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Examining College of Education Students' Metacognitive Consciousness in Solving Problems on Geometric Theorem

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Abstract

Improving the quality of mathematics education and achievement at both the College level and the Basic schools are dependent on effective teaching and learning strategies. This drives attention towards identifying underlying factors to competent performance which is dependent on the efficiency of teachers and students in the use of metacognitive learning strategies. To this effect, the interest was to determine whether College of Education students adopt metacognitive strategies to tackle problems on Geometric Theorem. To suit the purpose of the research, collective case study design was used to obtain the range of distribution of the variables of interest within the population. The study was conducted using nine Colleges of Education in the Northern Zone of the country. The sample comprising equal numbers of Elective Mathematics students and non-Elective Mathematics students were randomly drawn from two Colleges which were purposefully selected from the nine Colleges. Questionnaire was employed to collect the data which was adapted from a standard tool for measuring the subscales under metacognition. Mean and standard deviation for responses under the metacognition subscales (procedural knowledge, declarative knowledge, information management strategies, debugging strategies, planning, monitoring comprehension and evaluation) of the instrument showed that the respondents were conscious of their metacognitive strategies adopted in solving Geometric Theorem (GT) problems. The results revealed remarkable levels of consciousness in each of the subscales.

Keywords

Difficult Topics, Metacognitive Strategies, Cognitive Awareness, Geometric Theorem, Metacognitive Consciousness

1. Background of the Study

Besides the development of professional competence, transformations of the Colleges of Education in Ghana over the years were also geared towards improving the mathematics competence in both content and pedagogical knowledge. The programs rolled out over the years include, post middle certificate teachers training programme, phased out in 1992 and replaced with a post-secondary certificate teachers programme, which was also replaced with a Diploma awarding programme dubbed IN-IN-OUT programme with an introduction of a full academic year of internship. Currently a drastically reformed programme leading to the award of a four-year bachelor of education certificate with an enhanced exposure to practicum was implemented in 2018.

To improve content knowledge, the First-Year College Courses in mathematics are foundation courses meant to bridge the gaps in college students' High School mathematics (University of Cape Coast, 2020). To build a solid foundation in mathematics as a prerequisite, a more improved strategy of learning mathematics needs to be adopted by students in the Colleges of Education. To effectively achieve this drive, it is very crucial that more efficient strategies are adopted in teaching and learning in the Colleges of Education, considering that, products of the Colleges would also be involved in teaching of learners at the Primary and Junior High Schools. Metacognition should therefore be given significant consideration as a strategy for effective teaching and learning.

According to Tansyani (2016), consciousness in significant levels of metacognition is closely related to student's ability to develop and use improved learning process by designing enhanced models, monitoring, evaluating and reflecting on the process of learning. Ulfa, Sistiana, and Setiono (2018), cite a number of authors (Fauzi, 2013; Panchu, Bahuleyan, Seethalakshmi, & Thomas, 2016) who emphasized the need for good metacognition during learning and demanded great efforts from teachers and lecturers to empower students with metacognitive abilities. The argument from these authors presupposes that student with good metacognitive awareness will learn better and faster relative to those who do not have good metacognitive awareness. Cognitive awareness in effect would enhance learning abilities through reflection, self-regulation and self-evaluation.

Teachers in Colleges of Education are expected to equip student teachers with knowledge in both content and pedagogy to be able to teach competently as Basic School Teachers. It is therefore very critical that college students are exposed to comprehensive instructional methodologies which would strengthen their competencies and enable them to teach children mathematics effectively and as well enable them to use metacognitive skills in learning mathematics concepts and to solve mathematics problems. Schraw, Crippen and Hartley (2006), report that teaching students how to learn allows them to develop the ability of transferring skills which is essential for them throughout the period of furthering their education and career. This affirms the essence for teachers to equip their students with metacognitive skills to effectively learn mathematics concepts.

"Learner's use of metacognitive skills and strategies, such as task analysis planning monitoring checking and reflection, self and group monitoring skills, reading and writing skills, self-regulation (SR) and self-assessment (SA) helped them in mathematics problem-solving. The learners could also solve problems more easily through group discussions and thinking about their own thinking" (Tachie, 2019). Despite the significant overlap of metacognition with cognition, Mevarech and Kramarski (2014), however illustrates some differences between the two with an example. For example, remembering your Automated Teller Machine (ATM) card Personal Identification Number (PIN) is cognition but metacognition is being aware of the strategies by which you can recall the PIN.

Schofield (2012) concluded in a study that successful learning requires metacognitive capabilities. Metacognition is about becoming aware of what you know as well as knowing the gaps in what you know. She narrates that when students were interviewed, several of them noted that they often completed a task without really knowing if they understood it.

Metacognitive strategies refer to methods used to help students understand the way they learn; in other words, it means processes designed for students to "think" about their "thinking" (Inclusive Schools Network, 2015). Classroom practices considered as metacognitive strategies include; asking questions, self-reflection, self-quizzing, self-recording, modeling, directly teaching learners these strategies, availability and accessibility of mentors, solving problems with colleagues, think aloud, self-explanation, keeping learning journals and providing opportunities for making errors (Drew, 2020; Marilyn, 2015; Kim, Park, & Baek, 2009). Du Toit and Kotze (2009), also reviewed literature and enumerated a number of metacognitive strategies suggested by the authors. Among the strategies were:

1) Planning strategy: teachers draw learners' attention to the rules and steps at the beginning of solving a task.

2) Generating questions: Du Toit and Kotze (2009) writes that Ratner (1991), sees generating questions as a metacognitive strategy and considers questioning of given information and assumptions as a vital component of intelligence.

3) Choosing consciously: through teacher support learners would be able to identify underlying relationship between their actions and the results of their actions.

4) Setting and pursuing goals: evaluating the way of thinking and acting, learners look back on their learning activity and identify feasible (practicable) strategies, exciting situations, obstacles and distasteful experiences.

5) Additional strategies they listed were, identifying the difficulty of a task, paraphrasing, elaborating and reflecting on ideas of learners, problem-solving activities, "thinking-aloud", journal-keeping, cooperative learning and modelling.

Most Pre-Tertiary Curricula might contain some activities and processes which are metacognitive strategies but do not directly classify them as metacognitive strategies. However, early childhood curriculum directly lists metacognitive processes which is captured as "learning to learn" as one of the five key principles which must pervade every domain of learning at that level (New Zealand Ministry of Education, 2007). Metacognitive training programmes introduces individuals to a set of rules and effective strategies to learn concepts in specific subject areas like English, Mathematics and Science (Flavell, 1987). A wide range of metacognitive strategies that can be adopted include, error-detecting, effort and allocation, elaborating, self-quizzing, self-explanation, developing visual representation of ideas visually, activating prior knowledge, double reading of difficult questions and reviewing experiences and concepts learnt. Metacognitive strategies support learners to effectively manage and settle on main thoughts when confronted with conflicting thoughts (Lin, 2001). These metacognitive strategies stealthily find their way into students approaches of learning or tackling problems on GT. These approaches might have been adopted consciously through teacher coaching or unconsciously during interaction in class, peer interaction or through self-strategizing.

Khan (2020) and Pintrich and colleagues (1991) have established that, there was no significant difference in awareness, knowledge and control of cognitive process between students in the traditional learning environment and online sessions. In a similar comparison, Khan noted that there was very minimal effect of the online sessions compared to the traditional sessions in terms of achievement and metacognitive awareness though students in the online sessions developed higher enthusiasm.

Results in a study conducted by Rezvan et al. (2006) suggest that metacognitive training increased the academic achievement of the group that received treatment. Their study also showed that metacognitive training also raised the happiness score-average of the same treatment group. Abdellah (2015) concluded in another study, that metacognitive skills play a significant role in student learning and recommend the inclusion of metacognition courses in Colleges of Education Teacher Training Programs. Schunk (2012), also agrees to the assertions that metacognition improves achievement but draws attention to the sticky point that, even after metacognition awareness, learners would not automatically adopt it when they encounter a task. These then put the responsibility on tutors to expose learners to numerous task that would engage metacognitive strategies to a point, when learners on a regular basis consciously and unconsciously use these strategies in GT task.

Pintrich and De Groot (1990) attest that, though academic achievement is not solely dependent on metacognitive strategies, it plays an essential role in students learning progression. Metacognition is self-motivating and further improves a student's desire towards learning and academic achievement. It follows also that students who are capable of motivating themselves are equally able to engage in metacognitive strategies such as planning, assessment and evaluating how well they are accomplishing a learning task.

Cognitive strategy instruction comprises of the cognitive and metacognitive strategies which promotes and results in learning and higher achievements, where the complexity of the strategies varies as a function of task difficulty (Montague, Krawec, Enders, & Dietz, 2014). Coughlin and Montague (2011), add that instructional approaches that use cognitive strategies have been shown to increase academic achievements. In addition to this, it is more rewarding to students who have mathematics learning disabilities after their use of cognitive strategies that support mathematics problem solving proficiency.

Gurat and Medula (2016) enumerate the factors that affect failure or success of problem-solvers to include metacognitive strategy knowledge. During mathematics problem-solving, metacognitive strategy knowledge emerges in a three-phase cyclic model. The model comprises preparatory metacognitive strategy knowledge, production metacognitive strategy knowledge and evaluation metacognitive strategy knowledge. The problem-solver initiates the process of solving the task by planning metacognitive strategies that would be employed in solving the problem. The second phase involves designing and execution of the metacognitive strategy planned the first stage and eventually the going over the process and solution obtained to determine its success. This spiral into another cycle if the solution obtained is not satisfactory.

1.1. Problem Statement

Learners' challenges and aversions to mathematics might not necessarily be a result of bad teacher attitudes and strategies employed in the mathematics classroom but probably the approach students adopt towards learning and solving mathematics problems. A study carried out in a traditional classroom showed that students' achievement is largely related to a range of learning strategies (Weinstein & Palmer, 2002).

This study was borne out of the interest to probe and determine the metacognitive strategies Trainee Teachers adopt in learning Geometric Theorems which is considered by some teachers and most students as one of the difficult topics. Domingo (2016), mentions the topics that secondary school teachers encounter challenges in teaching to include Geometric Theorem. Geometric concept is one of the topics perceived to be difficult. This perception is the result of poor teacher instructional strategies, student-to-student interaction or misinformation on Geometry and the inability to use metacognitive approaches when they encounter problems on Geometry.

1.2. Objectives of the Study

The objectives of the study were to examine:

1) Whether College of Education students evaluate their abilities and vulnerability in Geometric Theorem problems during or after instructional sessions.

2) Whether College of Education students adopt metacognitive strategies when they encounter problems on Geometric Theorem.

1.3. Research Questions

The study sought to probe the problem through the following research questions:

1) Are College of Education students conscious of their cognitive abilities and vulnerability when solving problems on Geometric Theorem?

2) Do College of Education students adopt metacognitive strategies in solving problems on Geometric Theorem?

2. Methodology and Participants

The study adopted a largely quantitative research approach using a collective case study design which is in tune with the purpose. For collective or multiple case study, two or more groups are studied concurrently or simultaneously by researchers in their desire to generate a clearer view of the particular issue of interest (Crowe, Creswell, & Robertson, 2011). For collective or multiple case study, the groups selection is carefully done to allow for the merit of comparison across several groups which further allows for generalizing of theory (Yin, 2009).

The accessible population was level 100 students of Bagabaga College of Education and Tamale College of Education. These Colleges had a First-Year student population of 1396 comprising 696 from Bagabaga College and 700 from Tamale College.

Purposive sampling was used to select these two Colleges from nine Colleges in the Northern Zone of the country, whilst stratified sampling procedure was used to select the sample from the two Colleges. The participants in the population possessed similar characteristics. The basis for the use of purposive sampling to select Bagabaga College of Education and Tamale College of Education was based on the conviction that the two Colleges give fair representation of Teacher Education programmes in the country since the two Colleges combined, run all the various Teacher Education programs pursued in Colleges of Education in the country. Questionnaire was employed to collect the data which was adapted from a standard tool for measuring the subscales under metacognition. This instrument was so selected because it was designed by Schraw and Dennison (1994) to measure the subscales that were intended to be measured in this study. The study equally employed descriptive statistics for the analysis which were presented in tabular form.

3. Discussions

3.1. Research Question One

What extent are College of Education students aware of their cognitive abilities and vulnerability when solving problems on Geometric Theorem?

Mean ranges: 1.00 - 1.75 = Not much; 1.76 - 2.51 = A little; 2.52 - 3.27 = Some; 3.28 - 4.00 = A lot

Research Question One sought to find out the level of awareness of respondents in their use of metacognitive strategies. The results in **Table 1** show a

Mean score, ranging from 3.21 to 3.41, indicating a remarkable level of awareness of procedural knowledge. Pimentel (2019) states the interpretation of a Mean value of 3.28 to 4.00 as lot or strongly agree. This shows that, respondents are conscious of strategies they have used in the past which can be rewarding in new GT task they encounter. The overall mean score from Table 1 (M = 3.158) suggests remarkable levels of consciousness of procedural knowledge among the College of Education students. This is confirmed by a very low standard deviation of 0.205. Procedural knowledge is a component of knowledge about cognition (Flavel, 1979). For the last item, I restate the GT problems encountered, the Mean score of (M = 2.7; SD = 1.044), suggests that it is not a procedure frequently adopted by students in tackling GT task they encounter.

Mean ranges: 1.00 - 1.75 = Not much; 1.76 - 2.51 = A little; 2.52 - 3.27 = Some; 3.28 - 4.00 = A lot

Table 2 contains items on declarative knowledge and constitutes the second sub-scale under knowledge about cognition of the metacognitive awareness instrument. The overall mean score (M = 3.142) indicates that respondents largely

Table 1. Items on procedural knowledge.

Items	Mean	Std. Dev.
I try to use strategies that have worked in the past to solve GT problems	3.29	0.792
I have a specific purpose to each strategy I use	3.21	0.748
I am aware of what strategies I use when I study	3.41	0.650
I find myself using helpful learning strategies automatically	3.21	0.750
I resort to solving GT problems with a colleague or team	3.07	0.974
I restate the GT problems encountered	2.76	1.044
Mean of means	**3.158**	**0.205**

Source: Field Survey (2021).

Table 2. Items on declarative knowledge.

Items	Mean	Std Dev.
I can identify my intellectual strengths and vulnerability in GT	3.40	0.762
I know what type of information is most important when in a problem GT	2.99	0.881
I am good at organizing information	3.11	0.663
I am good at remembering information	3.20	0.705
I have control over how I learn	3.34	0.703
I am a good judge of how well I understand something	3.14	0.800
I learn more because I am interested in GT topics	2.82	0.916
Mean of means	**3.142**	**0.184**

Source: Field Survey (2021).

agreed to the items under the subscale confirming College of Education students' consciousness of this aspect of knowledge about cognition. Panda (2017) noted that, metacognitive awareness of learners improves in studying from early ages in school and develop remarkably in students at the College level. "I know what type of information is most important when solving a problem on GT" (M = 2.99, SD = 0.881) and "I learn more because I am interested in GT topics" (M = 2.82, SD = 0.916) were the only items that recorded mean values of less than three. The SD values (SD = 0.881, SD = 0.916) show that the responses were further away from the Mean values relative to items with mean scores greater than three.

Mean ranges: 1.00 - 1.75 = Not much; 1.76 - 2.51 = A little; 2.52 - 3.27 = Some; 3.28 - 4.00 = A lot

Results in **Table 3** give a high indication that information management strategies are adopted by the students (overall M = 3.252). The individual items each recorded Mean values ranging from M = 3.00 to M = 3.44. This suggests consciousness or use of strategies such as "focusing on important information on GT" (M = 3.44 SD = 0.727), "creating own examples to make information more meaningful" (M = 3.27 SD = 0.829), "representing GT problems diagrammatically" (M = 3.23 SD = 0.808) and "translating new information on GT problems into their own words" (M = 3.33, SD = 0.780). These affirm the assertions made by Victor (2004) cited in Belet and Guven (2011) representing GT problems diagrammatically and translating new information on GT problems into their own words are metacognitive strategies that complement the constructivist theories of learning.

Mean ranges: 1.00 - 1.75 = Not much; 1.76 - 2.51 = A little; 2.52 - 3.27 = Some; 3.28 - 4.00 = A lot

The results in **Table 4** give strong evidence of debugging strategies. That is, students make attempts to correct their mistakes or address challenges they encounter

Table 3. Items on information management strategies.

Item	Mean	Std. Dev.
I consciously focus my attention on important information related to GT when solving a problem	3.44	0.727
I focus on the meaning and significance of new information	3.29	0.721
I create my own examples to make information more meaningful	3.27	0.829
I draw pictures or diagrams to help me understand GT problems	3.23	0.808
I try to translate new information into my own words	3.33	0.780
I ask myself if what I'm reading is related to what I already know	3.32	0.701
I try to break GT problems into smaller steps	3.14	0.838
I focus on overall meaning rather than specifics	3.00	0.836
Mean of means	**3.252**	**0.262**

Source: Field Survey (2021).

Table 4. Items on debugging strategies.

Item	Mean	Std. Dev
I ask others for help when I don't understand something	3.61	0.615
I change strategies when I fail to understand	3.37	0.722
I stop and go back over new information that is not clear	3.30	0.835
I stop and re-examine a question if I get confused.	3.44	0.669
I do Self-reflection	3.13	0.898
Mean of means	**3.370**	**0.158**

Source: Field Survey (2021).

when they encounter problems on GT. From the results in the Table 4, students gave strong indication that, they stop and re-examine a question if they get confused (M = 3.61, SD = 0.615). The Standard deviation (0.615) confirms that a large level of responses to the item concentrated around the mean (M = 3.61). Similarly, the results show a strong agreement that respondents pause and go over their work when they get stuck; I stop and re-examine a question if I get confused (M = 3.44, SD = 0.669). From the open-ended items, students indicated that they always go over their work to effect corrections on mistakes made. The overall mean score (M = 3.370) reflects students' strength at the use of debugging strategies in learning or solving GT task.

Mean ranges: 1.00 - 1.75 = Not much; 1.76 - 2.51 = A little; 2.52 - 3.27 = Some; 3.28 - 4.00 = A lot

Items in Table 5 sought to determine whether students design a plan to tackle GT problems. The overall mean (M = 3.309) reveals that respondents are conscious of the need to design a plan as metacognitive strategy to tackle GT problems. Respondents strongly agreed to all the planning strategies mentioned in this subscale; students pacing themselves to work within time (M = 3.21, SD = 0.820), setting specific goals before executing a task (M = 3.16, SD = 0.839), considering or identifying the materials needed for the task (M = 3.21, SD = 0.810), considering several approaches to solving the problem (M = 3.39, SD = 0.716). The standard deviation values of less than one suggests that most of the responses are closer to the mean scores, thus, more positive affirmation to the consciousness of the need to design a plan as metacognitive strategy to tackle GT problems.

Mean ranges: 1.00 - 1.75 = Not much; 1.76 - 2.51 = A little; 2.52 - 3.27 = Some; 3.28 - 4.00 = A lot

Results in Table 6 give an overall mean of 3.231, generally showing that respondents monitor the strategies they adopt in solving metacognitive strategies. The results further reveal a high mean value (M = 3.33, SD = 0.714) to the response on whether they ask themselves how well they are doing or learning something new on geometric theorem. From Table 6 both the mean of means and overall standard deviations (M = 3.231 and SD = 0.095), the results show

Table 5. Items on planning.

Item	Mean	SD
I pace myself while learning in other to have enough time	3.21	0.820
I set specific goals before I begin a task on GT	3.16	0.839
I ask myself questions about the materials needed before I begin a task on GT	3.21	0.810
I think of several ways to solve a problem and choose the best one	3.39	0.716
I read instructions carefully before I begin a task	3.52	0.681
I organize my time to best accomplish my goals	3.36	0.739
Mean of means	**3.309**	**0.126**

Source: Field Survey (2021).

Table 6. Items on monitoring comprehension.

Item	Mean	SD
I ask myself periodically if I'm meeting my goals	3.33	0.714
I consider several alternatives to a problem before I answer	3.24	0.822
I ask myself if I have considered all options when solving a problem.	3.07	0.823
I periodically review to help me understand important relationships	3.11	0.781
I find myself analyzing the usefulness of strategies while I study	3.26	0.753
I find myself pausing regularly to check my understanding of the question	3.28	0.746
I ask myself questions about how well I am doing while I am learning something new	3.33	0.742
Mean of means	**3.231**	**0.095**

Source: Field Survey (2021).

that respondents strongly accepted that they pause regularly to check their understanding when they get stuck on GT problems.

Mean ranges: 1.00 - 1.75 = Not much; 1.76 - 2.51 = A little; 2.52 - 3.27 = Some; 3.28 - 4.00 = A lot

There was a remarkable level of evaluation of metacognitive strategies by students and this is supported by a Mean value of 3.150 and a small standard deviation of 0.098, as captured in **Table 7**. Mean score of responses to the individual items in the table range from 3.06 to 3.32 which is a further confirmation of respondents' consciousness and use of evaluation as a strategy to tackle GT task.

3.2. Research Question Two

What metacognitive strategies do College of Education students adopt in solving problems on Geometric Theorem?

From the results in **Table 8**, the overall mean score was computed as 2.86 which is evidence of the fact that some metacognitive strategies are rarely used

Table 7. Items on evaluation.

Item	Mean	SD
I know how well I did once I finish a test	3.32	0.841
I consider alternative approaches of solving problems on GT after I have completed a task	3.06	0.834
I summarize what I've learned after I finish	3.20	0.808
I ask myself if I have considered all options after solving a problem	3.12	0.799
I ask myself if I learn as much as I could have done once, I finish a task on GT	3.06	0.816
Mean of means	**3.150**	**0.098**

Source: Field Survey (2021).

Table 8. Respondent's use of metacognitive strategies in solving GT problems.

Items	Mean	SD
I resort to solving GT problems with a colleague or a team	3.07	0.974
I recall what I know about the problem	3.18	0.901
I simply recall formulae to use	3.09	0.891
I evaluate my knowledge on the topic	3.18	0.919
I evaluate the approach used in solving the questions	3.05	0.866
I evaluate the solution obtained	2.98	0.945
I try to adopt innovative methods not previously known to me	2.69	1.130
I do Self-reflection	3.13	0.898
I do Self-questioning	3.06	0.948
I Think-aloud (express your thoughts as they come)	2.75	1.024
I keeping learning journal or portfolio for mathematics learning	2.52	1.052
I List alternative approaches to solving GT problems	2.80	0.962
I restate the GT problems encountered	2.76	1.044
I only solve part of difficult GT questions and move on	2.40	1.070
If I don't follow the teacher's lesson on GT, I just ignore it	2.05	1.151
I try to explain to myself concepts that seem difficult	2.98	0.966
Mean of means	**2.856**	**0.308**

Source: Field Survey (2021).

by respondents. From Table 8, I resort to solving GT problems with a colleague or a team (M = 3.07, SD = 0.974), recall formulae to use (M = 3.09; SD = 0.891), Self-reflection (M = 3.13, SD = 0.898), Self-questioning (M = 3.06; SD = 0.948) were very often used by respondents. The frequent use of rote or recall of rules by students to solve GT problems was confirmed by Ozkan and Kesen (2008) but was blamed on educational systems that students went through.

4. Responses to the Open-Ended Items

The open-ended items offered respondents the opportunity to list both ordinary and innovative strategies they use to solve GT questions. The third and fourth open-ended items sought to determine the thoughts, feelings and emotions of respondents when they encounter difficult task. Respondents listed the following as strategies they adopt when they encounter GT problems:

1) Use of formula and the properties of geometric shapes
2) Reflection, recall and analysis of the problem
3) Breaking problems into smaller parts and approach it step by step
4) Use of pictures and diagrams to solve GT problems
5) Consider alternative strategies and select one
6) Change strategies when if one or the first one fails
7) Seek help from colleagues when they encounter difficult problems
8) Review previous topics/knowledge to see if old information relates to the new problems
9) Going over their work to check for lapses

Regarding their emotions when they encounter difficult questions, the common responses were: feeling of sadness, depression, disappointment and inadequacy in the learning of concepts. These strategies conform to the metacognitive strategies listed by many researchers (Inclusive Schools Network, 2015; Resourceaholic, 2014; Drew, 2020; Marilyn, 2015; Kim, Park, & Baek, 2009; Belet & Guven, 2011).

5. Conclusion

The research was borne out of the interest to determine the metacognitive consciousness of College of Education students in the strategies they adopt in solving problems on GT. It was found that, College of Education students were highly conscious of the use of metacognitive strategies when they encounter GT problems. This conforms to the assertions of Panda (2017) who conducted similar studies into metacognitive awareness of college students in Haryana state, India and observed similar findings. Hence, being conscious of metacognitive strategies help improve students' understanding and performance.

Recommendations

This study recommends College of Education students be made to adopt metacognitive strategies when they encounter problems in Geometry and other content courses. To raise the consciousness of trainee teachers the College of Education curriculum should deliberately mention metacognition and as well highlight activities in the curriculum that are metacognitive strategies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Abdellah, R. (2015). Metacognitive Awareness and Its Relation to Academic Achievement and Teaching Performance of Pre-Service Female Teachers in Ajman University in Procedia UAE. *Procedia—Social and Behavioral Sciences, 174,* 560-567. https://doi.org/10.1016/j.sbspro.2015.01.707

Belet, S., & Guven, M. (2011). Meta-Cognitive Strategy Usage and Epistemological Beliefs of Primary School Teacher Trainees. *Educational Sciences: Theory and Practice, 11,* 51-57.

Coughlin, J., & Montague, M. (2011). The Effects of Cognitive Strategy Instruction on the Mathematical Problem Solving of Adolescents with Spina Bifida. *Journal of Special Education, 45,* 171-183. https://doi.org/10.1177/0022466910363913

Crowe, S., Creswell, K., Robertson, A., Avery, A., & Sheikh, A. (2011). The Case Study Approach. *BMC Medical Research Methodology, 11,* Article No. 100. https://doi.org/10.1186/1471-2288-11-100

Domingo, A. (2016). *Analysis of Mathematical Topics Perceived Difficult to Teach by High School Teachers in Belize.* ReseachGate. https://www.researchgate.net/publication/306291682

Drew, C. (2020). *13 Examples of Metacognitive Strategies.* Helpful Professor. https://helpfulprofessor.com/metacognitive-strategies

Du Toit, S., & Kotze, G. (2009). Metacognitive Strategies in the Teaching and Learning of Mathematics. *Pythagoras, No. 70,* 57-67. https://doi.org/10.4102/pythagoras.v0i70.39

Fauzi, A. (2013). *The Effect of Academic Ability on Metacognitive Skills, Biology Learning Outcomes, and Retention of Class X High School Students with the Application of Cooperative Script Learning Strategies in Malang.* Malang State University.

Flavell, J. H. (1987). *Speculations about the Nature and Development of Metacognition.* In F. E. Weinert, & R. H. Kluwe (Eds.), *Metacognition, Motivation, and Understanding* (pp. 21-29). Lawrence Erlbaum Associates.

Gurat, M. G., & Medula Jr., C. T. (2016). Metacognitive Strategy Knowledge Use through Mathematical Problem Solving amongst Pre-Service Teachers. *American Journal of Educational Research, 4,* 170-189.

Inclusive Schools Network (2015). *Metacognitive Strategies.* https://inclusiveschools.org/metacognitive-strategies

Khan, B. R. (2020). Metacognitive Skills of Students in Mathematics Class with Supplemental Instruction and Online Homework. *Journal of Mathematics Education at Teachers College, 11,* 33-41.

Kim, B., Park, H., & Baek, Y. (2009). Not Just Fun, but Serious Strategies: Using Metacognitive Strategies in Game-Based Learning. *Computers & Education, 52,* 800-810. https://doi.org/10.1016/j.compedu.2008.12.004

Lin, X. (2001). Designing Metacognitive Activities. *Educational Technology Research and Development, 49,* 23-40. https://doi.org/10.1007/BF02504926 http://homepages.gac.edu/~dmoos/documents/DesigningMetacogAct_000.pdf

Marilyn, P. (2015). *Metacognition: Nurturing Self-Awareness in the Classroom.* https://www.edutopia.org/blog/8-pathways-metacognition-in-classroom-marilyn-price-mitchell

Mevarech, Z., & Kramarski, B. (2014). *Critical Maths for Innovative Societies: The Role of Metacognitive Pedagogies.* OECD Publishing. https://doi.org/10.1787/9789264223561-en

Montague, M., Krawec, J., Enders, C., & Dietz, S. (2014). The Effects of Cognitive Strategy Instruction on Mathematics Problem-Solving of Middle School Students of Varying Ability. *Journal of Educational Psychology, 106,* 469-481. https://doi.org/10.1037/a0035176

New Zealand Ministry of Education (2017). *Early Childhood Curriculum.* Learning Media. https://www.education.govt.nz/assets/Documents/Early-Childhood/ELS-Te-Whariki-Early-Childhood-Curriculum-ENG-Web.pdf

Nurajizah, U., Windyariani, S., & Setiono, S. (2018). Improving Students' Metacognitive Awareness through Implementing Learning Journal. *Indonesian Journal of Biology Education, 4,* 105-112. https://doi.org/10.22219/jpbi.v4i2.5788

Ozkan, Y., & Kesen, A. (2008). Memorization in EFL Learning. *Academia, 35,* 58-71.

Panchu, P., Bahuleyan, B., Seethalakshmi, K., & Thomas, T. (2016). Metacognitive Awareness—Evaluation and Implications in Medical Students. *International Journal of Research in Medical Sciences, 4,* 3570-3575. https://doi.org/10.18203/2320-6012.ijrms20162331

Panda, S. (2017). Metacognitive Awareness of College of Education Students: Perspective of Age and Gender. *Scholarly Research Journal for Interdisciplinary Studies, 4,* 8402-8412. https://doi.org/10.21922/srjis.v4i37.10551

Pimentel, J. (2019). Some Biases in Likert Scaling Usage and Its Correction. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 45,* 183-191.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and Self-Regulated Learning Components of Classroom Academic Performance. *Journal of Educational Psychology, 82,* 33-40. https://doi.org/10.1037/0022-0663.82.1.33

Pintrich, P. R., Smith, D., Garcia, T., & McKeachie, W. J. (1991). *A Manual for the Use of the Motivated Strategies for Learning Questionnaire.* University of Michigan.

Ratner, C. (1991). *Vygotsky's Sociohistorical Psychology and Its Contemporary Applications*. Plenum Press. https://doi.org/10.1007/978-1-4899-2614-2

Resourceaholic (2014). *Ideas and Resources for Teaching Secondary School Mathematics.* https://www.resourceaholic.com/circletheorems.html

Rezvan, S., Ahmadi, S. A., & Abedi, M. R. (2006). The Effects of Metacognitive training on the Academic Achievement and Happiness of Esfahan University Conditional Students. *Counselling Psychology Quarterly, 19,* 415-428. https://doi.org/10.1080/09515070601106471

Schofield, L. (2012). Why Didn't I Think of That? Teachers' Influence on Students' Metacognitive Knowledge of How to Help Students Acquire Metacognitive Abilities. *Kairaranga, 13,* 56-62. Retrieved August, 2021. https://files.eric.ed.gov/fulltext/EJ976674.pdf

Schraw, G., & Dennison, R. S. (1994). Assessing Metacognitive Awareness. *Contemporary Educational Psychology, 19,* 460-475. https://doi.org/10.1006/ceps.1994.1033

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning. *Research in Science Education, 36,* 111-139. https://doi.org/10.1007/s11165-005-3917-8

Schunk, D. H. (2012). *Learning Theories: As Educational Perspective* (6th ed.). Pearson Education, Inc.

Tachie, S. A. (2019). Meta-Cognitive Skills and Strategies Application: How This Helps Learners in Mathematics Problem-Solving. *Eurasia Journal of Mathematics, Science, 15,* Article No. em1702. https://doi.org/10.29333/ejmste/105364

Tansyani, W. (2016). The Effect of Learning Models and Metacognitive Awareness on Learning Outcomes of High School Students in the Subject Matter of Acids and Bases. *Journal of Educational Science and Technology (EST), 2,* 10-25.

University of Cape Coast (UCC) (2020). *Course Manual for Number and Algebra for Colleges of Education.*

Weinstein, C. E., & Palmer, D. R. (2002). *User's Manual: Learning and Study Strategies Inventory* (3rd ed.). H & H Publishing Company. https://www.hhpublishing.com/LASSImanual.pdf

Yin, R. K. (2009). *Case Study Research: Design and Methods* (4th ed.). Sage Inc.