

# Transformative Pedagogy via Digital Technology in Undergraduate Mathematics Education

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## Abstract

*The main purpose of this paper is to review the different papers and theories regarding transformative pedagogy used in mathematics education at the undergraduate level and draw transformative praxis used and unfold the gaps for further research betterment. Also, this paper explores the philosophical theory/idea that guides the transformative pedagogical practices via Digital Technology in education over the globe and analyzes digital boundaries in higher education in Nepal.*

**Key words:** *Digital Technology, Higher Education, Transformative Pedagogy*

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## Introduction

Prospective Teachers often assume that their mathematics content knowledge is sufficient to teach mathematics in higher education and try to run the class with a mono-cultural narrative. However, research has shown that pedagogically much of potential teachers' knowledge is procedurally based and lacks depth and conceptual understanding to facilitate active learning at students. In designing curriculum in mathematics teacher education program, both contents and pedagogical courses are associated to prepare them professionally sound in teaching mathematical contents using appropriate pedagogical approaches. The purpose of the inclusion of the content courses for mathematics teacher educators is to help teachers become more mathematically proficient, by relearning the mathematics that they believe they already know in deeper, more connected ways. It is necessary to incorporate transformative pedagogy in the process of teaching and learning mathematics content courses. Some important components are the basic ingredient to make transformative pedagogy. National Research

Council (NRC) defines five components of mathematical proficiency: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition that are interwoven and interconnected (Johnson & Olanoff, 2020). Anonymus (2002) argued that people become teachers of mathematics for many reasons. Some because they were inspired by their teachers of mathematics, some because they enjoy mathematics and wish to share this enjoyment with others, and some because they believe that education in general and mathematics education, in particular, is the only route through which we can create a more socially just society.

This is the bitter truth that lack of self-efficacy of teachers in different pedagogical skills is quite unfortunate and the social narrative what I experience in my academic journey that teachers are the ultimate sources of knowledge, whatever they communicate and provide the notes during instruction that is the concluding authority and students could not critically communicate with the teacher, whatever teacher is presenting, students must perceive it without critical conscience.

This temperament might be a barricade for transformative education.

Freire (1993) claimed the first concept that education becomes an act of depositing in which the students as the depositories and the teacher as the depositor. Instead of communicating, the teacher issues statements and makes ‘deposits’ which the students patiently receive, memorize, and repeat. A second concept that is at the core of this problem-posing approach of education is that of praxis. Praxis is moving back and forth in a critical way between reflecting and acting on the world. The third is the horizontal student-teacher relationship. This offers an educational atmosphere that is nontoxic, where anything can be shared and talked about, an obvious setting for raising one’s consciousness and facilitating an emancipatory transformation (as cited in Mezirow, 1998, pp. 17–18).

Transformative pedagogy (TP) in higher education and for the development of students’ transformative capabilities — autonomy, reflexivity, critical thought, creativity, and cooperation plays a substantial role in systematically expanding the horizon of learning possibilities (Pires et al., 2018). Transformative educators emphasize the need for renewal of student and teacher approaches, specifically highlighting its potential for democratic and emancipatory purposes. In this sense, they articulate pedagogic innovation with flexibility in higher education, exploring the possibilities given by Information and Communication Technologies, crossing boundaries within a systemic and integrative perspective.

Vengadasalam (n.d.) argued that in an academic setting, the transformational theory holds that students can reach their full potential through transformative experiences gained through engagement in an academic community. In this regard, transformative

pedagogy can be particularly useful together with academic and professional writing discourses are taught. Indeed, in writing, transformative pedagogy could be a methodological breakthrough.

Vieira, Silva & Almeida (2009) argued that the complexity of the societal transformations demands the construction of new meanings for higher education and in this context, researchers have highlighted that to transform pedagogy in HE is an inevitable need as cited in (Pires et al., 2018). These authors have discussed educational practices in higher education, pointing out the need to transform pedagogy to promote transformative learning. They further reiterated that to fulfill contextual demand in the global market they point out a set of transdisciplinary principles that can be taken into account to create transformative pedagogic practices in higher education: intentionality, transparency, coherence, relevancy, reflexivity, democratic, self-regulation, and creativity/innovation. Biesta (2010) states, there are three main dimensions in education; qualification, socialization, and subjectification that have been functioning as rationales for education. Perhaps the most interesting thing is to understand their intersections and synergies, to look for their potentialities.

On the other hand, Illich (1970) argued in the conflicting direction that why schools should not be established, many students, especially those who are poor, intuitively know what the schools do for them. He argued that the schools under the state always try to maintain the schooling of silence against regression, injustice, and repression. The state imposes the curriculum for the powerless poor people for the subservience of the elite/ruling class (Cole, 2020), those who lead the state, and schools provide the manpower with no critical conscience and only sustain the

cultural supremacy. That's why the schools cannot emancipate the injustice among the powerless people. The poor have always been socially powerless. The increasing reliance on institutional care adds a new dimension to their helplessness: psychological weakness, the inability to fend for themselves. For the liberation and radical transformation, Illich imagined deschooling society. Illich idea for deschooling here is not in the sense of absolute form rather in the relative form the school should provoke students for their rights and transformation against all kinds of prejudices in the favour of a larger volume of the population is an unending process. That's why academic institutions should advocate for decisive freedom.

The idea of Illich also provokes for transformative education in academic institutions that can make learners can aware of the repression/coercion and can challenge the ruling class for the perfect justice, equality, and equity of every castigation. In this sense, teachers' as the transformative educators' role is not only to teach mathematics but also to make students aware of how the policy of the state is conserving social inequality and unwilling for the radical transformation of society.

Nevertheless, If we are looking for the idea that education is a space of (inter)personal emancipation and social transformation (Vieria et al., 2011), higher education has a crucial role in the construction of the subject, sharing the perspective of "higher education for life" where the role of the educator is leading students to a learning community, interacting and participating, being mutually supportive and self-critical (as cited in Pires et al., 2018). The fundamental aim of transformative pedagogy is to construct academic institutions as agents for change, questioning the status quo of the societal

dynamism, which should strengthen the voice of learners, and inspire critical consciousness, to promote social change, which addresses the Illich point for the school. Biesta (2010) has argued that education should always contribute to processes of subjectification, the process of becoming a subject, allowing students to become more autonomous and independent, both in thinking and acting. Ernest (2004) argued that mathematical truth is fallible and corrigible, and can never be regarded as beyond revision and correction, mathematical knowledge is not absolute truth and does not have absolute validity, which is the multiplistic view of mathematics education. In Multiplistic views of mathematics multiple answers and multiple routes to an answer are acknowledged, but regarded as equally valid, or a matter of personal preference (Ernest, 2004). Also, this point supports the point of Biesta that education is the process of subjectification. Further, Pires et al. (2018) discussed that pedagogic practices are "places of mediation in which the person simply finds the resources for the full development of his self-consciousness and self-determination, or the restoration of a relationship with himself." The terms of autonomy and self-regulation translate a form of relationship that is of the subject with himself, a reflexive way of analyzing his own experience. In this sense, critical reflection is intrinsically articulated with autonomy.

Freire & Shor (1987) communicate about the agenda of issues raised by teachers interested in social change and liberating classrooms, real issues teachers face in recreating school and society. They raise the questions like how do teachers transform themselves into liberator educators. How do they begin the transformation of the students? Freire & Shor further appealed that teachers face too many classes, too many students, and

too much administrative control, so the need for something that works in class stands out stronger than the seeming need for theory. Still, the troubling failures of the school system call out new ideas.

Transformative praxis covers a wide range of scholarly pursuits for social change via reflexive research and practice (Luitel & Dahal, 2020). In the context of praxis for transformative pedagogy, the situation is gradually changing but there is no significant paradigm shift in conventional instructional practices in the classroom. The concern of this paper is to explore the existing pedagogical practices in undergraduate mathematics classes whether conventional phase (teacher-centered), transitional phase (semi-teacher centered), or transformative phase (5c's Creativity, Communication, Collaboration, Critical thinking) together with Connectivism (Rusdin & Ali, 2019; Siemens & Conole, 2011).

Siemens & Conole further reiterates that new technology that influences how information is created, communicated, and shared and how people connect and socialize hold promise for adoption in education. Much like the idea of a book necessitated the development of the library or the idea of structured curriculum and domains of knowledge produced classrooms, the idea of the Internet distributed, social, networked influences the structure of education, teaching, and learning.

### **Review of Literature**

Mezirow (1997) reasoned that transformative learning theory is a model of andragogy that attempts to reveal and clarify a learner's prior assumptions and then transform these assumptions into new understandings also, the role of the educator for TP functions as an initiator and provocateur rather than as an authority on the subject matter. Transformative learning conference

was held 23 ago in 1998 at teachers college, Columbia University (Johnson & Olanoff, 2020). The facilitator encourages learners to create customs that accept the order, justice, and civility in the classroom and respect and responsibility for helping each other learn; to welcome diversity; to substitute peer collaboration, and to deliver equal opportunity for participation.

The word transformation itself seeks for the change gradually or fast to some extent even challenge status quo state of condition and promotes the dialectical thinking (Mezirow, 1997; P. C. Taylor & Luitel, 2019; Taylor & Cranton, 2012). The conventional pedagogy remains around teacher-centered while TP looks for teacher-centric to student-centric, challenge the taken-for-granted knowledge, search for a theoretical idea to its practical implication, way of learning. TP endows learners to engage in interchange to co-construct meaning from educational material and experiences through an inquiry-based approach. It also promotes personal experiences, dialogical pedagogy, and aligning education with social justice. In fostering self-direction, the emphasis is on creating an environment in which learners become increasingly adept at learning from each other and at helping each other learn in problem-solving groups (Mezirow, 1997). The context of group learning fosters individual learning by supporting several skills and behaviors (Mezirow & Taylor, 2009).

Mezirow (1998) further argued that transformative learning attempts to explain how our expectations, framed within cultural assumptions and presuppositions, directly influence the meaning we derive from our experiences. He traced out three common themes for the process of meaning structure transformation centrality of experience, critical reflection, and rational discourse. Mezirow also sees development

as an outcome of the transformative learning process that is everlasting once completed; that is, once our understandings are clarified and we have committed ourselves fully to taking the action it suggests, we do not relapse to levels of less understanding. While Freire emphasis upon an emancipatory model for transformative education. Unlike Mezirow's transformation, Freire is much more anxious about a social transformation via the opening or demythologizing of reality by the oppressed through the emerging of their critical consciousness, where they gain to perceive social, political, and economic contradictions, and to take action against the oppressive elements of reality". For Freire education is never neutral, It either controls by informing the values of the dominant group so that learners assume things are right the way they are, or liberates, allowing people to critically reflect upon their world and take action to change society towards a more equitable and just vision (Freire, 1993).

Transformative learning offers a theory of learning that is uniquely adult, abstract, idealized, and grounded like human communication. It is a theory that is partly a developmental process, but more as "learning is understood as the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience to guide future action". Transformative learning explains the change in meaning structure that evolves in two domains of learning based on the epistemology of Habermas' communicative theory. First is instrumental learning, which focused on learning through task-oriented problem solving and determination of cause and effect relationships-learning to do, base on empirical-analytic discovery. Second is communicative learning, which is learning involved in understanding the meaning

of what others "communicate concerning values, ideals, feeling, moral decisions, and such concepts as freedom, justice, love, labor, autonomy, commitment and democracy"(Mezirow, 1998)

On the other hand, Boyd (1989, p. 459) argues that transformation is a fundamental change in one's personality involving conjointly the resolution of a personal dilemma and the expansion of consciousness resulting in greater personality integration. He reiterates that only through a transformation can significant changes occur in individual psychosocial development. The central purpose of a perspective transformation is to free the individual from his/ her unconscious content and accomplish cultural norms and patterns that constrain the potential for self-actualization. Boyd's transformation is much more about coming to terms with the first half of one's life and meaningful integration with the second half. In contrast to Mezirow, who focuses on cognitive conflicts experienced by the individual's relationship with culture, Boyd is much more focused on conflicts within the individual's psyche and the resolution among these entities that leads to a transformation (as cited in Mezirow, 1998:17-18).

In this sense, TP advocate for the equality and equity issues in the diverse classroom psychologically, socially, and economically for their sustainable knowledge which is irreversible. Mezirow introduced transformative learning as a comprehensive theory of adult learning, from the critiques from the educators he updated his theory where meaning is constructed by individuals in social contexts and is validated through communication with others (Kroth & Cranton, 2014). TP focuses on the creation of a climate that is beneficial for critical questioning and thoughtful presentation of the view of points that are contradictory in

the classroom praxis promoting and bridging equity agenda like college preparation, access to college, and, finally, success in reaching college goals together with identifying academic achievement gap in among students (Santamaría, 2012).

It is the reality even contradictory that in the developing country/third world (Freire, 1993) like Nepal, still, we are lacking basic digital infrastructure/ devices/software's while in the first world Harari (2018) argue that the twenty-first century is the age of digital dictatorship until and unless we are familiar with digital devices and its usage together with its long-run shortcomings, it's really difficult to sustain in this era. This shows that there is an irreparable gap in Digital Technology (DT) between the first world and the rest of the world. Educators argued that the contributions of the reflexive digital portfolios in higher education as processes of construction of knowledge, the transformation of practices and contexts, professional emancipation, and pedagogical innovation. In this framework, transformative strategy is understood as a collaborative act that demands interaction and support, valuing the peer work in the knowledge construction process; it integrates reflexive, critical, and conscious action on past and future experience.

The most concerning issue is the status of the digital boundary in third-world countries like Nepal. Well, it's the big question about who is responsible for the digital disparity. It demands a macro-level analysis of the geopolitical situation of the country. Epstein et al. (2011) argued that since the early 1990s, policymakers and rights advocates have worried that the benefits derived from information and communications technologies (ICTs) are inequitably distributed. Persistent gaps between developed and developing

nations, as well as gaps domestically along socioeconomic, geographic, educational, racial, and gender lines, have broadly come to be known as "the digital divide/boundary" a term that both names these differences and stands as an indicator for the concerns about them. Addressing the reasons for the solutions to these biases has been the public agenda, as part of nearly every conversation about information policy, since the emergence of the Internet. The teachers and students even the academic institutions themselves facing different complications for blending digital platforms for their day-to-day learning.

Digital technologies together with the internet and social networking are best described as game-changers for the knowledge industry (Blaschke & Hase, 2015) are used for saving time and most importantly seek for productivity by every person such as teacher, student, businessman, farmer officer, etc. (Albalawi, 2017, pp.111-133). In Nepal, several policies are made to support DT. For example, the National ICT policy 2015, the National Broadband Policy 2015, and the Electronic Transaction Act 2008 are some policies to guide the expansion and use of DT (Ministry of Communication and Information Technology [MoCIT], 2019). These policies and other strategies too by the government are helping to pledge digitization in public services and education. In this line, the Information Communication Technology (ICT) Policy 2015 aimed to increase ICT accessibility to a broader public arena through ICT infrastructure development, ICT industry promotion, e-Governance, and Human Resources Development in the field of ICT (MoCIT, 2015). Equally, the Broadband Policy 2015 aimed to encompass the connectivity, public-private partnership, universal access, and diminish the digital divide and increase the access and coverage of broadband Internet

service throughout the country by wireless or wired Internet connections (MoCIT, 2015).

Modern technology would be bizarre we thought mathematics is really for since mathematics also needs technology. The arena of mathematics education has altered significantly because of technology. Educational technology can simplify simple computation and the visualization of mathematics situations and relationships, allowing students to better understand mathematical concepts in practice. Technology can be a tool for students to model mathematical relationships in real-world situations. Technology is also an integral part of the Common Core State Standards Initiative and its emphasis on preparing students for college and twenty-first-century careers.

The motto of the policy is to enhance digital pedagogy for the long run and aimed to displace existing classroom situations by digital proficiency for better education and competitive manpower. Most importantly the policy aims to make the entire public/private official sector paperless by promoting e-governance. While in the academic field the slogan of the policy seems to enhance digital practices to meet the necessity of competent manpower and a better understanding of abstract ideas by digital visualization, promoting TP via digital devices and infrastructure. It does not mean that TP is only possible together with blending digital devices, the crux of TP is how a teacher deals with their students for sustainably communicating the knowledge even without the help of the latest digital platform, but being 21st century as the era of digital governance, how digital literacy can contribute for transformative instructional strategies for sustainable knowledge and production of competent manpower in the global market using 5c's is the gist of the study. Luitel (2018) contended

that TP has its philosophical underpinning guided mainly by the culminating epistemic metaphor of knowing as envisioning, a constellation of multiple ways of knowing, such as deconstructing, constructing, re-conceptualizing and imagining.

Van Dijk (2006; 2008; 2009) presents a socio-cognitive perspective on expansive context. His multidisciplinary approach draws on findings from cognitive science and social psychology. At the heart of his theory is the idea that context should be understood as an ongoing updated participant construct of the relevant contextual features of text and talk (Treanor, 2009). Van Dijk also postulates a “K-device” nativist concept a special knowledge management function focusing on the context for the social dynamicity and plays a vital role in challenging the status quo. If the relationship between social structure and discourse structure is superficial, surely psychological phenomena are also superficial, so transformative education is not beyond the social structures.

Luitel & Dahal (2020) owing to the great diversity of contexts, practices, and people, there is no single and prescribed technique for transformative praxis, apart from the goal of cultivating the critical conscience of researchers, practitioners, participants, and actors through ethical and participatory engagement in the life world. ICT Policy 2015 intended to upsurge ICT accessibility to a broader public arena through ICT arrangement development, ICT industry promotion, e-Governance, and Human Resources Development in the field of ICT (MoCIT, 2015). Likewise, the Broadband Policy 2015 pointed to extend the connectivity, public-private partnership, universal access, and minimize the digital divide and increase the access and coverage of broadband internet service throughout the country by wireless

or wired Internet connections (MoCIT, 2015). Technology provides supplementary prospects for learners to see and interact with mathematical concepts. Students can explore and make discoveries with games and digital tools. Digital technologies are electronic tools, systems, devices, and resources that generate store, or process data. Well, known example includes social media, online games, multimedia, laptop, tablet, and smartphones.

The use of DT in the mathematics classroom for TP has long been a topic for consideration by mathematics teachers. DT tools in mathematics include a portable, graphic calculator and computerized graphics, specialized software, programmable toys or floor robots, spreadsheets, and databases. Students will also have personal technology such as a tablet, a smartwatch, a smartphone, or similar with which they are familiar to use mathematical focused applications. These tools are allowing pupils to collect data, and manipulate it using spreadsheets and databases for work in numeracy (Moseley, 2009). Conventionally the way of communication was through sharing their information, idea, skill, and the use of paper-based/ chalk and talk approach but now the way of communication has been significantly changed because of the development of DT and social media. Now a day, we use different types of DT such as computers, mobile, projectors, and social media (Facebook, Twitter) email, internet, Google, YouTube, etc. which are particularly used in every stage of human life.

MoCIT (2019) explained that digital learning is any type of learning that uses technology. Presently DT in the classroom can be reserved to mean digital processing systems that encourage active learning, knowledge construction, inquiry, and exploration on the part of the learners,

and which allow for remote communication as well as data sharing to take place between teachers and/ or learners in different physical classroom locations. The Internet has been an essential means of DT and information in Nepal in recent years. There were only about 7000 Internet users by 1999, and this number reached nearly 30,000 in the year. It grew further to 19.7% of the total population in 2016 and 34% in 2017 (The World Bank, 2020). Internet broadband penetration increased sharply from 2016 to 2017. International Telecommunication Union (ITU) report showed that 21% of individuals using the Internet in Nepal (Khanal et al., 2020). Still, there are 79% of people seem to be an outreach of the internet, which is worrisome. Digital transformation strategies including an inclusive information society require substantial investment in organizational capabilities, process innovation, and institutional.

DT and social media for transformative, effective, and interacting learning that must be used to self-learning, sharing-based learning, collaborative learning, web-based learning, and virtual learning for teaching and learning (Clark & Gorski, 2002; Dhakal, 2019). Technology can enhance the relationship between teachers and students and is helpful for transformative learning (Taylor & Luitel, 2019). Moreover, technology supports sustainable learning to visualize abstract ideas basically in mathematics education. Johnson & Olanoff, (2020) suggest that one way for mathematics teacher educators to incorporate transformative learning theory into their mathematics content courses. Transformative learning theory is an application of andragogy, which is a method or technique used to teach adults. Through transformative learning theory, learners contribute in a process where they are presented with a perplexing predicament that troubles their



prior understandings. Learners work through the dilemma by critically reflecting on their prior understandings and participating in rational discourse with others. Ultimately, learners are tasked with making connections between their prior understandings and their new knowledge.

Kovacs (2018) mentioned that change is a process that does not come effortlessly to a school setting. For education systems around the world, enabling change and innovation comes with a bit or much difficulty because the system and the practices formulated around education are complex, rigid, and strongly traditional. Ndibalema (2020) highlights the necessity of engaging youth in transformative learning tasks through technology as a necessary pedagogical tool for improving digital competence. Also, instructors are integrating ICT in their teaching while tasks for promoting TP. Again, there were several hesitant chunks to the 21st Century skills acquisition, such as low accessibility of online resources, learning management systems LMS, and untrustworthy internet. Further Ndibalema restates technological literacy should be part of the education curriculum across different levels of education to ensure that every member of society becomes digitally competent. To achieve this, deliberate measures to invest in technological facilities are inevitable. Jørgensen et al. (2020) argued that the intersection between the internationalization of higher education and educational technology has been explored using theories of third space (online environment). They further claimed that the hybrid “third space” created when students from different cultures meet in a virtual environment can provide new and exciting opportunities for critical intercultural learning and internationalization of curriculum for transformative education. Third space theory

explains the uniqueness of each person; if we manage this in the classroom praxis the new knowledge can be generated.

Also, the need to equip instructors with technological skills for improving students’ learning practices for 21st Century skills is foreseeable. If the right and appropriate technologies are developed among instructors, learners will have an opportunity to engage in technology-based learning which leads to the development of their skills and knowledge for the 21st century. On this basis, weights must be on equipping instructors with capacities to promote emerging 21st Century skills among youths. These studies also emphasize the use of the digital platform for TP for sustainable learning.

Jørgensen et al. (2020) argued that the juncture between the internationalization of higher education and educational technology has been discovered using theories of third space. They claimed that the hybrid third space created when students from different cultures meet in a virtual environment can provide new and exciting prospects for critical intercultural learning. Moreover, the study also highlighted that the learning potential in projects such as these can be limited by the fact that many teachers remain unable to escape some of the boundaries of the second space. This in turn restricts the opportunities for students to draw on their first space experience and knowledge to make learning transformative. They restate that unless higher education institutions provide more productive conditions for projects like virtual exchange, third space, further opportunities for transformative learning will be missed.

Cook & Garneau (2017) questioned that TP should challenge mathematics problems should only be solved in one particular way; mathematics is an isolating, solitary activity; and school mathematics

holds little relevance to the real world. Connecting mathematical ideas with real-world problems in interesting multiple ways is the main concern for transformative educators connecting DT. Transformative thinkers emphasize that change at all levels is required, starting with a top-down commitment to new ways of learning, personalized curriculum, and a learner-centric environment (Blaschke & Hase, 2015, p. 244). Conventional pedagogy is in the transitional phase, it is of utmost necessity to rethink sustainable pedagogical skills in a transformative way to address the shortcoming of conventional teaching strategy. To discourse the forthcoming 21st-century societal real-world problems, it is the precise time to plan for transformative learning. The increased interaction among societal stakeholders to promote the transfer of relevant knowledge and skills signifies the inevitability of transformative education. Dennis & Dailey-Hebert (2015) further conveyed that virtual mobility, blended team learning, pedagogy, gaming, creativity, judgments about own learning, use of embedded feedback processes throughout courses, investigate a future in which people and computers interface in new ways, and ensuring that all assessments generate worthwhile study should be the pillars for transformative education.

Karkoub & Abdulla (2020) contend that educators at all levels have been trying to revamp their teaching styles to heighten the learning process. The availability of new virtual and technical instructional tools has led to a noteworthy increase in research in teaching methodologies whose outcome can be split into three categories: (1) lecture delivery, e.g. flipped classroom; (2) interactivity, e.g. instantaneous gathering of students' feedback; and (3) technology in the classroom, the energy for transformation has originated from

schools, educators, students, government and nonprofit agencies, professional organizations, industry, etc. and all have their reasons. Many academic institutions have been looking for ways to provide distinctive learning experiences to students which take advantage of the communication, technological, and pedagogical advancements and account for the change in the ways students learn these days. Which advocates the technological pedagogical content knowledge (TPACK) for the advancement of TP in the classroom (Schmidt et al., 2014).

When teachers effectively integrate DT into the subject area it makes teaching and learning more effective. Digital technologies are very powerful tools for transformative education. Also, it helps to contact outside experts an audience beyond the teacher, meaningful contact between teachers and students working on the same activity out of school, ways for students to view and build on the work of others in their group or class, purposeful interaction between students in different schools, levels or classes across time frames and distance a means to enhance the participation of all students. It gives the facility for timely feedback from teachers and peers. Student-centered education, improving students' engagement in learning and assessment in higher education, developing their digital competence, and facilitating the construction of their identity, more specifically in the learning and professional domain. TP targets the students for more autonomy, to participate in assessment processes, and improve the students' creativity by developing innovative ways to make their competencies transparent in digital environments. Johnson & Olanoff (2020) discussed that TP seeks the teachers/learners who have a *self-concept, role of experience, readiness to learn, and orientation to learning*.

In mathematics education, we have seen a gradual change in the range of uses of digital technologies to support teachers in the classroom for TP basically in urban areas, and to enable students to access school work from home (Oldknow, 2011). So, we need to prepare for a new era in which students do not just have access to an electronic calculator, but the potential to run applications that can support all forms of mathematical and scientific computation, as well as to program their own. If we are to make the best use of the potential of such digital technologies to radically improve teaching and learning mathematics, we need to take stock of what we know now, what we have seen to work, what we would like to see tried as well as how to introduce, support and sustain the innovations required. Technology can enhance the relationship between teacher and student. So, teachers and students are connected and can make good use of this platform for the working of their education. It helps to connect to their students on campus as well as with their old students (Sha, 2017). Further, the practice of DT in mathematics education is compulsory for TP in mathematics education.

### **Research Objectives**

The main objective of this study is to review the papers regarding TP were to explore the philosophical/theoretical underpinnings about TP in mathematics education via digital technology and to look for TP theory in teaching and learning mathematics education.

### **Methodology**

This is some sort of systematic study to form/generate research questions regarding transformative pedagogy. My ontological perspective is knowledge is socially constructed with multiple realities, While epistemology is what might represent knowledge or evidence, or data. The knowledge is created in a dialogical and dialectical manner.

### **Discussion**

Cochrane et al. (2014) articulated that one way of designing transformative learning environments is to frame teaching and learning around building learning communities. The research posts were implemented to encourage students to develop critical visual analysis skills and by doing so build their visual literacy skills. Analyzing images is both a necessary skill and a learning method within visual communications. As a skill, it is necessary as it helps us critique images on various levels, such as on their aesthetics or as a piece of communication. This section discusses the research question based on thematic analysis. What seems the situation of using DT and praxis of TP in the mathematics classroom?

### **Practices of DT in Mathematics Classroom**

DT helped the students and teachers to improve engagement, the practice of 5c's, encourage individual learning and it also helps teachers with content delivery. It gave resources, new opportunities for learning, and a way to collaborate with teachers and students. Also, it helps to connect with outside experts, meaningful contact between teachers and students working on the same activity out of school, ways for students to view and build on the work of others in their group or class, purposeful interaction between students in different schools, level or classes across time frames and distance means to enhance the participation of all students. It gives the facility for timely feedback from teachers and peers (Seechailo, 2014). The use of DT flourish for TP in mathematics class increase the interest of students, it contextualizes the content, visualizes the content in culturally contextualized mathematics education (Luitel, 2009).

Motivating the students is one of the challenging tasks for the teachers in Nepal, it

visualizes the content so that the classroom becomes more interactive and interesting, and it also connects the classroom with the international collaborative partner classes (P. C. Taylor & Luitel, 2019b). Different mathematical software, YouTube videos, and other internet sites could help students for the conceptual learning, it refers our students for self-learning and also connects the teachers from worldwide in a moment, due to the process and the learning ability in the mathematics DT motivate the students in learning (Epstein et al., 2011). DT tools support visualization of mathematical concepts in various ways of expressions, and as such may foster versatile thinking, especially when these representations are dynamically linked. DT tools have a positive impact on TP in mathematics learning. DT tools provide meaningful experiences to mathematics students including mathematics, reading, and research. Following interpretive/critical paradigm with multiple reality of philosophical underpinning, I could not claim that DT is one and only one way for working TP in the mathematics classroom, but what I come to know from the literature reviewed that DT can play a vibrant role for practicing TP in mathematics education.

Appropriate use of DT allows mathematical learners to have the freedom of choice to decide their own time and place to study mathematical content easily (Hess & Leal, 2001). Our curriculum has not managed to meet all the needs of the 21st century: e.g. DT has not yet been applied much in education (Ilomaki & Lakkala, 2018). DT looks for the taken-for-granted pedagogical praxis to meet the aspirations of students. Critical self-reflection, generation of self-critical conscience is the motto of transformative education.

Freire's first concept of education that is banking pedagogy (Mezirow, 1998),

is somehow a second concept problem-posing back and forth but the practice is still lacking for the third concept as mentioned by Freire. Meaningful digital classroom praxis encourages students to think through what they are learning and enriches their experience using ICT.

### ***The practice of Online Resources***

Any resources available on the internet and Google for teaching and learning are helpful for transformative learning. Social media, different e-portals are the most popular online resources for learning. Online resources are Internet-based equivalents of more conventional curriculum resources: books, articles, pictures, movies, games, email, etc. Formats include web documents, audio files, images, videos, animations, word processing documents, and others.

Joshi & Rawal (2021) mentioned that online resources boost up the existing knowledge of students. The teaching experience is a contributing factor to the use of online resources whereas teaching level and qualifications are contributing factors of using the software

### ***The practice of Mathematical Software GeoGebra and Mathematica***

GeoGebra and Mathematica, MatLab, Mapple are the most popular software's in undergraduate mathematics education for solving the problem besides there are PhotoMath, Microsoft Math Solver, HiPER Scientific Calculator, Brainly, Khan Academy, Mathway, etc. are various types of mathematical apps and web portals that visualizes abstract ideas on three or more dimensional spaces. GeoGebra and Mathematica are dynamic mathematics software for all levels of education that brings together geometry, algebra, spreadsheets, graphing, statistics, and calculus in one easy-to-use package. GeoGebra is a rapidly

expanding community of millions of users located in just about every country. GeoGebra has become the leading provider of dynamic mathematics software, supporting science, technology, engineering, and mathematics (STEM) education and innovations in teaching and learning worldwide. Mathematica is a symbolic mathematical computation program, sometimes called a computer algebra program, used in many scientific, engineering, mathematical, and computing fields.

This is the era of DT so most of the students are familiar with DT (Joshi & Rawal, 2021; Schmidt et al., 2014). Due to the economic shortage of third-world countries like Nepal, we have many difficulties in using DT such as lack of internet access, lack of digital devices, lack of well-equipped classrooms, etc. So, most of the students are still out of reach. The situation of students studying in other parts of the country can be easily predicted as even the students studying in the capital of the country like Kathmandu Valley do not have well access to technology. Therefore, emphasizing the use of DT to facilitate learning is also indispensable today.

#### ***Challenges of TP in mathematics education***

Motivating the students is one of the challenging tasks for the teachers in Nepal. Different mathematical software, YouTube videos, and other internet websites could help students with conceptual learning. DT tools support visualization of mathematical concepts in various ways of expressions, and which may foster versatile thinking, especially when these representations are dynamically linked. DT has a positive impact on mathematics students learning. Most Nepali mathematics teachers are digitally literate and have at least one digital resource or device however the expertise of mathematical software is still lacking, which is the hurdle for TP in mathematics education (Khanal et al., 2020).

The use of digital technologies has been suggested as a means to respond to continuous changes. In terms of improving the learning experiences of the students, the impact of digital technologies has so far been rather imperfect. Learners must be aware of their learning characteristics in informal settings and adapt them to formal settings (Lai, 2011). The digital environment of schools and universities is not satisfactory but at the same time practice of TP blending digital platforms is growing up progressively. Various policies and provisions have been formulated for the development of technology in teaching and learning but its practical implementation is going slowly. The digital infrastructures consistent internet seems challenging.

#### **Conclusion**

TP not only advocates for individual sustainable learning as competitive manpower for the global market but also, provokes students for social transformation for emancipation, liberation, and autonomous responsible thinking. Most mathematics students are practicing DT in mathematics education. DT provides a great opportunity for undergraduate students to improve their teaching and learning processes. There is a growing concern of teaching/learning mathematics among students, teachers, curriculum designers, policymakers, experts for the improvement of mathematics achievement by using DT but the concern of digital inequality in virtual society in the days to come is significant to address. Hence, the educators' views about the digitalization of mathematics education for empowering and promoting DT in mathematics teaching and learning signifies TP for sustainable knowledge, the need for teacher motivation, integration of mathematical concepts. There are many challenges and opportunities to use DT for TP in mathematics education.

Consequently, the use of digital devices plays a significant role in transformative instruction, From the study what I come to know that it is of utmost necessity for all the students and teachers of mathematics should be digitally capable and the state should not only invest a huge amount to bridge the gap of digital boundary among the teachers and students and boost up digital infrastructures throughout the academic institution but also plan for addressing digital inequality in the digital society. This demands the estimation of the long-run policy of digital mastery campaigns nationwide for dynamic TP in education.

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