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Empowering Students through a Self-Directed Learning Pedagogy in Mathematics Education

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Abstract:
Mathematics is important subject in our daily life. It is taught in school level all over the world. Nowadays students are indifferent towards learning mathematics. Those indifferences are related to learning strategy in mathematics teaching. The main purpose of this study is introduce Self-Directed Learning (SDL) pedagogy in the context of mathematics education. The research employed a qualitative document analysis methodology, synthesizing information from diverse sources to explore a self-directed learning pedagogy through the development of conceptual and theoretical categories. We have prepared different theme related to self-directed learning such as concept of self-directed learning, nature of self-directed learning, mathematics and self-directed learning, role of SDL learners and teacher, philosophical underpinning of SDL, SDL models in practice, self-directed learning and its strategy. From those themes, we concluded that SDL is a teaching and learning pedagogy that encourages students to utilize their imaginative and intuitive abilities, fostering mindfulness, constructiveness, critical thinking, independence, cooperativeness, confidentiality, and autonomy, and promoting self-motivation, self-management, and self-monitoring. Moreover, Self-Directed Learning (SDL) is a self-directed pedagogy that encourages students to take charge of their education, focusing on engaging, creative, and independent learning methods. Under those themes self-directed emphasizes in fostering autonomy, creativity, and active engagement, while acknowledging the need for more specific models and stages for effective implementation in school mathematics education.

Keywords: Self-directed learning, Mathematics, School, Autonomy, Engaging, Model, Shift.

1. Introduction

Mathematics as a principal discipline has been contributing to development of other disciplines and technology. With this importance, it has a key position in school education all over the world. Mathematics is essential for everyday life as well as for higher study in every field (Poudel, 2020). It is also known as the queen of science (Burton, 2003). Despite this fact, many students consider mathematics as a difficult subject (Yadav, 2017). Similarly, mathematical power influences the process and learning outcomes of a person to achieve skills, attitude, and knowledge that will be replicated in everyday behaviour. It also aims to stimulate and motivate the achievement of students in interdisciplinary studies (Kusmaryono, 2014). There are many students who are indifference towards learning mathematics from school level to university level (Pandit, 2007). In context of Nepal,

Similarly, ERO (2013) found that SLC dropouts struggle with Mathematics, English, and Science. In 2010, 29.62% of students failed mathematics, increasing to 38.79% in 2011 and 42.09% in 2012. The main causes of failure in SLC examinations were poor teaching-learning environments, lack of qualified teachers, coaching, remedial classes, traditional didactic teaching methods, and ineffective communication between school staff, parents, and students. ERO (2017) reported an average grade VIII mathematics score of 49.2, compared to 50.8 in 2015. Math learning achievement declines annually, with 59% of students performing at or below the basic level, indicating low competency. ERO (2020) reports that less than 32% of students meet competency in class 8, and one-third perform below the national average in math. Students struggle to acquire basic knowledge and are unable to solve higher-order thinking problems. Poor teaching environments, lack of qualified teachers, coaching, remedial classes, traditional didactic teaching methods, and ineffective communication between school staff and parents contribute to declining math achievement. Further research is needed to identify the causes and introduce newer approaches to teaching mathematics. Khanal (2015) argued that Mathematics students at secondary school of Nepal has difficulties in understanding, investigating and generalizing the mathematic situation, has increased the number of unsuccessful students and poor achievement scores in mathematics examination. Similarly, Panthi & Belbase (2017) further added that the enrolment of student in mathematics at the school level to the university level is satisfactory, but the pass percentage is relatively less in Nepal. We additionally observed two secondary level mathematics classroom scenarios in a face-to-face setting where classroom scenarios in Nepal reveal a non-interactive teaching approach, with teachers focusing on the board and providing solutions without considering alternative methods, leading to student indifference. Self-directed learning, as described by Borich (2011), is an active approach that encourages students to play an engaged role in their own learning, promoting the development of higher-order thinking skills. It also nurtures their creative and intuitive abilities. According to Hamlet (2006), self-directed learning becomes meaningful when students take the initiative to plan and initiate their learning independently. Learners engaged in self-directed learning exhibit characteristics such as setting clear goals, demonstrating self-motivation, self-assuredness, self-control, a proactive attitude, and a willingness to absorb new knowledge (O'Shela, 2003). Grows (1991) contends that self-directed learning often commences with teacher-directed instruction, but over time, the responsibility for learning gradually shifts from the teacher to the learner. Now we are comprising to presented scenario of two class in mathematic teaching and above indicated version about self-directed learning. In the current mathematics teaching scenario, teachers are primarily focused on coaching and evaluation, while self-directed learning involves teachers as motivators, need analysts, counsellors, organizers, and facilitators. Students in self-directed learning are self-motivators, self-planers, self-confidence, managers, autonomous, collaborative, and constructive (O'Shela, 2003). However, students in the current scenario lack these qualities. Due to those scenarios of teacher and students in mathematics class in context of Nepal, mathematics learning is not interesting and meaningful to the students. This condition can be improved by using ICT in the classroom. (Pokhrel & Poudel, 2024). For effective and meaning full learning, a self-directed pedagogy applying in mathematics teaching in the present context. These facts show there is a need to rethink on existing mathematics teaching learning approach at school education. Concerning this issue, we will attempt to introduce new teaching pedagogy such as self-directed learning in mathematics teaching.

2. Objective of the Study

The objective of the research article is to introduce Self-Directed Learning (SDL) pedagogy for student in the context of mathematics education.

3. Methodology

Research methodology refers to the philosophical and intellectual framework about how to collect data for the research study. It is qualitative in nature with critical outlook. This study is based on document analysis method. Document analysis is a systematic procedure for reviewing or evaluating documents both printed and electronic materials. Document analysis requires that data be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge (Bowen, 2009, p. 27). To meet our objectives, we collected and analysed books, journal articles, research papers, forum, dissertation and online documents. We used key words such as Self-directed learning, learning styles, learning theories and models. Google Scholars, digital library of Tribhuvan University, Central Library in digital resources and published books and journals. After full reading of those sources, we prepared different themes and accumulated themes to prepare conceptual and theoretical categories and presented making sections on those categories. While writing, arguments are build up based upon the ideas expressed in the articles with necessary citations. we used the articles as sources of information and data while making analysis and interpretation.

4. Reviews and Discussion

4.1 Concept of Self-Directed Learning

Self-directed learning is a process for meaningful learning. It is a process where students make the key decision regarding how to plan, continue, and evaluate their educational experience (Merrian et al., 2007). In order to achieve desired results, self-directed learning calls for students to assume responsibility for their own learning (Pham, 2011). It is possible to determine that self-directed learners establish their own methods for action, identify the resources necessary for learning and success, and assess the degree to which they have met their own learning objectives. It assumes a learner is fully autonomous in his learning. But this level of autonomy may not be fully applicable for junior's students, however their own- action for learning is essential. With the same spirit, Hamlet (2006) argued that Self-directed learning involves students setting individual learning goals, selecting strategies, and evaluating their achievement and success. It is a process that progresses through stages, leading to independent self-directed learners. Teachers support this process, ensuring students reach self-directed positions.

In the realm of education, self-directed learning (SDL) is a prominent teaching approach that plays a pivotal role in engaging students actively in the learning process. This pedagogical approach, as highlighted by Borich (2011), not only encourages students' participation but also serves as a catalyst for the development of higher-order thinking skills and the stimulation of creativity. This is supported by the research of Reatnawati and Apino (2016), who emphasize that SDL encompasses both lower and higher-order thinking, thereby enriching students' cognitive abilities. In particular, SDL has been shown to enhance higher-order thinking skills, including the capacity for analysis, evaluation, and creative synthesis. Such findings align with the research of Teo (2006), who underscores that SDL

fosters critical thinking and imaginative problem-solving, enabling students to make connections between seemingly unrelated concepts, participate actively in discussions, and evolve their perspectives with fresh insights. This transformative process equips students with the essential skills to tackle real-world challenges and develop a robust foundation in critical thinking. Furthermore, as illuminated by Burke (2006), SDL empowers students to take an active role in constructing their own knowledge and meaning, promoting not only reasoning and problem-solving but also critical thinking regarding the subject matter. Hence, SDL emerges as a dynamic teaching approach that not only fosters active engagement but also enriches the cognitive landscape of learners, paving the way for the development of well-rounded, self-directed individuals who are well-equipped for a lifetime of learning and growth. Moreover, Huda (2014) suggests that self-directed learning (SDL) is a learning model that promotes learner autonomy and lifelong learning skills. Autonomous learners take control of their learning activities independently, leading to meaningful outcomes. SDL encourages students to take personal responsibility and cooperative control of cognitive and environmental processes, resulting in life satisfaction and meaningful learning in mathematics teaching. This continuous process of self-motivation, self-modification, self-management, and self-monitoring contributes to the success of SDL in fostering lifelong learning and life satisfaction (Garrison, 1997). Hence self-directed learning is process of meaningful learning and can be utilized as a pedagogy in mathematics learning. But its empirical justification is necessary and may need to develop different pedagogical models utilizing these conceptualizations, for it is not a prescriptive entity but is a growing entity.

4.2 Nature of Self-Directed Learning

Self-directed learning concept was initially developed for adult learning. Adult learners' behaviour is autonomous, and they like to lead their learning by themselves. The learning process by nature is adult focused. SDL then was concentrated to lifelong learning and as continued self-directed learning for the preparation of the life. Few studies are conducted in children's learning. The major concern in its nature is to make fit SDL for young learners. Literature mostly focused on SDL for adult, and it is an essential skill to be acquired for the promotion of life long learning's is a re-conditioning process that help learners to rediscover their willingness and should emphasis be meaning making as well as taking responsibility for learning (Leach, 2000). Burke (2006) argued that SDL helps student to construct their own understanding and meaning and help them to reason, solve problem and think critically about the content. So SDL is constructive as well as critical nature. SDL as a tool for promoting critical thinking and problem solving skills among the students. SDL is a type of self-planed, self-initiated and autonomous learning principle derived from the humanistic psychology that regard learners as responsible for their own learning experience (Oyibe et al., 2015).

SDL is used in teaching and learning situation which involves getting student to unleash their imaginative and intuitive capacities, thoughts, learnings and promotes maximum interaction between and among the student's strength to enhance efficient decision making (Borich, 2011). Hence SDL is imaginative and autonomous nature. In learning mathematics, a learner needs to be an independent thinker and an actor to get meanings of its contents. However, not much research are conducted in teaching and learning mathematics. SDL can support to understand the abstract nature of mathematics. However, the developed model of SDL by its autonomous learner nature focusing on adult learning may not perfectly match for children learning, but could be beneficial for undergraduate and graduate

level of student. Now the question is how to modify the SDL nature making best fit to young learning. Takaendengan & Santosa (2018) argued that self-directed learning helps students to be more active in mathematics class and more initiative in learning mathematics considering SDL by nature is active and student centred process.

Self-directive learning takes initiative and is responsible for the planning, implementation and evaluation of their own work (Hamlet 2006.) SDL strategy is a type of self-planned, self-initiated and autonomous learning principally derived from the humanistic psychology that regards learners as responsible director of their own learning experience. It used in teaching and learning situation which involves getting students to unleash their imaginative and intuitive capacities through learning and promote maximum interaction between and among students to in hence efficient decision making which discussing and analysing social issues (Oyibe et al., 2015). SDL therefore is much humanistic as well as independent nature.

On the process of learning, individual as well as cooperative learning, provides the foundation of effective SDL. Cooperative learning occurs only when five basic elements are structured into the situation. Those five elements are positive independence, individual accountability, promote interaction, appropriate use of social skills and group processing. Those elements related to intrinsic motivation, competence motivation, development motivation, continue motivation, learner control and internalizing imposed goals and creativity (Johnson & Johnson 2019). Cooperative learning is practice in school education guided by constructive learning theory principle. But the ways of managing cooperative learning for school children is different to the adult learner. As SDL is cooperative and motivational nature, the concern is how to make it effective in school education particularly learning mathematics. Johnson & Johnson (2019) argue that students are motivated in SDL for students own planning and carrying out of learning activities. Critical question is to search the method to motivate young students in planning their learning. What types of the young students are self-directed and self-motivated is the big issues? At present, students' motivation to learning is a critical. SDL is possibly the student individually is able to define own goals; the goals are related to his/her central needs or values, able to define the path, their achievement of those goals structured cooperatively and not competitively. Thus SDL can be helpful to meaningful mathematics learning. SDL has four dimensions such as namely, choice, competence, control and confidence. Those dimension are closely connected, and student are allowed to make choice in learning, their awareness of control will consequently also be affected (Vanderwalt, 2016). Utilizing those dimensions completely needs overall education policy in this direction. Hence Self-Directed Learning (SDL) is autonomous pedagogy that empowers their own learning. It aims to make learning more enjoyable, imaginative, engagement and autonomous allowing students to make choices and be in control. However, the best ways to implement SDL for students in school are still being explored.

4.3 Mathematics and Self-Directed Learning

Mathematics influences students' overall education and further mathematical knowledge development (Hodanova & Nocard, 2016). It helps to achieve success in interdisciplinary studies (Kusmaryono, 2014). Mathematics is seen by society as the foundation of scientific-technological knowledge that is vital in the social-economic development of a nation. In spite of realizing the

important role of mathematics in all-around the word, nowadays students are indifference towards learning mathematics and seem uninterested toward learning mathematic at school to university level (Khanal, 2015). Students' motivation and engagement in learning is a problem to mathematics teachers. Educationists and the state are facing the challenges with the problems of failure in mathematics in SLC examination (Acharya, 2017). Mathematics is a cause of dropout in schools. The statistics shows that students' self-engagement in learning mathematics is decreasing day by day at every level. To address the issue of learning mathematics, different, learning strategies are suggested for meaningful teaching and learning. Learning strategies are developed according to the needs of learners and types of subject matters to be taught with the aim of making teaching-learning process effective and meaningful(Pandit,2007). One of the main learning strategy or approach is self-directed learning. Self-directed learning is the process (approach) for meaningful learning where student is self-planed, self-monitoring, self-management and become collaborative and constructive as an autonomous learner (Oliver, 2019). Student views mathematics as one of the boring or tedious subjects and believe that only genius can study mathematics. This reduces their confidence in working alone. Similarly, teachers believe that only talent student can study mathematics. Mathematics follows rules and facts, collection of symbols, and body of pure knowledge. (Schoenfeld 1992 & Panthi and Bellbase, 2017). Those views about mathematics reflect negative perception toward learning mathematics. These views are developed due to existing teaching learning process in mathematics classroom and are obstacle to initiate new approach of teaching and learning. When students are self-aware, naturally motivated, curious, responsible, creative, goal oriented, self-confidence, want to learn, self-evaluators, self-motivator, self-manager, self-planner in mathematics classroom (Gidding, 2014 & Hamlet, 2006) certainly increase learning outcomes. Self-directed learning is an approach that promote the active engagement of students in the learning process to acquire higher order thinking skills, such as problem solving, critical thinking and reasoning (Oliver,2019&Mentz & Bailey 2019). Positive attitude of students and teacher towards self-directed learning process can ensure possibility of its use in mathematics class. The diagram given below explains about the attributes necessary in students and teachers for successful implementation of self-directed learning strategy in classroom teaching.

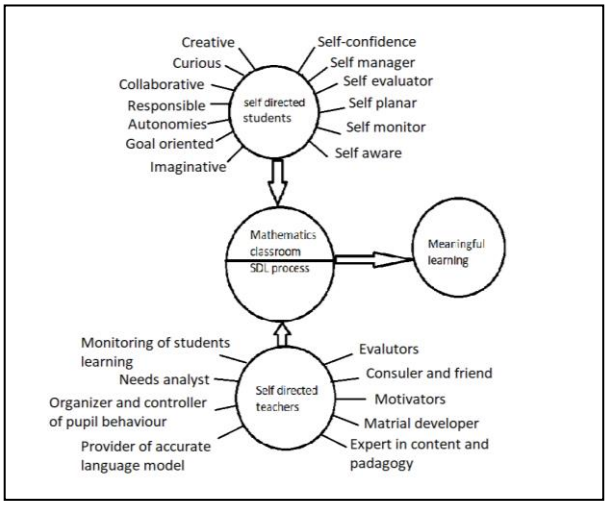

Figure 1 ; Attributes necessary for learning

Knowles has pointed out five step on diagnosing their learning needs, formulating learning goal, identifying human and materials resources for learning, choosing and implementing appropriate learning strategy and evaluating learning outcomes (Knowles, 1975). As the attributes below mentioned are in teacher and students and follows those step of SDL, then SDL can be applicable in classroom and mathematics learning becomes meaningful and develop positive perception toward mathematic and mathematics learning. Hence, Self-Directed Learning (SDL) can help overcome declining student interest and motivation in mathematics classes by encouraging active involvement, problem-solving, and critical thinking abilities. This approach can change unfavourable attitudes towards studying mathematics, leading to a happier mathematics learning when both teachers and students possess the necessary skills for successful implementation.

4.4 Role of SDL Learners and Teacher

Self-directed learners must actively engage in self-motivation, planning, monitoring, and evaluation to achieve meaningful learning goals (Oswalt, 2003). But in school student, teacher may help to design to self-motivation, self-planning, monitoring, self-evaluation for meaningful learning. According to Askin and Denirel (2018), a self-directed learner is one who sets clear goals for themselves, shapes their learning process in real life with goals and plans, evaluates the results of their own learning, is autonomous, has self-motivation, is open to learning, is curious, willing to learn, values learning, has self-control, and takes initiative to help others. Guglidmino (1977) proposed a list of qualities that self-directed learners should possess, including initiative, independence, persistence, a sense of responsibility for one's own learning, a tendency to see problems as challenges, self-discipline, a high level of curiosity, a strong desire to learn or change, the ability to use basic study skills, the ability to organize one's time, self-confidence, the ability to develop a plan for completing work and joy in learning. Hence self-directed learners are creative, collaborative, imaginative autonomies for meaningful learn. Self-directed learners should therefore be able to acquire new knowledge (what) and manage the learning process (how) throughout their entire lives (Olivier, 2019) readily and skilfully.

Moreover, self-directed teacher is essential to the learning process because they either give overt instructions to the most dependent pupils or serve as mentors to those who take greater responsibility for setting their own learning goals and conducting self-evaluations (Hamlet, 2006). According to Henschke and Henschke (2016), Self-directed teachers should reduce learner dependence, assist students, create a welcoming environment, emphasize experimental approaches, encourage problem formulation, decision-making, and organizational ownership. According to Brandt (2020), self-directed teacher involve plan, monitor and adapt, and reflect and evaluate as well as good motivators, facilitators and learning managers. Moreover, I draw the conclusion from the discussion above that self-directed learners are using autonomous learning, and self-directed teachers are using a student’s-centred approach to teaching.

4.5 Philosophical Underpinning of SDL

SDL's philosophical roots are a synthesis of pragmatics, humanism, and constructivism (Morris, 2019). As a result, SDL borrows ideas from humanistic, pragmatic, and constructivist philosophy. Carl Rogers (1969) is a major humanist philosopher who believes that humans develop

truth through experience and claims that a fully functioning person must maintain a positive self-esteem towards self-actualization and that effective meaningful learning necessitates authenticity and openness between learners and facilities, a deep introspective evolution of values, and the freedom to pursue intrinsic goals (Parker & Roessger, 2020). Rogerian humanism was introduced in the field of SDL by Knowles. Knowles give the ideas of andragogy that focus on higher level of learning for adult's self-actualization and accommodate their increasing autonomous and self-directed approach to learning (Knowles, 1975). Those ideas related to humanist assumption that adults have unique self-concepts, free choice, and the ability to solve their own problems (Parker & Roessger , 2020). Servant-Miklos and Noordegraaf-Eelens (2021) argue that the self-directed learning developed in 1970 follows humanistic education principle starting by Houle (1961); Tough (1971) and Knowles (1975) with ontological belief of SDL is individualized view of self and challenging its ability to meet our present education needs. Critically analysing the above arguments, we can say that SDL follows the assumption of humanism. Similarly, Pragmatism developed by John Davey, James and Charles in 19th and 20th centuries. The philosophical basis of pragmatism is "knowledge has to do with the values or meaning of experience" (Colliers, 2022, p.150). This philosophy is democratic philosophy of education which focuses on engage, independent, free for choice of learner and encourages with interaction to obtaining knowledge (Firmanto et al., 2019) which is related to SDL. In the same way, Fattah (2010) argued that self-directed learning integrates self-management, self-monitoring, and motivational dimensions, rooted in constructivism. This approach emphasizes active learners' participation in seeking knowledge and information to develop understanding, either individually or in small groups.

Hence, Self-directed learning (SDL) is based on three epistemological views: Pragmatism, Constructivism, and humanism. It emphasizes self-flourishing, democratic engagement, student autonomy, personal responsibility, and choice, reflecting the learner's innate curiosity.

4.6 SDL Models in Practice: Critical Reflections

Self-directed learning (SDL) combines self-management and self-monitoring and views learners as guardians of their own learning processes (Song & Hill, 2007). It acknowledges the important part that motivation plays in boosting a learner's effort. Therefore, self-directed learning as the fundamental notion related with three overlapping concepts such as self-management, self-monitoring, and motivation (Garrison, 1997). In a similar vein, Long (1998) distinguishes between sociological, educational, and psychological aspects of self-directed learning. These factors are crucial for SDL. SDL is a type of learning that emphasizes self-initiated, self-planned, and independent learning (Parasafar & Tabtabaei 2012). The SDL paradigm integrates self-management with self-monitoring and considers learners as responsible owners and managers of their own learning process (Brockett,2002). Up to now there are no self-directed learning model in school education but there are different learning models connected to SDL in adult learning. Long model of self-directed learning gives four situations of learning management with the degree of student's self-control over their learning and facilitator's supports. Upon the identification of the student's engagement levels, teachers have to set the learning situation determining the facilitation approach teacher's own support, group work, peer support etc.

Similarly, Candy (1991) proposes a two-dimensional interactive SDL model. One dimension is the level of control within an institutional environment, and the second is student control in situations outside of the official institutional framework (Bosch et al, 2019). At one end of the first dimension's continuum, the educator has complete control over how the subject is given, what is studied, and what outcomes are anticipated from the pupils. The other end of the spectrum reflects a scenario in which the learner has complete control over the learning process (Candy, 1991, as cited as Bosch et al, 2019). This SDL model takes into account two directional processes in learning, which are related to educator control and student control. The learning process and outcomes are clearly understood to be under the control of the educator and the learner. The educator is in charge of the subject presentation, the amount and process of study, and the outcomes anticipated of the pupils. Similarly, student control over the learning experience is specific to a given body of knowledge and can only be created if the learners have developed a mental map of the subject matter.

Student control and autodidaxy (educator's control) are important components of mathematics as an abstract structural discipline. At the beginning of mathematics learning, teacher control is necessary for meaningful engagement in learning design and process. This model of self-directed learning is suitable in teaching mathematics, where student control and educators' control in the classroom. It is related to guided discovery approach and student-center approach, which allows students to solve problems with teacher's facilitation.

Similarly, Personal Responsibility Orientation (PRO) Model by Brockett and Hiemstra (1991) depicts two dimensions of SDL: personal responsibility in the teaching-learning process and personal responsibility in one's own thoughts and actions (Bosch, et al, 2019). SDL is a process in which a student takes primary responsibility for planning, implementing, and evaluating the learning process in the first dimension. SDL is defined as a goal in the second dimension that focuses on a learner's desire or preference for taking responsibility for learning (Brockett & Hiemstra, 1991, p. 29). Even though they have no influence over the situation itself, people have control over how they react. Even though they call it personal responsibility, the element of control, personal accountability does not always include total control over the learning environment. However, it suggests that the reaction to the circumstance is under one's own personal control (Bosch, et al., 2019). This concept places a strong emphasis on the idea of individuals taking ownership of their own learning. According to this paradigm, SDL is motivated by the learner's assumption of responsibility for the design, execution, and assessment of the learning process. This approach is aided by instructional support that varies in accordance with learner skill, a collaborative learning environment, and learner motivation to take charge of their own learning (Oswalt, 2003). This model combines individual accountability in the learning and teaching process with thought action. Students use a collaborative planning, implementation, and evaluation process when learning. This model was somewhat linked to the approach used in math instruction that emphasizes problem solving**.** In an educational context, Garrison model (1997) presented an SDL model that incorporated external management, internal monitoring, and learning-motivating variables (Fattah, 2010). Self-management, self-monitoring, and motivation are crucial components of effective learning, according to Garrison's SDL model. In order to accomplish their learning goals, students who practice self-management take charge of the learning

environment. This control suggests collaboration with others while also allowing for independent learning within the context (Bosch, et al, 2019).

Similarly, another model is Garrison's learning model, Garrison's learning model self-monitoring and self-management are integrative to motivation. Learners' motivation reflects to self-management and self-monitoring obtained self-directed learning(Garrison,1997). Implication of these model in learning emphasizes on students should plan and adapt thinking after which they should engage in critical reflection, assimilating new knowledge with existing knowledge. Garrison (1997) describes self-management as collaborative control of external activities associated with the learning process, such as goal setting, method for how learning goals are satisfied and establishing outcomes. In this model, self-monitoring address bath cognitive and metacognitive process, whereby learners take responsibility for monitoring the learning process and make learning meaningful through reflection and collaboration. Self-monitoring is a process whereby self-directed learning use between internal and external feedback to evaluate current learning strategies and to shape those strategies to help them learn best (Oswalt, 2003). Hence Garrison (1997) stresses that the process SDL must occurs in a collaborative and constructive learning environment. In this model, learners are motivated to mentor and manage their learning process. Similarly, Oswalt's Model of SDL (2003) founds nine key concepts concerning SDL such as "opportunity, support, collaboration, motivation, context, cognitive skills, skill with content, skill with SDL, and willingness to control one's own learning'' (Oswalt, 2003, p. 24 as cited as Bosch, et al, 2019, p. 5). Again, Oswalt divides the nine components into three major groups such as learning situation, components of learning and student's attributes. First group includes opportunity, support, and collaboration. The second group integrates content skill, SDL skill and willingness to direct one's own learning. And third group integrate motivational, contextual, and cognitive (Oswalt, 2003, p:25). According to him, SDL can only be successful if the learner is prepared to put in the time and effort necessary to promote his or her SDL abilities. This concept is related to the cognitive motivational and contextual aspect of learning. The learning scenario, learning components, and learning attributes are the three main components of SDL. Although students take charge of managing their own learning, instructors still need to offer tools and scaffolding to aid students in acquiring new knowledge and skills. Hence Oswalt's model of SDL is more advance than other model. In this model, SDL is implying the combination of three components such as learning situation, component of learning and learner's attributes.

The models developed by Long, Candy, Brockett and Hiemstra, Garrison, and Oswalt were some of the SDL learning models that were discussed where all model base on adult learning. The educational and psychological control of Long's model is its foundation. Students' SDL abilities will be influenced by the amount of control they are provided in this model. According to this concept, the education system gives students authority over some parts of their education, including the topic they choose for an assignment, the resources they use to learn, and the ways they learn. The depth of our understanding of SDL was increased by Cady's model. The self-direction of a student may vary across several curriculum areas, according to Candy's approach. When creating a setting to support SDL, it's crucial to keep this aspect of SDL in mind. Process, individual characteristics, and social context are all combined in the PRO model in which the social context of learning is the physical setting in which learning takes place, such as tertiary institutions, libraries, and museums. Garison (1997) places equal

emphasis on motivation, self-management, and self-monitoring. Self-control and self-monitoring are facilitated by motivation. The greater number of SDL components are somehow integrated by Oswalt (2003), who also presented a more comprehensive picture of SDL. In mathematics classroom, there are more diversity such as gender, cast, learning styles, geographical, and anymore. Those models are applying in adult learning, but they have not considered diversity variables in the classroom. Moreover, new innovation can be observed developing in school education. But those models cannot cover those new dimensions in educational strategy with pedagogy in school education. Hence, there is a need to develop and use new SDL model that can relatively fit mathematics education.

4.7 Self-Directed Learning and its Strategy

According to Bosch et al. (2019), self-directed learning follows a sequential process that involves modelling (show me), scaffolding and support (help me), and finally, transferring knowledge and skills (let me). Self-directed learning (SDL) is enhanced through various instructional strategies, such as collaborative learning (CL), problem-based learning (PBL), and process-oriented learning (POL). CL involves teamwork to achieve common goals, while PBL promotes active learning and accountability. POL focuses on interaction processes and shifts the teacher's role to facilitate SDL. These strategies empower students to set goals, seek resources, and reflect on their learning progress, helping them become autonomous learners (Francom, 2009; Golightly & Guglielmino 2015; Bosch & Pool, 2019). Hence, Self-directed learning focus students to select learning objectives, learning strategy, promoting active participation through collaboration, conversation and dialogue. Similarly, grow (1991) suggested that self-directed learning starts with the teacher directed and then gradually gives more responsibility to the learner. He describes this process in four stages, which involve changes in the roles of both students and teachers. Students go through four phases in their learning journey: first, they are dependent on teachers; then, they become interested and motivated; in the next stage, they engage in collaborative learning; and finally, they become self-directed learners who seek guidance as needed(Leach, 2000). Similarly, Harvey (2019) proposed a four-step process for self-directed learning, which includes assessing readiness, setting goals, engaging in the learning process, and evaluating learning. Students play a crucial role in this process, consulting with teachers as needed, self-assessing readiness, defining goals, developing a learning contract, monitoring the learning process, taking initiative, and re-evaluating goals as needed. Teachers serve as advisors, build a cooperative environment, motivate and direct students, facilitate their learning initiatives, and be available for consultations during the learning process. All of the SDL stages or steps are based on adult learning, and there is not a recommended stage or approach for learning mathematics in schools, thus new stages and models need to be developed for students to learn mathematics.

5. Result and Conclusion

The current situation of mathematics education is plagued by challenges, including low student interest and achievement, attributed to traditional teaching methods and negative perceptions of mathematics. To address these issues, the introduction of Self-Directed Learning (SDL) as an innovative pedagogical approach offers a promising solution. To meet the objectives, we analyzed various sources, including books, journal articles, research papers, forums, and dissertations, to understand self-directed learning, learning styles, theories, and categorized them into conceptual

categories such concept of self-directed learning, nature of self-directed learning, mathematics and self-directed learning, role of SDL learners and teacher, philosophical underpinning of SDL, SDL models in practice, self-directed learning and its strategy. From those theme we conclude that SDL empowers students to take control of their learning, fostering autonomy, motivation, and self-responsibility. Moreover, Self-Directed Learning (SDL) is a self-directed pedagogy that encourages students to take charge of their education, focusing on engaging, creative, and independent learning methods. Further, self-directed learning, a method that promotes active engagement and critical thinking in mathematics education, rooted in pragmatism, constructivism, and humanism. By implementing SDL in mathematics education, it is possible to create a more meaningful and effective learning environment, ultimately transforming students into self-directed, creative, and enthusiastic learners. This article critically reviews various self-directed learning models, highlighting their educational and psychological foundations, social context, self-motivation, self-management, and self-monitoring, and calls for a new model tailored to the diverse and evolving dimensions of school mathematics education. Self-directed learning is a systematic approach that involves stages like modeling, scaffolding, and knowledge transfer, which is complementary to problem-based and collaborative learning strategies, but more specific models and stages are required for school mathematics education.

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