker-Lewis Index (TLI), and the Comparative Fit Index (CFI) were used to test the model fit to the Kenyan sample. Confirmatory factor analysis ($N = 180$) of the six-factor model resulted to acceptable fit indices as follows: CMIN/DF = 2.275, RMSEA = 0.084, SRMR = 0.058, TLI = 0.913, CFI = 0.933 (Schumacker and Lomax 2004; Ho 2006). Reliability analysis of the questionnaire was determined using Cronbach's Alpha for the different subscales and the overall scale (DK = 0.65; PK = 0.67; CK = 0.73; $P = 0.65$; M = 0.70; E = 0.86; overall scale = 0.92). All the alphas were within the acceptable range, hence, confirming that the MAIT scale measured precisely the underlying constructs.

Interview analysis

The thematic content analysis approach was used to scrutinize interview data by first identifying the common themes across the dataset (Creswell, 1994). The analysis involved six steps as suggested by Miles and Huberman (1994): (1) Listening to the tape and transcription of the interview; (2) Becoming familiar with the transcripts by reading them over and over; (3) Coding; (4) Summarizing the coded data; (5) Data interpretation; and (6) Confirming the findings. Confirmation of the findings was done by taking the transcript and the interpretation back to the respondents, and they were asked if they agreed with the interpretation. All the participants agreed with the interpretation.

Findings

The findings of the present study were categorized into quantitative (descriptive, t test, and ANOVA statistics) and qualitative (interview analysis).

Descriptive statistics

Descriptive statistics were used to examine the perceptions of teachers regarding their metacognitive awareness. The analysis indicated a mean score of 3.31 for items under the metacognitive knowledge dimension and a mean score of 2.91 for items under the metacognitive skills dimension. All the items under the metacognitive knowledge dimension had a mean score of between 3.11 and 3.53 which corresponded to "often" on a 5-point Likert scale implying mathematics teachers had a high perception of their metacognitive knowledge. Regarding the metacognitive skills dimension, the mean score range was between 2.63 and 3.13 with an average of 2.91 corresponding to "often." Teachers had the lowest perception of Items in the subscale of evaluative skills (21, 22, 23, and 24) as compared to items in other subscales.

In general, the perceptions of mathematics teachers regarding their level of metacognition can be rated as positive although the perceptions regarding metacognitive knowledge were higher than perceptions regarding metacognitive skills. Tables 2 and 3 give a summary of the descriptive statistics regarding the teachers' perceptions of their levels of metacognitive awareness.

Further analysis of the three subscales of metacognitive knowledge revealed that teachers had a higher perception of their declarative knowledge as compared to procedural knowledge and conditional knowledge. Regarding the subscales of metacognitive skills, teachers had a higher perception of their monitoring skills as compared to planning and evaluating. Table 4 shows the descriptive results of the six subscales of the metacognitive scale.

T test and ANOVA results

Independent samples T test and one-way ANOVA were used to examine the effect of background factors (gender, teaching experience, and qualification) on teachers' perceptions of their metacognitive awareness. The t test results exhibited non-significant differences in the means of male ($M=3.31$, $SD=0.46$) and female teachers ($M=3.32$, $SD=0.40$); t $(211)=-0.13$, $p=0.90$ for metacognitive knowledge. Similarly, no significant difference in the means of male ($M=2.88$, $SD=0.73$) and female teachers ($M=2.98$, $SD=0.60$); t $(211)=-1.08$, $p=0.28$ for metacognitive skills was found.

There was no effect of teacher qualification on teachers' perceptions at $p=0.05$ for the four categories of teacher qualification [F $(3, 209)=0.56$, $p=0.64$] for metacognitive knowledge and metacognitive skills [F $(3, 209)=0.59$, $p=0.62$]. Similarly, a one-way ANOVA conducted on teaching experience resulted in a non-significant

Table 2 Descriptive statistics of teachers' perceptions on metacognitive knowledge ($N = 213$)

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Overall mean
M	3.32	3.36	3.46	3.53	3.20	3.37	3.44	3.24	3.27	3.27	3.20	3.11	3.31
SD	0.79	0.74	0.68	0.75	0.83	0.78	0.74	0.85	0.78	0.88	0.92	0.83	0.45

Table 3 Descriptive statistics of teachers' perceptions on metacognitive skills ($N = 213$)

	Item 13	Item 14	Item 15	Item 16	Item 17	Item 18	Item 19	Item 20	Item 21	Item 22	Item 23	Item 24	Overall mean
M	3.00	2.59	3.08	3.13	3.00	3.03	3.11	3.07	2.90	2.63	2.64	2.70	2.91
SD	0.89	1.22	0.95	0.85	0.98	0.96	0.91	1.02	1.11	1.15	1.24	1.21	0.71

Table 4 Descriptive statistics of perceptions on metacognitive awareness sub-skills ($N = 213$)

	Declarative knowledge	Procedural knowledge	Conditional knowledge	Planning	Monitoring	Evaluating
M	3.41	3.31	3.32	2.95	3.05	2.72
SD	0.52	0.53	0.63	0.67	0.79	1.00

difference [F (3, 209) = 0.16, $p = 0.92$] for the four categories of teaching experience regarding metacognitive knowledge. There was also no significant difference [F (3,209) = 0.53, $p = 0.66$] for the four categories of teaching experience regarding metacognitive skills. Table 5 gives a summary of the mean and standard deviations of metacognitive knowledge and skills for the background factors.

Interview analysis

Ten teachers participated in the interview. The interview consisted of eight semi-structured questions with associated probes. The interview aimed to help triangulate the research and hence strengthen the findings from the quantitative data. The analysis centered on the two major themes of metacognition and the six subthemes that had already been established during the quantitative phase.

Theme 1: metacognitive knowledge

Declarative knowledge

The interview guide for questions on declarative knowledge sought to find out more information on teachers' awareness of person, task, and strategy variables. The main question that was asked related to teachers' declarative knowledge

Table 5 Descriptive statistics of teachers' perceptions based on background factors

Background factors		Metacognitive knowledge		Metacognitive skills	
		M	*SD*	*M*	*SD*
Gender	Male	3.31	0.46	2.88	0.73
	Female	3.32	0.40	2.98	0.63
Teacher qualification	BEd	3.32	0.45	2.92	0.72
	BA/BSc	3.20	0.47	2.90	0.72
	Diploma	3.30	0.41	2.70	0.70
	MEd	3.53	0.53	3.05	0.55
Teaching experience	Up to 5 years	3.30	0.44	2.93	0.74
	6 to 10 years	3.31	0.47	2.85	0.69
	11 to 15 years	3.35	0.47	2.96	0.68
	Above 15 years	3.27	0.46	2.75	0.62

about their strengths and weaknesses: *what would you consider as your strengths and weaknesses in teaching mathematics?* This question aimed to find out if teachers were aware of their strengths and weaknesses. All teachers interviewed responded that they were aware of their strengths related to content knowledge, class control, giving feedback to students, and the use of different student-centered approaches in teaching. Regarding knowledge of their weaknesses, eight teachers admitted they have some weaknesses and were aware of them. Some of the weaknesses mentioned included poor time management and a negative attitude towards some topics.

> Teacher 1: I always have a problem with time management in almost all of my classes however much I try. To me, 40 minutes are never enough and I even hardly notice how time passes when I am teaching. I think I do much of the talking. I may need to work on this weakness.

Two teachers were, however, skeptical about mentioning their weaknesses. One of the teachers (teacher 4) said:

> I enjoy teaching mathematics and I don't have issues with any topic. I have taught mathematics for over 15 years and the major challenge I have always encountered is on dealing with students' negative attitudes towards some topics.

Procedural knowledge

The interview guide for questions on procedural knowledge sought to gain an understanding of teachers' utilization of their procedural knowledge. The main question asked was *what do you consider before deciding on a particular method to use in your teaching?* This question elicited varied responses based on teachers' teaching experience. One more experienced teacher reported that he used various methods depending on the topic and the class size.

> Teacher 2: My choice of the teaching method depends on the topic and the class size. If for example am teaching a topic like statistics, I just divide students into groups and give them a task to work on. Some topics will require me to do a demonstration on the chalkboard and ask students to work individually especially if the class is large.

One teacher (less than 5 years of teaching experience) demonstrated the use of procedural knowledge although he seemed to be slightly limited as compared to the more experienced teacher.

> Teacher 7: Mathematics is a hands-on activity and so I always prefer working with students in small groups. I first do a demonstration on the chalkboard then give them activities in groups. I don't want to teach mathematics the way I was taught (teacher-centered approach) because it makes students passive participants.

Conditional knowledge

Questions on conditional knowledge investigated teachers' application of their declarative and procedural knowledge. The main question concerned how teachers use their strengths and weaknesses: *how do you make use of your strengths and weaknesses?* Most teachers said that they maximize their strengths and seek assistance in their weak areas.

> Teacher 9: Whenever I come across a difficult problem, I usually ask my colleagues to assist or sometimes I give the challenge to my students. My students may know some concepts better than I do. Team teaching has worked well in my school since no one has a monopoly on knowledge.

Theme 2: metacognitive skills

Planning

The questions on planning focused on how teachers plan their teaching to attain lesson goals. The main question asked was: *how often do you prepare your lesson plans?* All the 10 teachers admitted that they rarely prepared lesson plans although they always had an idea of what to teach. Regarding lesson organization, the ten teachers mentioned that they divided their lesson into the introduction, body, and conclusion although in most cases they hardly followed the plan.

> Teacher 6: I prepare the lesson plan once in a while because it's part of the requirements. It's rarely practical for every lesson. Like on average I have 28 lessons per week so it's almost impossible to have an elaborate lesson plan. Besides, I may prepare and end up failing to follow it.

Monitoring

The questions on monitoring focused on teachers' self-testing skills needed to regulate learning. The main question asked was *how often do you question yourself whether you are meeting your teaching objectives while teaching?* Questions on monitoring elicited different responses which included the following:

> Teacher 5: Based on my experience, with time I have known what works for me and what fails to work. In most cases, I assess my teaching techniques after the lesson. I can be able to tell if students understood the concept or if they need a remedial lesson.

> Teacher 10: Sometimes it's hard to check the understanding of the students during the lesson but after giving them some tasks, I can be able to check the understanding based on their responses to the tasks.

The analysis showed that teachers generally self-test their skills but after the lessons. Some of the reasons they pointed out as affecting their self-monitoring processes were the heavy workload and large class sizes. It seemed from the responses that teachers engage in self-monitoring processes only after assessing the students' performance on continuous assessment tests.

Evaluating

The questions on evaluating related to how teachers examine their progress as they strive to achieve the set goals. An example of the question asked was *how often do you evaluate your teaching goals at the end of each lesson?* Responses to the questions relating to evaluation showed that this was one of the skills that teachers rarely thought about. All teachers said they rarely evaluate their teaching goals because in most cases they hardly prepare the lesson plan.

> Teacher 9: Once I finish teaching the first class, I am always in a hurry to attend the next class. I don't even have time to evaluate my teaching as much as I know the importance of doing so. During my free time, I am busy marking students' books and rarely get time for reflection.

Related to evaluation, teachers were requested to rate how their teaching approach predicted their students' achievement based on the previous end-of-term performance (*Do what extent did your teaching approach predict students' achievement at the end of term one exams?*). Out of the ten teachers, seven teachers reported that they tried to do their best to employ the student-centered approaches in their teaching but their efforts were rarely reflected in students' performance. When they were requested to rate on a five-point scale, seven rated themselves on a scale of '1' which corresponded to rarely, and three rated themselves on a scale of '2' which corresponded to sometimes.

The final question asked teachers whether they considered themselves as metacognitive teachers (*Do you consider yourself a metacognitive teacher? Briefly explain?*). This seemed to be a challenging question for the teachers as most of them exhibited little understanding of what metacognition was all about. The first two teachers that were interviewed considered themselves as metacognitive teachers but their reasons showed a lack of clear understanding of what metacognition involved.

> Teacher 1: I think I am a metacognitive teacher because I involve my students in active learning through discussions and group activities that are mainly hands-on.

> Teacher 2: I think I am a metacognitive teacher because I prepare my lessons and reflect on what I want to teach even though I don't always have a lesson plan with me in class.

Based on the responses of the first two teachers, there was a need to explain the meaning of metacognition and its components to the remaining eight teachers before they were asked whether they considered themselves as metacognitive

teachers or otherwise. All eight teachers said they were aware of their metacognitive knowledge (declarative, procedural, and conditional knowledge), and used it to a greater extent while teaching students. Regarding the regulation of cognition, five of them reported that they monitor and reflect on their teaching but in most cases fail to plan and evaluate their teaching. Three teachers felt they were less effective in utilizing their metacognitive skills:

> Teacher 5: I think to be a metacognitive teacher needs more than just writing down a lesson plan. One must be intentional and have enough time to plan and reflect on the lesson to be taught. As much as I would wish to plan and evaluate my teaching, I have little time for that. On a scale of "1 to 5", I can give myself a 3.

> Teacher 7: I sometimes reflect on the topic but sometimes fail to prepare adequately due to other factors like large class sizes and greater workload without any extra pay.

Discussion

Previous research findings have suggested that metacognitive skills training improves students' achievement (Baas et al. 2014; Hattie 2013; Muijs et al. 2014; Stel and Veenman 2010). These findings are, however, based on the assumption that teachers are themselves metacognitive and can train students on how to use metacognitive strategies in their learning. Perhaps the question that researchers need to ask themselves is whether the teachers are aware of their metacognition. The argument paused in the present study is that one can only give out what he/she has. In other words, teachers can only train students on how to be metacognitive if they are also metacognitive. The present study thus explored the mathematics teachers' perceptions of their metacognition, the effect of background factors on metacognition, and teachers' conception of metacognition.

Teachers' perceptions

Research question one established the extent to which secondary school mathematics teachers in Kenya perceived their levels of metacognitive knowledge and skills in teaching mathematics. Descriptive statistics analysis showed that mathematics teachers rated themselves highly regarding their level of metacognitive awareness although their rating for metacognitive knowledge was higher than the rating for metacognitive skills. The analyses, thus, imply that teachers have positive perceptions of their metacognitive awareness. Descriptive statistics results were also supported by the qualitative analysis of the interview where teachers reported that they were aware of their metacognitive knowledge and skills. Özsoy and Günindi (2011) similarly found a medium to high-level metacognitive

awareness of the pre-service teachers. Koc and Kuvac (2016) too found positive perceptions of metacognitive awareness by prospective science teachers.

Background factors and teachers' perceptions

The second research question examined if there was any effect of gender, teaching experience, and level of education on the metacognitive awareness of secondary school mathematics teachers in Kenya. This question was answered by conducting an independent samples *t* test and ANOVA statistics. The outcome of the analysis showed a non-significant effect of gender, teaching experience, and level of education on both the metacognitive knowledge and metacognitive skills of the participants. The non-significant effect could be due to team teaching which is a common practice in secondary schools in Kenya, especially for mathematics teachers. This is a case where two or more teachers teach the same class but on different topics. Team teaching may have influenced teachers' perceptions of their cognition and regulation of cognition. Constant interactions and sharing of classroom experiences may have similarly shaped the teachers' perceptions.

Previous studies although dealing with pre-service teachers also found statistically non-significant gender differences in teachers' metacognitive awareness (Alci and Karatas 2011; Ekici et al. 2019). The current findings show that background factors of gender, experience, and level of education have little influence on the in-service teachers' perceptions of metacognition. This being an exploratory study on teachers' metacognition, the results are very important in informing the nature of intervention programs, especially in the Kenyan context.

Teachers' conception of metacognition

The third research question sought to get a deeper understanding of the Kenyan secondary school mathematics teachers' conception of metacognition as reported through interviews. The analysis was based on the two major themes and the subthemes identified during the questionnaire analysis. The first theme, metacognitive knowledge which relates to person, task, and strategy variables (Mahdav 2014) is divided into declarative knowledge, procedural knowledge, and conditional knowledge. The interview of teachers regarding their metacognitive knowledge revealed that teachers made use of their metacognitive knowledge. For instance, they were able to identify their strengths and weaknesses (declarative knowledge); used varied teaching approaches (procedural knowledge); and made good use of their strengths and weaknesses (conditional knowledge).

The second theme analyzed teachers' metacognitive skills which encompass planning, monitoring, and evaluation. Regulation of cognition enables one to know what to do (task orientation), what to achieve (goal setting), and how to achieve the goal (planning). Teachers get involved in the regulation of cognition when they plan their teaching, monitor themselves during lesson delivery, and evaluate the outcome of their teaching. Analysis of teachers' metacognitive skills revealed that teachers

generally had an understanding of the skills involved in the regulation of cognition but rarely put them to use. These results show that more effort is needed for teachers to translate their metacognitive regulation to actual classroom teaching. Thienngam et al. (2020) found out that training primary science teachers improved the metacognitive regulation for early childhood learners.

Teachers mentioned large class sizes, greater workload, and lack of motivation as some of the reasons that hindered their use of metacognitive skills. The interview analysis generally revealed that teachers failed to utilize their metacognitive skills fully. Earlier studies on teachers' promotion of self-regulatory strategies in classes have shown that teachers rarely supported the use of metacognitive skills in classrooms but instead promoted cognitive strategies (Dignath and Büttner 2018; Dignath-van Ewijk et al. 2013; Spruce and Bol 2015).

One interesting finding in the interview analysis was the misapprehension that some teachers had about the term metacognition. This was revealed through question eight when teachers were asked whether they considered themselves as metacognitive teachers and to give reasons why they thought so. Most of the teachers took metacognition to mean students being actively involved in learning, and therefore, the assumption was that as long as students were engaged in discussion and group work activities, metacognitive strategies were being utilized. The responses from the teachers revealed that the understanding of active learning is also misunderstood.

Active learning is defined as "anything that engages students in doing things and thinking about the things they are doing" (Bonwell and Eison 1991, p. 19). Metacognition, on the other hand, involves students thinking about their learning process by engaging in self-regulatory processes like self-monitoring and self-evaluation. In other words, active learning appeals to cognitive processes instead of metacognitive processes. Active learning can be treated as a prerequisite for metacognition but it does not imply that active engagement of students in learning activities is being metacognitive. Teachers in most cases apply active learning pedagogies like engaging students in hands-on activities but little do they consider minds-on activities.

Limitations

The present study was conducted in the western part of Kenya, and the results can, therefore, be generalized only to the schools in the western region of Kenya. Future research can consider replicating the same study to other regions in the country. Although triangulation using questionnaires and interviews was employed in the study, future studies can also incorporate the observation of teachers in classes to increase the validity of the results. This study only focused on three background factors relating to experience, level of education, and gender. Other socio-psychological factors such as attitude towards the teaching profession, self-efficacy, motivation, and school support can also be investigated in future studies.

Conclusions and suggestions

Research has shown that metacognition is crucial to the learning process, and it determines learning performance to a large extent. Both quantitative and qualitative analysis of data in this study has revealed that mathematics teachers perceive themselves as highly metacognitive. These perceptions are, however, hardly translated into the teachers' actual classrooms. The report from the teachers' interview showed that teachers face challenges that hinder them from utilizing their metacognitive skills. There is, therefore, a need for addressing the challenges so that teachers can consciously utilize their metacognitive skills and model the same to their students.

This study has revealed the need for in-service teacher training on metacognition implementation in the classrooms. Teachers must be made aware of the benefits of metacognition in students' learning. There is, therefore, a need of introducing metacognition as a course in the teachers' training colleges and in-service training so that teachers are equipped on how to integrate metacognition in their teaching. It is important to integrate metacognition in the in-service training of teachers so that teachers will be able to model the same to the students. Teachers can also make use of other metacognitive strategies like mind maps and concept maps that will help students to consciously solve new and challenging problems.

The findings of this study contribute to the limited literature regarding in-service secondary schools mathematics teachers' conception and perceptions of metacognition. The results have shown the need for training teachers on the implementation of metacognition in secondary schools. The similar perceptions of teachers based on the three background factors inform the type of training programs that can be given to teachers. The study shows that teachers' metacognition is not influenced by gender, teaching experience, or level of education. In-service teacher training should, therefore, not be based on these factors.

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Declarations

Conflict of interest The authors did not report any potential conflict of interest regarding this study.

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