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PROMOTING TRANSFORMATIVE MATHEMATICAL LEARNING THROUGH HEUTAGOGY, PARAGOGY AND CYBERGOGY APPROACHES

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ABSTRACT

The mathematics curriculum of higher education teaching requires changes to produce highly qualified graduates, who can respond quickly and creatively to economic change. In fulfilling this aspiration, the criteria of the heutagogy, paragogy and cybergogy approaches can explain the role of mathematics educators in educating students on future life preparation. This study aims to generate the criteria of heutagogy, paragogy and cybergogy approaches for mathematical teaching and learning at Higher Education level. For each approach, the themes and its' characteristics will be determined to inform the mathematics educators the ways to implement the heutagogy, paragogy and cybergogy approaches in class. The intensive and rigorous literature review were done for analyzing teaching and learning models from the theoretical, model or conceptual aspects, several education policy documents that are related to teaching and learning at higher institution as well as best practices in effective learning environments both locally and abroad in general and in the field of mathematics education as well as the literature review on aspects of heutagogy, paragogy and cybergogy approaches. This study has successfully generated the criteria of heutagogy, paragogy and cybergogy approaches for mathematical teaching and learning at Higher Education level. For each approach, several themes have been identified, and for each theme there are several items that are described in detail for guidance. Six themes with 36 items were identified for the heutagogical approach and the main key focus is learner-centeredness where the contexts and content are learner-generated. For the paragogical approach, five themes with 35 items were identified which provide information on best practices for managing peer learning. The key

theme for this approach is the learners and educators are the creator for learning and teaching context. Finally, cybergogy approach composed of three interdependent domains with 39 items should be well thought-out in implementing this approach; cognitive, emotive and social domains. These input themes and items of the heutagogy, paragogy and cybergogy approaches which are mutually supporting each other may promote the mathematical learning transformation in this era, hence contributing to knowledge gap within the mathematics education research for the information about the guidance and strategies for implementing those approaches as well as contributing to Future Ready Curriculum paradigm.

INTRODUCTION

To fulfill the aspirations of the Malaysian Education Development Plan (Higher Education) [1] as well as education transform in Malaysia that will produce future graduates with "Future-Proof Talents" features, educators and lecturers in the Higher Education Institution (HEIs) need to emphasize teaching and learning using the Education 4.0 paradigm that focuses on the Future Ready Curriculum (FRC) [2]. One aspect that is emphasized in the FRC curriculum is the transformative learning and teaching deliveries which has elements of 21st century pedagogy that are heutagogy, paragogy and cybergogyin producing graduates who could carry out their knowledge based on their interests and inculcate lifelong learning ([3], [4]).

Educators must ready for the implementation of the FRC that incorporates technological revolution in the daily lives of students [5]. The world of education is now facing a generation categorized as users of digital technology and resilience that will fill the country's labor market [6]. This generation is constantly trying different things and developing new skills, desires and high expectations. The FRC philosophy is a guide for Higher Education Institutions to check their academic programs at their institutions so that the academic programs are still relevant and competitive in the market. There are three main elements that have been constructed, namely the structure of the curriculum is fluid, the delivery of transformative learning and teaching and the use of alternative assessments. For the elements of the transformative learning and teaching deliveries, the FRC focuses on the 21st century pedagogy by promoting the heutagogy, paragogy and cybergogy approaches. In addition, futuristic learning spaces, technology 4.0 in learning, and in-depth learning are also mentioned [7].

Based on review of literature, this FRC framework does not give a detailed guidance to carry out the heutagogy, paragogy and cybergogy for the teaching and learning[8], specifically in mathematical learning at higher education level. According to [9], the education system plays a very important role in shaping future generations and leaders. Therefore, the mathematics curriculum of higher education teaching requires changes to produce highly qualified graduates, who can respond quickly and creatively to economic change. In fulfilling this aspiration, the criteria of the heutagogy, paragogy and cybergogy approaches can explain the role of educators or lecturers in educating students on future life preparation. Therefore, this study will specifically generate the criteria of heutagogy, paragogy and cybergogy approaches for mathematical

teaching and learning at Higher Education level. For each approach, the themes and its'characteristics find on how the mathematics educators can carry out the heutagogy, paragogy and cybergogy approaches in class.

LITERATURE REVIEW

Heutagogy

Heutagogy or self-determined learning is a student-centered learning approach that develops student's autonomy, abilities and capabilities ([10], [11]), where learning occurs when the learners prepare and not when the teacher or lecturer expects or intends it [12]. The main goal of this approach is of a consistent nature to produce students who are ready for a challenging work environment with complexity life. Self-determined learning emerged in 2000 [11]. The heutagogy concept is based on Vygotsky's humanistic and constructivism ideas ([12], [13]). However, recent developments indicated that connectivism theory associates with heutagogy as a more compatible theory ([14], [15]). The heutagogy concept compromises certain ideologies and practices that could be well-thought-out as a reaction to the advancement technology developments within higher education. A heutagogical learning atmosphere eases growth of skillful learners and highlights the learner competencies development as well as development of the learner's capability and ability to learn [16].

Recently, the educational institutions have begun to discover and carry out the concept of heutagogy within their organizations. According to [16] and [17], some vocational and training institutions have been on the forefront of investigating with heutagogy. Moreover, in recent times this concept of learning has also gained interest within higher education and primary school settings due to its learner-centered approach ([18], [19], [20]). Advances in educational technological developments such as the multimedia, Internet, social networks, and MOOCs have led to an increased interest in the theory, as affordable of the new technologies align closely with heutagogy theory ([14], [21]). Theuse of heutagogy has been reported in a variety of educational settings [22], however, there still remains lacking within the research for the information about the guidance and strategies for implementing the approach.

Paragogy

Paragogy or peer learning is an educational practice in which students interact with other students to obtain educational goals [23]. Moreover, this type of learning encourages students to exchange information and improve their learning strategies and improve their communication skills. Paragogy is adapt from the concept of andragogy learning and addresses the disadvantages of andragogy learning that centers on the educator-only. It emphasizes the student-centered model and encourages students to actively communicate in a conducive and relaxed learning environment [24]. In fact, according to [24] this model promotes socio-cognitive and the use of technology in knowledge

development. In short, the learner in spite of being the key agent in the learning process, he/she is also a provider to other major learners in their respective group. Hence, the crucial word in paragogical method of learning is peer-produced educational process.

Several studies recently have investigates various model of structured teaching and learning as well as assessment, drawn from the paragogical perspectives such as [25], [26], [27] and [28]. For example, a study by [29] explored a peer learning method encompasses the self-directed and student-centered learning in designing a design/project based learning approach in a third year engineering unit. Their study revealed that peer learning encourages students to interact with peer and staff to meet educational aims. In another study, [26] studied MOOCs for Research Method course with a model of flipped assessment that drawn from elements of paragogy and the IR Model that acknowledges and exploits peer learning opportunities. The findings showed that the MOOCs for Research Method as well as other open courses are ideal for investigating students' peer learning and monitoring students' iterative and incremental development. Furthermore, the elements of MOOCs extramural compromise a better degree of autonomy for the paragogical innovation. In a more recent time, a study by [27] suggests a practice lesson study and peer learning methods to strengthen Rwandan science and mathematics teaching.

The results showed that lesson study practiced and the peer-to-peer learning improves teaching and learning process. Mostly the study that used the paragogical perspectives only developed the effective method using learning principles to give a structure for the teaching and learning process without any guidance on how carry out the paragogical approach. Hence this study will specifically be done to develop the criteria for paragogical approach to help mathematics educator to design their courses effectively.

Cybergogy

Technology-based education transformation is a 21st century learning feature that proposes a socio-constructive learning and student-centered learning environment where students build their knowledge and understanding through authentic digital media creation([30], [31]). For example, students who design and program digital games related to social and educational interests have the potential to support this educational transformation ([32], [33]). Educational technology integration has created new teaching and learning concepts, namely the cybergogy or virtual learning.

Cybergogy focuses on helping students learn easily and technology enables autonomous and collaborative learning that is student-centered in a virtual environment. In essence, cybergogical strategies used for face-to-face learning may not the same in a virtual environment. Literature reviews have concluded that students' active participation in the learning process affects their learning outcomes [34]. In any learning environment, highly engaged students exhibit behavioral, intellectual, and emotional support for all of their learning tasks

([35], [36]). The Sociological Learning Model creates by [35]. The model is a synthesis of theories, concepts and theoretical frameworks with respect to the level and nature of domains in online learning that encompasses three interrelated domains of cognitive, social and affective factors [35]. Recently, many studies have related the approach in the teaching and learning process in experimenting the cybergogy concept based on the Wang and Kang's model ([34], [37], [38], [39]). Nonetheless, earlier studies have shown that there are still no methods that describe in detail how mathematics lecturers can specifically apply the cybergogy approach in the process of teaching and learning.

METHODOLOGY

This study was carried out to determine the criteria of heutagogy, paragogy and cybergogy approaches for mathematics teaching and learning at Higher Education level. The themes and its' items will be defined to instruct the mathematics educators the means to implement the heutagogy, paragogy and cybergogy approaches in class. The intensive and rigorous literature review were done to analyze the teaching and learning models from the theoretical, model or conceptual aspects, several education policy documents that are relevant to the teaching and learning at Higher Institution as well as best practices in effective learning environments both locally and abroad in general and in the field of mathematics education. This phase will determine the themes and items that are relevant to the criteria of heutagogy, paragogy and cybergogy. There were two methods that were used to search the relevant and appropriate literature of the study. These approaches were suggested by [40] and well thought-out as the suitable and efficient ways to ascertain significant literature.

At the first phase, several related electronic databases were explored to investigate for the relevant articles, such as EBSCO host, Elsevier, Science Direct, Emerald, JSTOR, ProQuest, Sage Publications, SciVerse, Scopus, Springer Link, Taylor and Francis Online and Wiley Online. The main keywords used were heutagogy, paragogy, cybergogy, twenty-first century teaching and learning, the effective teaching and learning in general and specifically in mathematics subject at higher institution, Furthermore, each single journals on teaching and learning in mathematics education at higher institution were examined individually to find more pertinent papers, such as, ASEAN Journal of Teaching & Learning in Higher Education, Transformative Perspectives and Processes in Higher Education, Journal of Interactive Online Learning, Journal for Research in Mathematics Education, Journal of Further and Higher Education, International Journal of Education and Pedagogy, An International Journal of Complexity and Education, Eurasia Journal of Mathematics, Science and Technology Education, Global Citizen Digest, Higher Education Management and Policy, Journal of Social Sciences and Humanities, Open Learning: The Journal of Open, Distance and E-Learning British Journal of Educational Technology and others.

At the second phase, the relevant articles were identified based on the pull out bibliography of the crucial articles of the above literature review using the snowballing method. The literature exploration was done from May 2018 to January 2020 and restricted to only teaching and learning studies available between 2000 and 2019. This leads to the limitation of this study. If it is found that an article fulfilled these three elements: (a) it focused predominantly on teaching and learning in general and specifically in mathematics subject at higher institution, (b) it examined elements of heutagogy, paragogy and cybergogy in teaching and learning of mathematics or other subjects in general; (c) the investigation was carried out in the venue of higher institutions and among mathematics lecturers, then this article will be included in this study. The peer-reviewed articles that were published in academic journals were also included. Furthermore, conference proceedings, and theses, were also included from this review. Duplication, indistinguishable and identical publications that irrelevant was removed. Those articles were selected for relevance, essentially based on the title, abstracts, and keywords.

As mention above, an intensive literature review was also done for analyzing teaching/learning models from the theoretical/model/conceptual aspects. Besides theories and models related to related to heutagogy, paragogy and cybergogy such as the humanistic theory, connectivism theory and Cybergogy model, two theories underlying mathematical learning and teaching were chosen in this study; mathematical understanding by [41] and Ausubel [42] learning theory. In researching Skemp's theory of understanding [41], a student has two forms of understanding in mathematics; instrumental and relational. Students with a relational understanding will have the knowledge of how to find the results of their own learning. Self-learning is also a learning process using the heutagogy approach ([11], [14]) as suggested in the Future Ready Curriculum [7]. In addition, they will have the knowledge of how and why to seek the results of their own learning including selecting specific methods for solving problems and justifying why they can solve problems [43]. Ausubel [42] meaningful learning and concept of advance organizer connects with those approaches of heutagogy, paragogy and cybergogy because it impacts the classroom environment by changing the activities to motivate students to engage in meaningful learning.

Several documents also have been reviewed in the context of higher education development in Malaysia, and have extended this study in terms of the integration and relevance of the higher education system including strengthening the quality and competitiveness of higher education institutions. The following are the strategic initiatives for the development of first-class human capital in Malaysia namely, (i) Malaysian Education Development Plan (Higher Education) 2013-2025 (ii) National Higher Education Strategic Plan 2020 (iii) National Transformation 50 (iv) Vision 2020 (v) 11th Malaysian Plan (2016-2020) (vi) Future Ready Curriculum for Malaysian Public University. In short, Figure 1 showed the conceptual framework of the study.

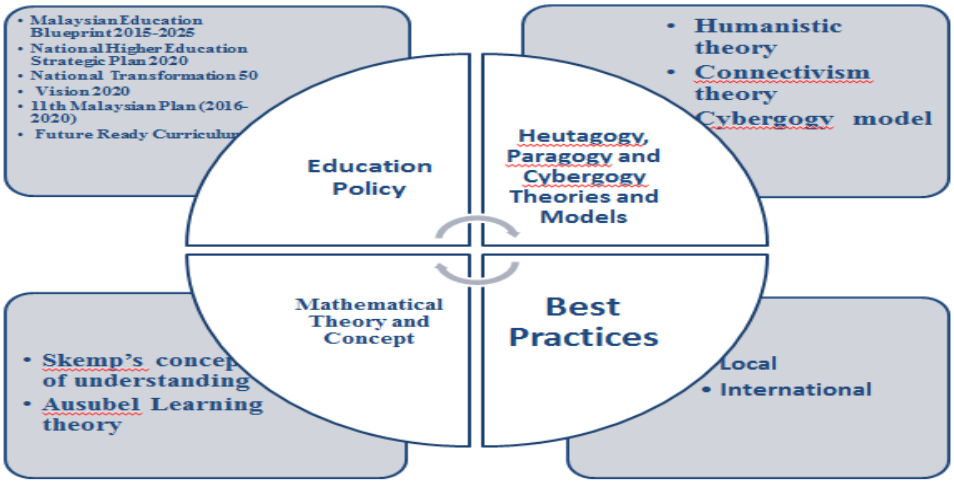

Figure 1: Conceptual Framework of the Study

FINDINGS AND DISCUSSION

This section will discuss vis-à-vis the findings on the criteria of heutagogy, paragogy and cybergogy in teaching and learning of mathematics. Figure 2 portrayed the themes of heutagogy in teaching and learning of mathematics.

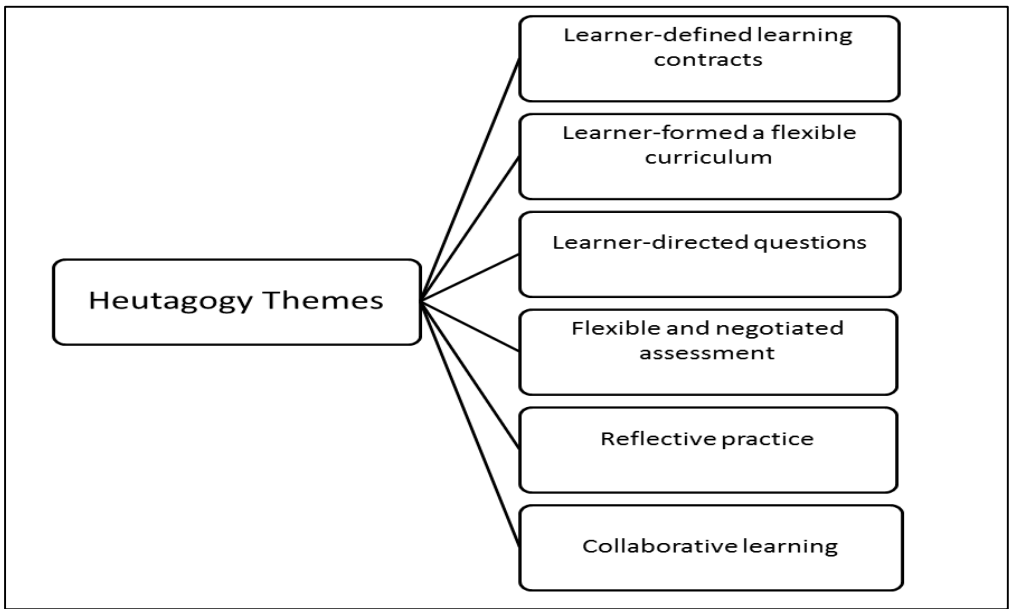

Figure 2: Themes of heutagogy in teaching and learning of mathematics.

The finding of the study discovered six themes for the heutagogy criteria in teaching and learning of mathematics, namely (i) Learner-defined learning contracts, (ii) Learner-formed a flexible curriculum, (iii) Learner-directed questions (iv) Flexible and negotiated assessment, (v) Reflective practice, and (v) Collaborative learning. For each theme, there are 5, 5, 7, 5, 8 and 5 items respectively, which totaled up to overall items for the heutagogy criteria is 35.

The main element for a heutagogical approach to learning and teaching is learner-centeredness where the contexts and content are learner-generated [14]. For the first, several studies have argued that learning contracts or agreements supports students in shaping their learning pathways ([17], [44], [45]). In this case, the lecturers need to inspire student in giving ideas on how the course content be studied as well as encourage students to suggest what will be assessed or evaluated in the teaching and learning processes. The second theme, the learner is also the vital person in developing a flexible curriculum in which the actions of learning will always consider the students' negotiation, hence is always adapted and evolved according to their needs [46]. However, despite of giving the opportunity to involve students in creating course curriculum, teaching and learning activities and assessment method, [47] reminded mathematics educators to upkeep students to contextualize concepts, knowledge and new understanding which emphasized on relational understanding rather than just instrumental understanding.

In heutagogical approach environment, the learners need to pose directed question in teaching and learning of mathematics, which referred to the third theme. The discussion, argument and dialogue that were consequences from the posed directed-questions will be functioned as tools for assisting learners in making sense of the course content, would help to illuminate the ideas and facts, as well as stimulate in promoting individual and group reflection [17]. In this situation, the instructors need to plan on how to encourage students to define self-directed questions, boost students to probe questions about course contents, make sure that students bring intelligibility to ideas of course content, monitor students how to be perceptive about ideas and contents of the course, stimulate students' individual and group reflection, and give tasks that encourage students to discuss in helping involve in planning their assessments as well as assimilate students' negotiation into the assessment process consistent with the learning agreements or contracts([48], [49]). This will take into concern several techniques of assessing understanding of course contents that uses the method of authentic assessment namely, the use of rubrics for students' self-assessment process, evaluating students' discussion skills and teamwork skills.

The fifth theme of the heutagogical is concerning practicing a reflective practice ([14], [45], [50]). It is an important learning skill which means knowing how an individual student learns various activities can be blended in the learning processes to encourage reflective practice such as the use of reflective journals in teaching and learning [14] and the implementation of action research [48]. Thus, in this learning environment, students can mirrored upon the contents of the course and discussion and discover new ideas, concepts and facts, form a continuous practice of reflection in the teaching and learning process and carry out action research to provide students with opportunities to explore and research real-life scenarios, which can help prepare them for future work. [13] also suggested, instructors also can practice double–loop teaching and learning to facilitate metacognition teaching and learning elaborative learning is the sixth theme for the heutagogy approach

where students learn together, cooperating in a collaborative space to explain a shared concept, fact or idea, and thinking together about how they learn and how to apply those ideas in their practice [48]. In today's technology advancement, instructors also should apply e-learning so that the student can be collaborators in their learning.

Figure 2 depicted the themes of paragogy in teaching and learning of mathematics. This study had found five themes for the paragogy criteria in teaching and learning of mathematics, such as i) Context as a de centered center, (ii) Meta-learning as a font of knowledge, (iii) Peers provide constructive feedback; (iv)Learning is distributed and nonlinear, and (v) Mutual support and motivation. There are 7, 8, 5, 8 and 6 items respectively for each theme. The overall total of the items for the paragogy criteria is 34.

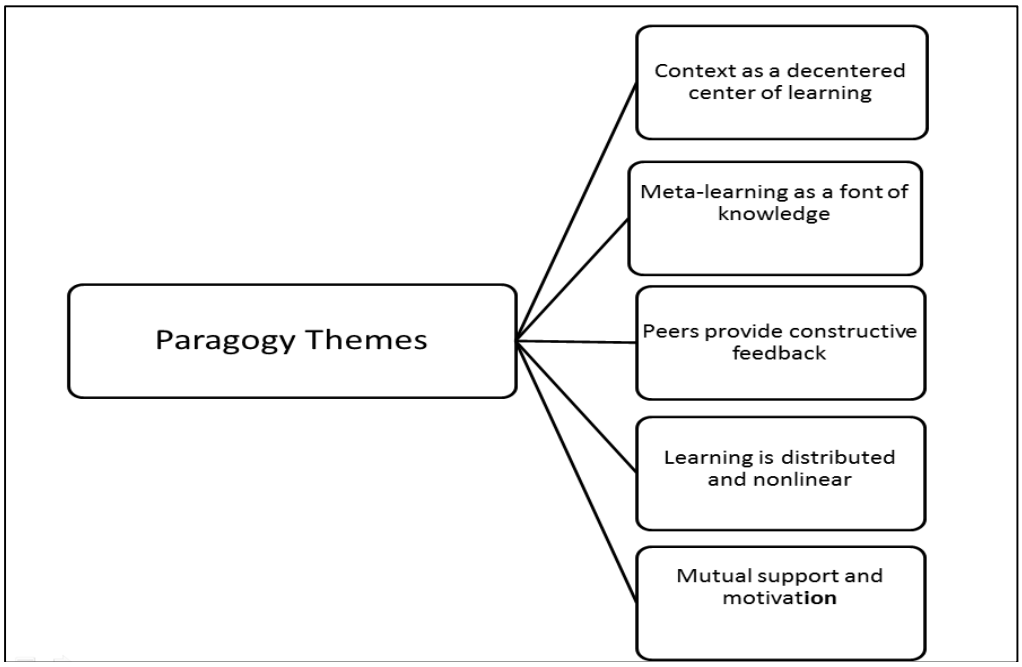

Figure 2: Themes of paragogy in teaching and learning of mathematics

The paragogy themes provide guiding principles on best practices for building successful peer learning experiences. The first theme for this approach is context as decentered center of learning. This means that the key focus in paragogical approach is learners and educators are co-context creator for the learning processes. According to [23, p.3], "the environment should not be taken as "given" but should instead be viewed as co-created by peer". In this learning situation, students learn the importance of sharing ideas in teaching, aware of contexts that support a variety of interactions as well as contributing ideas tore define the learning contexts. The next theme is meta-learning is a font of knowledge. Here, the concern is on the individual effort about learn how to learn and learn how to support their peers in their learning effort ([23], [26], [50]). This theme is crucial in learning mathematics as this notion is referred as the higher order thinking which involves active control over the

cognitive processes engaged in learning [51]. Therefore, instructors need to encourage their students to think about what they are learning and why they are learning it, guide students to evaluate the effectiveness of their learning method and also monitor students to manage their learning according to the needs of their learning assignments.

The third theme is peers provide constructive feedback. This paradigm approach through meta-learning is one key approach used for students ([52], [53]). Students need to interact to ensure a deep understanding of what they are learning, deal with differences of opinion as a learning experience, engage in discussion activities, always responsive to any issues raised by the lecturers and interact by making constructive criticism of the learning concepts. The fourth theme is learning is distributed and non-linear. According to [54], learning does not go in a traditional straight path. This statement is aligned with the vital strand in the paragogical perspective of peer learning where the learners and educators are co-context creator for the learning processes. In this learning environment, instructors provide many opportunities for students to learn using a variety of methods, activities and assessments. The last theme for the paragogy criteria is the mutual support and motivation. The perspective of paragogy focuses on intentional practice [55] where students should openly spell-out their motivations as well as the aimsof learning. Furthermore, they, thenkeep track of their progress towards reaching the aims. As highlighted by [23], learning is identical to an inactive game without thinking critically about the goals you want to achieve. Hence, students are given the opportunity to present what they have learned andthe projects created in learning are endorsed by the relevant community.

The themes for cybergogy criteria in teaching and learning mathematics are illustrated in Figure 3. Three main themes for cybergogy criteria were established such as (i) Cognitive domain, (ii) Emotional domain, and (iii) Social domain. There are 18items for the cognitive domain theme, 13 items for the emotional domain, and finally 8 items for the social domain. Altogether, 39 items contribute to the cybergogy criteria.

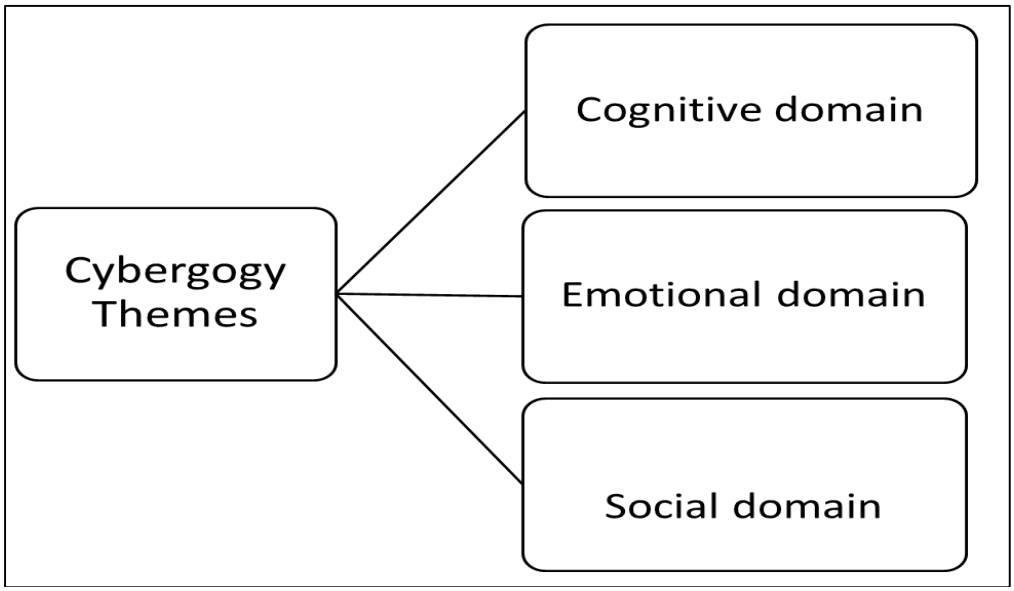

Figure 3: Themes for cybergogy criteria in teaching and learning mathematics

Cybergogy learning environment is focusing on helping students learn easily and technology enables autonomous and collaborative learning in a virtual environment. In essence, cybergogy strategies used for face-to-face learning may not be the same in a virtual environment. Literature reviews have concluded that students' active participation and engagement in the learning process affects their learning outcomes [34]. In any learning environment, highly engaged students exhibit behavioral, intellectual, and emotional support for all of their learning tasks ([35], [36]). This study has identified three keys domains for themes that contribute to the cybergogy paradigm. The first theme is the cognitive domain. Students must have sufficient existing or prior knowledge and skills for online learning. Before online learning is implemented, students must deal with the misconceptions in mathematics [56]. In addition, instructors need to provide variety of activities for students to involve actively in simulations so that they are stimulated to provide feedback on the concepts learned.

The second theme for cybergogy criteria is the emotive domain. Emotive factors profoundly affect students' engagement in the learning [34].According to [34], instructors need to be attentive and responsive to students' emotional state, need to make initiative to direct students' emotions to the save zones, namely the curiosity zone, flow zone and productive path zone. For examples, in cybergogy learning environment, students are exposed to learning strategies that foster positive emotions during the learning process and are provided with messages or images intended to encourage them to actively engage in meaningful and reflective processes.

Finally the third theme is the social domain which referred to the social aspects involving the interaction between oneself and others. Instructors need to create a cybergogy learning environment where students feel comfortable

with the environment and feel a strong sense of community and social commitment. For instance, students can significantly use communication tools such as email, whatsapp applications, telegram applications, online conferencing and others to enhance interaction levels. In addition, they can use significantly the database and other platforms in facilitating access to information. A better amalgamation of social factors as well as human factor need to be considered in e-learning environment in helping to reduce forms of e-learning challenges and shed new insights for the cybergogy perspectives [57].

CONCLUSION

This study has successfully generated the criteria of heutagogy, paragogy and cybergogy approaches for mathematical teaching and learning at Higher Education level. For each approach, the themes and its' characteristics has been determined to guide mathematics educators in implementing the heutagogy, paragogy and cybergogy approaches in class. For each approach, several themes have been identified, and for each theme there are several items that are described in detail for guidance. In summary, the main theme for a heutagogical approach is learner-centeredness where the contexts and content are learner-generated. For a paragogical approach, the themes identified provide information on best practices for managing peer learning. The key theme for this approach is both parties, the learners and educators are the creator for learning and teaching context. Finally, for the cybergogy approach, three domains that are interdependent are important factors that should be considered in implementing this approach, especially using the online learning method. To ensure successful online learning cognitive, emotive and social factors need to be taken into consideration by mathematics educators such as students need to have sufficient prior knowledge, students are presented with a variety of ways to be motivated to learn, and students are obtainable positive engaging and comfortable learning environment and feel a strong sense of community and social commitment.

These input themes and items of the heutagogy, paragogy and cybergogy approaches together may promote the mathematical learning transformation in this era and contribute to FRC paradigm as a whole. However, these criteria are still theoretical and therefore needs to be validated through systematic studies of forming a new framework of the heutagogy, paragogy and cybergogy approaches. Further development of the criteria through empirical research need to be done using the Exploratory Factor Analysis, Confirmatory Factor Analysis as well as Structural Equation Modeling analysis to ensure the themes and items are relevant, hence contributing to knowledge gap within the mathematics education research for the information about the guidance and strategies for implementing those approaches.

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