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Students' cognitive and metacognitive learning strategies towards hands-on science

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ABSTRACT

Cognitive and metacognitive learning strategies are geared towards giving autonomy to every learner in their studies. Students' affordances on cognitive and metacognitive learning strategies in their studies are believed to predict their academic success and performances in their learning tasks. This study determined the cognitive and metacognitive learning strategies in science among the 278 education students in the three campuses of a state university in the Philippines as bases in crafting a developmental plan to bolster the science instruction in the university. Using the descriptive-inferential research and employing a questionnaire on the cognitive and metacognitive strategies of education students, the following are known: incomparable affordances of the students along planning and information management practices while comparable affordances were determined on the respondents' cognitive learning strategies; and incomparable affordances along procedural knowledge while comparable affordances along declarative and conditional knowledge were determined on the respondents' metacognitive learning strategies. Based on the results, a developmental plan was designed to bolster the science courses in the education programs of the university centering on the inclusion of research camp, research expo, shepherding on research through the niche program, immersion, and hands-on science. It was recommended that the proposed enhanced science program will be implemented in the university system as there is only one science course in their respective programs in the new curricular plot.

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1. INTRODUCTION

Learners employ various unique strategies in facilitating their route processes in learning, i.e., memorizing and processing concepts particularly in science. Science, as a highly technical subject, involves the application of unique strategies like the cognitive and metacognitive learning strategies. In fact, it is claimed that the employment of cognitive and metacognitive learning strategies poses significant relationship with the students' academic achievement in schools and universities [1], [2].

Considering the dynamic learning situation, learners consolidate cognitive and metacognitive learning strategies and employ it in a unique manner. Their ability of understanding concepts and tailoring strategies to understand concepts center the idea of cognitive and metacognitive learning strategies. In the Metacognitive Theory of Learning, Flavell [3] postulated that metacognition is employed in monitoring and regulating learning processes which recoils their ability to manage their own learning situation (selection, evaluation, revision of cognitive tasks, goals, and strategies).

Furthermore, the theory included four classes of metacognition including metacognitive knowledge, experiences, goals and tasks, and strategies or actions. Metacognitive knowledge centers on the learners' knowledge and beliefs about their thinking processes. This is related to the learners' interests, abilities, and goals that complement their cognitive and metacognitive knowledge. Apparently, learners integrate their information, memories, and a-priori experiences which accounts for the generation of strong affective responses in the process of building better cognitive and metacognitive knowledge. Preceding the learning process is the development and improvement of knowledge about a certain concept or problem. When realized, learners tend to draw goals and tasks through an ordered process and strategies. These processes and strategies ensure the attainment of the drawn goals under their self-regulation techniques [2], [4]–[6].

Science as a built-in course in the teacher education programs offered in the current study is observed in three unique affordances. Moreover, there is only one science course offered in the said program. This concordance impinges analyses so as to prepare prospective teachers to become science teachers. The crux is cognitive and metacognitive knowledge and skills of students in science is very important considering the previous discussions. However, this was never conducted in the university and yet, there is a varied instruction in science unique to their locale in the three campuses of the study although a minimum learning competency is formulated. It is for this reason that the researchers envision to assess the cognitive and metacognitive learning strategies of the first- and second-year college students in science so as to come up with a developmental plan in improving further their affordances in learning science. Aptly, this study was designed to determine the cognitive and metacognitive learning strategies of education students in science in the three campuses of a state university in the Philippines. Likewise, a documentary analysis on the current status of science instruction in the research locale was employed in crafting a developmental plan to bolster the science instruction in the university.

2. RESEARCH METHOD

The descriptive-inferential method was employed in this study. Furthermore, the comparative design was employed to compare the cognitive regulation practices and metacognitive strategies of the respondents. The descriptive design was used since the proponent's collected information from respondents without manipulating any condition that can possibly change their perceptions, beliefs, and dispositions with regards to the thesis of this study. Furthermore, this design fits best when the objective is to obtain information concerning the current status of the phenomena which is described like what exists with respect to variables or conditions in a situation. It also employed a documentary analysis on the current instructional delivery of the course in the three campuses of a state university through the course syllabus that the instructors and professors are using in their respective classes. Particular attention was given to the learning activities and major course requirements required by the professors in the three campuses of the study.

A total of 278 education students participated in the study. This number is determined through G*power. G*power is a statistical software that computes samples vis-à-vis power analyses of various tests like t-test, ANOVA, and some exact tests. Through, stratified random sampling technique, this number is equated to the population in the three campuses of the locale of the study to ensure equal representation.

The state university where this study was conducted has three campuses: i) Campus 1 is the main campus that offers Bachelor in Secondary Education (BSE), Bachelor of Elementary Education (BEEd), and Bachelor of Technology and Livelihood Education (BTLE) programs; ii) Campus 2 only offers the BEEd program; and iii) Campus 3 only offers the BTLE program. It must be noted that only Campus 1 offers a course that specializes teacher education students to become science majors through its BSE program. The BEEd and BTLE programs do not intend to produce science majors. However, graduates from the BEEd program are expected to teach science subjects later when they opt to as they would be teaching general education courses in the elementary grades. Furthermore, it must be noted that the students in the BEEd program take only one science subject (science, technology, and society) in completing their academic degrees. The offering of this science course in the three campuses is not uniform. Campus 1 and 3 offer it during the second year of their students while Campus 2 offer it during the first year. Albeit offered in different curriculum year levels, the authors deemed it irrelevant since there is only one science subject offered in the various programs except for the BSE program. Hence, the current study only employed their campus as grouping variables.

The respondents' affordances on cognitive and metacognitive learning strategies were determined by using a questionnaire formulated and standardized by Lai [7]. The questionnaire posted an alpha value of .78 in the current study; thus, it is reliable. There are two parts of the questionnaire: i) Part 1 covers the regulation practices; and ii) Part 2 covers the metacognitive practices of the respondents in their science subject. The regulation practices include planning, information management, debugging or correcting, and comprehension and evaluation. On the other hand, the metacognitive practices include the respondent's procedural, declarative, and conditional knowledge. Indicators of each variable in the questionnaire were rated by the respondents based on a 4-point Likert scale showcasing their degree of agreement (1=disagree to 4=very much agree).

The gathered data were analyzed through mean, ANOVA, and Scheffe test. Range was employed in determining the general descriptive interpretation on their agreement. The range is: 1 (1.0-1.74)=Disagree; 2 (1.75-2.49)=Agree; 3 (2.50-3.24)=Much Agree, and 4 (3.25-5:00)=Very Much Agree. The results of the statistical treatment were the bases of discussion vis-à-vis the research problems. Conclusions were also drawn based on the results.

3. RESULTS AND DISCUSSION

3.1. Regulation practices on cognition

Table 1 shows the regulation practices of the respondents along planning, information management, debugging, and comprehension and evaluation monitoring. It shows that students in Campus 3 are better in planning when compared with their counterparts in Campus 1 and Campus 2 (F-value and p-value of 5.640 and .004, respectively). As to information management, respondents from Campus 3 are again better than their counterparts in Campus 1 and Campus 2 (F-value and p-value of 7.830 and less than .001, respectively) while students in Campus 1 are better than their counterparts in Campus 2. On the other hand, respondents have comparable employment of debugging and comprehension and evaluation monitoring strategies.

Table 1. Regulation practices on cognition among education students

	Regulation practices on cognition	Campus 1		Campus 2		Campus 3	
		Mean	DI	Mean	DI	Mean	DI
1	Planning	3.18^{A}	MA	3.10^{A}	MA	3.30^{B}	VMA
2	Information management	3.17^{AC}	MA	3.04^{B}	MA	3.32^{CA}	VMA
3	Debugging (Correcting)	3.29^{A}	VMA	3.29^{A}	VMA	3.21^{A}	MA
4	Comprehension and evaluation monitoring	3.20^{A}	MA	3.12^{A}	MA	3.25^{A}	MA

Note: VMA-Very Much Agree; MA-Much Agree
*Indicators of the same letter within rows are comparable at .05 level of significance; cells within rows labelled with different letter post significant results; cells labeled with two letters identify which group differ significantly. Post hoc is calculated via Scheffe test

The foregoing results imply disparity between and among the respondents' regulation practices on cognition. It is believed that the interplay of the respondents' peers and teachers play significant effects on their concordances, practices, activities, attitude, and behavior. Previous studies [8], [9] construed that the perceptions of students on their cognitive learning practices of students from school to school is influenced by their peers and teachers. Henceforth, it is recommended that a complementing community of inquiry and practice may be simulated and practiced in the three campuses through Science Camps, Field Studies, Research Expos, among others. In this way, they may find their niche and may develop the culture of science inquiry which could stem into innovative minds through research and immersion. It must be noted that cognitive strategies are paramount to one's academic achievement [10]–[12] and better motivations in doing such learning tasks under their self-regulations [13]–[15].

Moreover, it was claimed that planning strategy is very important in the process of mental cognition [6], [16]. This mental cognition, on the other hand, is controlled by the experiences, skills, and self-regulation of the student-learners as they employ their distinct cognitive strategies in learning [6], [17]. Students need to have a clear view on the planning requirements of their respective courses for the students to plan out in meeting the activities required of them particularly in science [18]. In the case of the current study, planning is very important as the course (science, technology, and society) needs to employ academic rigors along research. It could be noted that the course requires science innovations through research, i.e., documenting investigatory projects, indigenous knowledge system of the locality, ethno-medicine, pseudo-science, among others.

On the other hand, information management is also a very important part of the processes in cognition. Students, under self-regulation principles, need to manage the information that they acquire in their learning tasks. Information management, as part of the regulating practices in cognition, increases the chances of a well-processed learning task vis-à-vis educational objectives, materials, and activities [12]–[14].

Owing to the aforementioned results, it can be concluded that the respondents in the three campuses of the locale of the study accorded incomparable regulation practices in cognition along planning, information management, and debugging or correcting. This impinge a potent factor in terms of the comparability of graduates of the teacher education programs in the university; hence, a unified curriculum and program of activities may be crafted and adopted at a bar-none standard.

3.2. Metacognitive strategies

Table 2 presents the metacognitive strategies of the respondents along procedural, declarative, and conditional knowledge. It can be gleaned that the respondents from Campus 3 vouched better employment of procedural knowledge when compared with their counterparts from Campus 1 and Campus 2 (F-value and p-value of 3.066 and .048, respectively). On the other hand, comparable results were observed on the responses of the respondents along declarative and conditional knowledge.

Table 2. Metacognitive strategies among education students

	Metacognitive strategies	Campus 1		Campus 2		Campus 3	
		Mean	DI	Mean	DI	Mean	DI
1	Procedural knowledge	3.24^{A}	MA	3.21^{A}	MA	3.54^{B}	VMA
2	Declarative knowledge	3.19^{A}	MA	3.15^{A}	MA	3.26^{A}	VMA
3	Conditional knowledge	3.36^{A}	VMA	3.37^{A}	VMA	3.30^{A}	VMA

Note: VMA-Very Much Agree; MA-Much Agree
*Indicators of the same letter within rows are comparable at .05 level of significance; cells within rows labelled with different letter post significant results; cells labeled with two letters identify which group differ significantly. Post hoc is calculated via Scheffe test

It may be noted that science is a laborious discipline which entails academic rigors and a lot of actions, e.g., performing experiments, conducting field studies, writing narratives and journals, observing and reporting. Each activity employs various strategies. It was claimed that metacognitive strategies are considered as the most important factors in developing the abilities of every learner as they enable the learners to monitor their progress, accomplishments, and learning directions [12], [17].

When students developed their metacognitive awareness and practiced them holistically, they tend to become autonomous, performers, and activators of learning [19], [20]. Part and parcel to this activation is the act of building connection [21], [22]. In this situation, the learners embed activities that hone their connection with other individuals like their peers and knowledgeable others (KOs) like their teachers. Discovering and discussing strategies are extensive practices that every learner employs in the learning process [4]. This continued practice of inquiry sustains and leverages their learning experiences until this inquiry becomes a practice reciprocating efficacy among them.

It is construed that students who can characterize information that they have learned from what is not learned are most likely the students who academically succeed in their learning tasks; hence, metacognition is a strong predictor of academic success [4], [23], [24]. However, it must be noted that differences on self-efficacy beliefs, level of expertise, goal orientations, susceptibility to social influences, and cultural differences affect the metacognitive affordances of students [2], [6], [25]–[29].

In the case of the current study where there is only one science course in the program of studies of the respondents, it matters to employ metacognitive learning strategies to enable them to be science teachers in the future especially those who are taking the BEEd program. Teachers assisting these prospective teachers must employ attention in the development of these scientific knowledge, procedure and practices, as well as the attitude relevant thereto. Shepherding and the umbrella system in developing their competence towards a certain niche are very much wanting particularly in research.

3.3. Status of teaching science, technology, and society in a state university in the Philippines

The three campuses in the current study, although they are from a university system, offer the course (science, technology, and society) in different nomenclature unique to the instructor or professor teaching the course. In Campus 1, the course is offered using hands-on science practices, research and immersion activities, and culminated in a research expo as reflected in the course syllabus. Students were grouped to come up with investigatory projects and social researches and are required to present in a colloquium. On the other hand, Campuses 2 and 3 do not employ activities as employed in Campus 1 as evident in their course syllabi. The course is taken in a pure theoretical offering although varied forms of learning designs are undertaken.

Since the three campuses are using the prescribed curriculum for their academic programs, the science course (GE 7–science, technology, and society) is a general education course taken by all teacher education students before the completion of their academic degrees. However, the three campuses offer it in different curriculum year level.

3.4. Developmental plan in enhancing the hands-on science of education students in a state university in the Philippines

Metacognitive strategies empower students to think about their own thinking. Awareness of the learning process enhances control over their own learning. It also enhances personal capacity for self-regulation and managing one's own motivation for learning. Metacognitive activities can include planning how to approach learning tasks, identifying appropriate strategies to complete a task, evaluating progress, and monitoring comprehension.

Individuals with well-developed metacognitive skills can think through a problem or approach a learning task, select appropriate strategies, and make decisions about a course of action to resolve the problem or successfully perform the task. They often think about their own thinking processes, taking time to think about, and learn from mistakes or inaccuracies. Teaching metacognitive skills can greatly enhance learning for all students in all subject areas. The objective of this intervention is to make science students independent and successful thinkers while the goal of metacognitive skills is to help students understand the way they learn. It is a process designed for students to 'think' about their 'thinking.'

The schematic diagram presented in Figure 1 depicts the process on what should be done in school and in the community in order to produce education graduates who possess the knowledge and skills required of the 21st century science teachers. In order to attain the goal, the science teachers on the ground should put into practice the following: In the classroom, the teacher should do more hands-on activities, inquiry-based instruction, as well as problem-based learning that is "learning by doing" activities. Experimentation is another important activity. Conducting experiments, as a way of investigating scientific phenomena and acquiring scientific knowledge and skills, is a very significant method in teaching and learning science. In every activity, leaners need to design mechanisms and implement courses of actions in investigating their assigned tasks from their prior knowledge and experiences, scientifically frame allowable time to complete the activity, and draw appropriate direction and offshoot of the possible outcomes based on rigorous investigation. Hence, it is very important for the learner to have a clear understanding on the aforementioned questions in the planning stage of each activity.

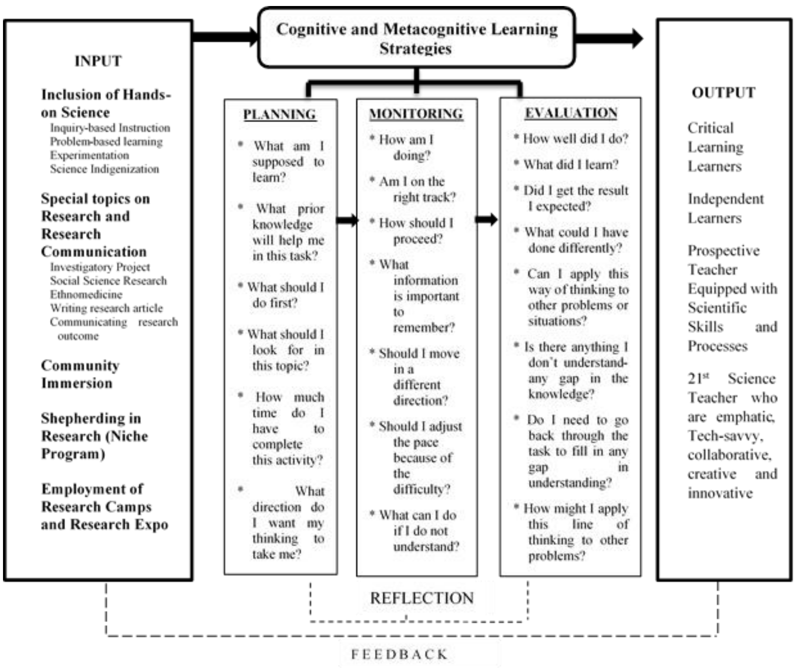

Figure 1. Developmental plan in enhancing the hands-on science of Education students

Special topics on research and research communication are equally important in the classroom. Doing investigatory project is common in science but not all school perform investigatory projects. Learners should be exposed to varied forms of research like social sciences, ethno-medicine, research writing, and communicating research outcomes. Again, in every stage of each activity, planning has to take place and at any stage of any activity, monitoring has to take place in order to assess whether everything in the activity is going smoothly, and if not, remedial measures have to take place. It is important for the learner to assess any learning gained in every activity. If learning is not gained, then the learner has to review the planning and monitoring stage to assess what went wrong. Henceforth, teacher-facilitators may consider student metacognition when implementing active-learning strategies.

Schools do not thrive in isolation. Schools exist in the community. So, the teachers and the learners should make the community as an avenue of learning, discovery, and research. The community should serve as an immersion center where students put into practice what they have learned and at the same time to use their own community as a source and location for learning [30]. The state university, which is located in a vast area composed of abundant natural resources, endemic plant and animal species, culture, and belief, can successfully implement this developmental plan to enhance the lone science course in the curricula of the teacher education program. This is where education students can actualize their educational experiences in science, technology, and society. In this manner, education students may continuously wonder on the processes of science particularly on conducting science investigatory projects and the social sciences aspects of science like documenting the Indigenous knowledge system of the locality, ethno-medicine, pseudo-science, among others. The community where the university is based is a dynamic laboratory where students can find their specimen for classroom investigation.

Education students, who are prospective teachers in elementary and secondary schools, may developed a sturdy culture of research and innovation, scientific processes, procedures, and attitudes in completing venues, the classroom and the community. Furthermore, teaching them to do research, community immersion, and writing journals and journal articles will ensure robust scientific cognition which they could model when they are already in the field. The development of holistic understanding and scientific knowledge and competencies is a parlance in the teacher education programs as they will soon model and transfer their learnings to their future students.

4. CONCLUSION

The study found that the regulation practices in cognition of the respondents are afforded averagely much agree. The metacognitive practices of the respondents are afforded optimally very much agree. There is significant difference on the affordances of the respondents on their regulation practices in cognition and metacognitive practices in learning science. A developmental plan may be integrated in the course that will center on the inclusion of hands-on science, special topics on research and research communication, community immersion, shepherding in research through the Niche Program, and the employment of Research Camps and Research Expos.

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