Introducing the Design Thinking Approach for Teaching and Learning at Tendruk Central School in Samtse Dzongkhag

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Abstract

Design thinking is a human-centric, iterative, and collaborative approach to solve complex problems. Current study has made an attempt to implement design thinking (DT) as one of the pedagogical means to respond to the need for teaching, learning, and assessment and specifically, the study was intended to explore strategies to implement DT in designing and delivering lessons in the classrooms of a higher secondary school at Samtse. The study was conducted through a participatory design approach which involved co-designing lessons using DT between the researchers and teacher participants. The data for this study was obtained from observations, semi-structured interviews, focus group discussions, and reflections. Eventually, for data analysis thematic analysis and narrative descriptions were used. As such, this study provides information that broadens the understanding of the integration of the DT approach in the classroom in the Bhutanese context, and its impact on the development of skills in students. The findings of the study unveiled that using DT empowers teachers to be innovative in planning learning activities that enables lessons to become more engaging and exciting. Further, the finding also revealed that DT assists students to develop problem solving skills and creativity.

KeyWords: Design Thinking, Teaching and Learning, Participatory Design, Co-design, Creative Thinking, Problem Solving.

1. Introduction

As of 2020, the modern/western educational system in Bhutan embarked six decades since its introduction in 1961. Despite the late start, school education in Bhutan has witnessed unprecedented growth and progress within a period of over six decades. The modern education system has expanded from about 11 schools prior to the 1960s to 1132 schools and other educational institutes in 2020, spanning from early childhood care education to tertiary and technical and vocational education (MoE, 2020).

The Bhutanese education system has scaled many milestones through periodic efforts in policy changes and adaptation to modernistic approaches such as an expansion of access to education and the subsequent nationalization of the school curriculum since the early 1970s. Introduction of the New Approach to Primary Education (NAPE) in 1985, and the nationalization of education for Gross National Happiness (GNH) in 2010, brought out tremendous development in the education process, which is holistic, inclusive, and sustainable. The Ministry of Education has taken forward a lot of initiatives in enhancing the teachers' content and pedagogical competencies in recent years. In 2014, the Teacher HR Policy was implemented to engage teachers and principals continuously in professional learning and development with the expectation that they will acquire teaching and leadership competencies for the twenty-first century (Schuelka & Maxwell, 2016). Further, teachers as the central role player in the quality of education, the year 2016 was declared as the "Teacher Professional Development Year" (MoE, 2017). Despite the progressive evolution of Bhutanese education since its inception in the 1960s, a need to revamp teaching, learning, and assessment has been voiced often both in oral and print media. A study on the implication of transformative pedagogy in classroom teaching by Dorji, et. al, (2020) revealed that some school leaders and teachers are still inclined towards conventional lecture methods due to the mere excuse of insufficient resources, crowded classroom and thick curricula to infuse the activities in the classrooms. These to some extent indicating a lack of authentic practice of deep critical thinking, creativity, and problem-solving skills-based activities in the schools by teachers.

Bhutan Education Blueprint (2014-2024) reflected that the process of education should be stressed more in acquisition of values and skills such as critical thinking,

creativity, communication, collaboration (regarded as 4Cs). One of the ways to increase those skills is developing DT skills (Luka, 2014). The need for a paradigm shift in the Bhutanese education system has come out discernibly as His Majesty, the king of Bhutan, Jigme Khesar Namgyel Wangchuck symbolically handed over to the people of Bhutan, two *kashos* (Royal edicts) on the reforms decreed for the education and civil service on December 17, 2020.

While transforming the education system for a loftier present and future is beyond the scope and capacity of this study nevertheless, an attempt in using DT in teaching and learning in the classroom can bring a positive implication in providing some initial steps in leveraging the aspirations of Bhutanese education. The positive proposition of DT in education has been tested and documented by scholars and educationists. Design thinking as an instructional tool can be used to allow students to express their ideas without constraint while engaging in design activities. Thus, it is an essential tool for creativity and innovation (Carroll et al., 2010). In education, DT is often referred to as "design-based learning". It is seen as a model for creativity, endurance, engagement, and innovation enhancement (Dolak et al., 2013, p.2). It is further described as an orientation to learning that encompasses active problem-solving and putting one's ability to create impactful change through building on the development of both resilient and highly optimistic creative confidence (Kelly, 2012; Carrol et al., 2010).

Therefore, to nurture our students with relevant knowledge befitting the present society, empowering teachers with DT is deemed indispensable as one of the means to progressive education. Hence, this study made a maiden attempt to experiment with and implement DT in secondary school and explore its implications with the research question **"**How can the use of DT be initiated in Bhutanese higher secondary classrooms?" The study was anchored on the following selected purpose: Outline the process of implementing DT in Bhutanese higher secondary classrooms; Empower Bhutanese secondary school teachers to design, modify, and implement DT in their lessons; Enable students to develop creative and problem-solving skills.

Significance of the study

The use of new educational approaches is rapidly expanding in Bhutan. This trend is now likely to be bolstered as the education system in the country is venturing into the

reform process. His Majesty, The King of Bhutan, Jigme Khesar Namgyel Wangchuck in the Royal *Kasho* (Royal edict) on education reform issued on December 17, 2020 (Kuensel, 2021) stated that Bhutanese educators must revisit curriculum, pedagogy, and learning strategies to shift student practice away from passive modes of learning. New and revitalized educational practices must prepare students to thrive in the modern era, embodying such qualities as an inquisitive disposition and ability to problem solve. DT, with its emphasis on equipping students with the tools and capacity for innovative and creative thinking, offers great promise to make progress toward this vision. The outcome of this research on DT was anticipated to be wide-reaching. On the practical end, participants engaged in this study would be able to apply the approach of DT in their teaching as well as can now share the principles with other educators. Accordingly, these participants were able to teach students to define a challenge or opportunity with empathy, an understanding of bias, and a view toward community / professional needs.

While new professional development opportunities continue to be offered throughout the country, evaluation of their effectiveness and impact remains limited. In order for these new educational trajectories to make lasting change, baseline research is needed covering not only "what" new strategies are being introduced, but how effective those introductory training processes are. Such research in Bhutan is critical to facilitate the transition from a conventional teaching approach to one that is learner-centered. This study to a certain extent, therefore, has provided an opportunity to outline steps in introducing DT in teaching and learning.

2. Literature Review

Primarily, the concept of DT is frequently associated with architecture, engineering, and businesses, but its adoption is also seen in several organizations outside the field of design, such as those in education and information technology. DT's significance has been identified as relevant to all disciplines and professions (Retna, 2015; Lindberg et al., 2010; Beckman & Barry, 2007). Nowadays, DT is not only a motor for innovation promoted by designers, but it offers new models of processes and toolkits which help to improve, accelerate and visualize every creative process, applied or integrated not

only by designers but in multidisciplinary teams in any kind of organization or fields (Brown & Kuratko, 2015; Tschimmel, 2012).This increased interest in DT as an approach to innovation has resulted in its adoption by non-design-trained professionals (Wrigley & Straker, 2015). Thus, design thinking has been discussed and applied for several years in various disciplines, and more recently, in education, because of its ability to advance creativity and innovation by applying an empathetic, flexible and iterative approach (Luka, 2019; Lor, 2017)

DT is a discipline that uses the designer's mind set and sensibility and methods to satisfy the needs of the end-users to arrive at a strategy that is both technologically feasible and business viable thereby converting into customer value and market opportunity (Brown & Kuratko, 2015). Harvard University (n.d.) defines DT as a mindset and approach to learning, collaboration, and problem-solving. In practice, the design process is a structured framework for identifying challenges, gathering information, generating potential solutions, refining ideas, and testing solutions. As an instructional tool in an educational setting, it helps in responding to students' queries as to why they have to learn a specific concept or topic (McCurdy et al., 2020). Carrol et al. (2010) described DT, as applied in education, as a learning process that focuses on building the creative confidence of students and where students engage in hands-on projects that focus on building empathy, promoting a bias toward action, encouraging ideation, and fostering active problem solving (Carrol et al., 2010). They also stated that through meaningful, hands-on projects, students develop a deep understanding of a domain while developing skills in building empathy with user collaboration, and prototyping. DT seeks to utilize knowledge and practices to find viable solutions that would meet the needs and interests of people in the context of the challenges of contemporary society (Koh et al., 2015).

The Hasso Plattner Institute of Design at Stanford (d.School) describes DT as a five-stage process that constitutes empathize, define, ideate, prototype, and test. These stages are not always sequential, and teams often run them in parallel, out of order, and repeat those in an iterative fashion (Dam & Siang, 2020). Further, as an iterative process, it essentially does not follow the sequential waterfall model where progress is seen as flowing downwards. The whole idea is to fail, and fail fast, to learn from the failures and rapidly iterate in order not to miss opportunities and waste

resources (Lor, 2017, p. 43). All stages are indispensable and should be conducted subsequently without leaving some of them (Wolniak, 2017).

DT is gaining momentum as it was shown that it can find, propose and implement appropriate solutions, even in entirely new fields (Kurokawa, 2013). It is now seen as an exciting new paradigm for dealing with problems in many professions; including IT, Business, Education, and Medicine (Dorst, 2010). Educators and researchers who have applied DT in education pointed to several implications for education. Li et al. (2019) argue design and DT are vital to creativity and innovation and have become increasingly important in the current movement of developing and implementing integrated STEM education. Further, Carrol (2015), Kwek (2011) and Scheer et al. (2012) argued that DT, as a constructivist learning strategy, motivates students for exploration and problem solving, being open to ideas, allowing them to be innovative and creative. Furthermore, within the educational context, the characteristic of DT focuses on collaboration and iteration which is relevant to learning theories within education, developmental psychology, and social psychology (Hennessey & Mueller, 2020). Vygotsky's (1976) social learning theory states that interacting with others is essential to learning, and experiential learning theory (Kolb, 1984) describes learning as the process through which knowledge results from gaining experience. Hence, in line with the zone of proximal development of Vygotsky's socio-cultural theory, DT provides a learning experience for the students with the help of the teachers.

Implementing DT in education or the classroom, not only benefits students but has also benefited the teachers such as having more creative confidence, better project management processes, stronger collaboration culture, strategic decision-making (Tran, 2017), and assisting classroom instruction (Carroll et al., 2010). There are also common benefits for teachers and students in terms of meeting teacher and student's needs and providing productive teaching and learning (Tran, 2017). DT as a model of teaching and learning could support the integration of STEM education through multi-disciplinary subjects or projects in schools. Hence, it can be concluded that using the DT approach in education can offer multiple benefits to students in their learning and teachers in their profession. There are several ways DT can be implemented or integrated into the teaching and learning process in the classroom. One way, in

education, DT skills can be learned through pedagogical approaches that involve problem-based learning, project-based learning, or inquiry-based classroom activities (Bouchard et al., 2005).

Despite overarching benefits and opportunities offered by DT in education, adopting and implementing the DT approach is attributed to some limiting factors. Introducing a new model, concept, or approach to educational practice raises issues that affect teachers, students, and all stakeholders who contribute to teaching and learning in schools (Retna, 2015). In the study, Retna (2015) identified that the class size was an issue of challenge for the participants. Class size is an important indicator of teaching and learning effectiveness. Research asserts that a small size classroom is effective for promoting interactive learning. Besides class size, research also claimed that DT was not possible or useful across all subjects and disciplines. However, the real benefits of any DT process or activity depend on how educators apply it in their curriculum (Aflatoony & Wakarry, 2015).

Another challenge is attributed to the physical resources in terms of a room, materials, and time that is conducive for the DT process (Retna, 2015, Gompel, 2019). Other challenges include teacher competency. For example, the study by Campos (2011) reported that too many teachers were frustrated at the thought of teaching DT in their classrooms because of the lack of proper training. Further, Hennesey and Mueller's (2020) study reported that one potential challenge associated with implementing DT in an educational context is assessment (e.g., assessing skills and attitudes related to DT). They also reported that educators indicated two main resources that would facilitate integrating DT into their classrooms. First, many stated that collaboration and discussion with colleagues would be beneficial to generate ideas, including how to maximize activities during class time. Second, educators indicated that appropriate technological support would be advantageous to integrating DT into teaching.

3. Methodology

With DT as the core element of the study, deep inspiration has been taken from Vygotsky's zone of proximal development as the theoretical underpinning for this study

(1978, p. 86). Further, Vygotsky elaborated that the use of signs leads humans to a specific structure of behavior that breaks away from biological development and creates new forms of a culturally-based psychological process (Vygotsky, 1978, pp. 39-40). He emphasized strongly that social interaction is very crucial in the development of cognition.

The design of the study was a case study within a qualitative approach. The case study was administered through an intervention strategy where participants were taken through a two-staged process where in the first stance the researchers oriented the teachers on the principles and process of using DT in teaching, learning, and assessment. An intervention workshop through a Future Workshop strategy was implemented for this study to introduce the concept of DT to teachers using incomplete sentences. A typical Future Workshop consists of a preparatory, critique, fantasy, and follow-up phase (Jungk & Müllert, 1987).

Empowered through the intervention workshop and encapsulated by the principle of Participatory Design (PD) in the second stage the participants in collaboration with the researcher's co-designed lessons using DT for implementation in their classrooms. According to Muller and Druin (2013) PD workshops are usually held to help diverse parties communicate and commit to share goals, strategies, and outcomes; they usually introduce novel producers that are not part of conventional working practices, and they take people outside of their familiar knowledge and activities. To foster DT in the lessons the researcher co-designed lessons with the teachers, and hence PD has been the specific research design for this research.

The participants in this study consisted of science teachers and students from Tendruk Central School under Samtse Dzongkhag. The selection of participants and study site followed the purposive sampling technique within the non-probability sampling method, considering the approach and design of this study. The sample size and data collection consisted of fifty-five teachers for the stage one professional development workshop. Nine teachers (7 male and 2 female) who taught the lesson using DT as a teaching strategy were selected and the interview was administered after the lesson observation. The primary aim of the interview was to find out the perceptions of the teacher on the lesson taught through DT strategy. Six students of

two different grades: grade XI and XII who had been taught the lesson using DT were identified for the focus group interviews. The interview was administered using semi-structured questions to find out and collect the perceptions on the lesson taught using DT as a teaching strategy. Each participant was offered the opportunity to share his/her perceptions on DT being used as a teaching-learning strategy. The data collection tools consisted of observation, interviews, documents (lesson plans), audio-visual (interview records), and digital materials (photographs of students' engagements during the DT steps and the prototypes. The data was analyzed a through qualitative thematic approach for interviews and a narrative description for observation.

4. Analysis and Results

4.1 Stage – 1 Professional Development/Intervention Workshop

Professional development on DT for fifty-five teachers including the school Principal of Tendruk Central School was conducted on 12th August, 2021 for the duration of three hours via zoom. Prior to the zoom session participants were provided materials to do pre-reading. The professional development workshop was facilitated by visiting faculty from Teton School of Science (TSS) to Samtse College of Education (SCoE), *Mr. Alexander Sivitskis,* and was coordinated and supported by *Dr. Kinley* and *Dr. Reeta Rai* from SCE.

According to the teachers, the professional development workshop on DT was found meaningful and insightful. Many expressed that DT can be an interesting approach to be tried out by teachers in teaching-learning. Some of them were excited and motivated to implement the approach as it was new and learner-centered. For example one of the teachers said that "Earlier I thought that DT was some technique to be used by people who are designers but after attending the session today, I came to understand that it is a teaching approach any teacher can use to make students innovative".

The Principal of the school said that "after attending the workshop on DT, I feel that it is an emerging, very important, and relevant teaching approach for teaching and learning of subjects like Science and Social Sciences". He is of the view that DT as a teaching-learning approach enables teachers to create opportunities for children to

learn through different approaches resulting in enhanced engagement and learning. Further, he mentioned that through the workshop he understood that DT has the potential to develop learners as problem solvers. He was very grateful to the research team for this timely and meaningful workshop for the teachers of his school.

The workshop was followed by sharing of lesson plan templates, sample lesson plans, and reading materials for the teachers. For the first batch, 12 teachers from the science department committed to developing lesson plans using the DT approach. After a month's time, the draft lesson plans were sent to the researchers for comments/suggestions/feedback. The researchers provided written constructive feedback and provided oral feedback through the Telegram platform to individual teachers to enable them to implement the lesson plans.

Following the implementation of the lesson plans, the following data was gathered and its source:

- **Lesson Observation** –The observation of the classroom teaching of three teachers was undertaken and recorded as descriptive observation notes. During the observation, it was seen that the learning environment appeared different. Learners were found playing active roles all throughout the lesson. Predominantly, the engagement of learners was enhanced through the DT approach. Even learners seemed motivated and engaged in deep discussion as the teachers led them through five distinct phases of DT: empathy, the definition of the problem, ideation, prototyping, and testing.

4.2 Thematic analysis (interview and focus group discussion)

After the interview transcripts were managed through the coding process and three broad themes emerged from the analysis. Accordingly, the results are presented based on the following three themes:

- Teachers' perceptions and experiences of using DT as an approach to teaching
- Students' learning experiences through the DT principle

- Opportunity and challenges of effective implementation of DT

Keys/codes:

Teacher participant 1….9 (T1, T2, T3……)

Focus Group 1, 2….. (FG1, FG2……)

4.3 Teachers' perceptions and experiences of using DT as an approach to teaching

The teacher participants were interviewed and enquired to share their perceptions and first-hand experiences on delivering the lessons using the DT approach. A total of nine teachers participated in the interview. The findings suggest that all the participants perceived that DT is one of the inspiring approaches to use as a teaching and learning tool in the 21st century. The teacher participants expressed that DT is the right teaching approach for promoting the needs of 21st-century core skills and competencies. For instance, teacher participant (T4) expressed that DT, if used across the subjects for delivering content, not only makes the learning interesting but also instils creativity and critical thinking in teaching-learning processes among the learners.

In addition, participants expressed that teaching through a DT approach can provide a platform for the students to develop broader thinking skills, allow students to extend the horizon of thinking ability and problem solving, innovations and increase their cognitive level (T1, T6, T7, T9); and a more of the student-oriented teaching-learning process (T1, T8). The findings from the teachers' perception suggest that DT in the teaching and learning process provides a new pedagogy shift in educating the students focusing more on skills-based and practicality over conventional lecture methods. Teacher participants indicated that integrating DT in their teaching lessons motivates and generate interest in their learners.

Teacher participants were further enquired to share their experiences of using DT in their classrooms. The finding suggests that all the teacher participants had acquired new and enriching experiences from this implementation process. One prominent experience voiced out by the participants throughout the interview was the high level of motivation and excitement developed in the students during the whole process of DT activities in the classrooms. Besides, motivation and excitement, teacher

participants expressed that DT activities keep students engaged meaningfully throughout the class.

Participants (T1, T2, T3) describe that DT activities promote collaborative learning, critical interactions, and active participation among the students while participants (T3, T4, T5, T6, T7, T8) experienced that DT activities keep students actively engaged, highly excited and motivated to generate the solution for the real-world problems ("think outside the box") than normal classroom lessons.

The findings suggest that one significant outcome of the implementation of DT in classroom teaching was that while all stages of the DT steps were used there has been more emphasis in the first stage "empathize", 3rd stage "ideation" and 5th stage "prototype". The participants expressed that these three stages were very significant and inspiring in fostering the skills and values in the students. The analysis also suggests that other participants who experienced all the steps of DT are significant and inspiring ones.

Therefore, the results indicate that teacher participants are of the positive perceptions and experiences that DT is one teaching and learning approach that can be used in the classroom to deliver the relevant lessons. More importantly, the perceptions and experiences voiced by the participants indicate that DT is an approach that is relevant to the development of 21st century skills such as creativity, critical thinking, problem-solving, and innovation. All the participants committed to using DT in their future lessons when the lesson topics are relevant and suitable.

4.3 Students' learning experiences through the DT principle

In focus-group discussions with students, new learning experiences acquired from DT lesson activities were discussed. When asked to share the different learning experiences they acquired from the lessons taught through DT approach as compared to other regular classes, the student participants mentioned that active learning and engagement have happened during the class. Students expressed that their interest and concentration in the class are enhanced due to active individual participation and there is no room for sleeping as it happens in other lessons due to less opportunity for students to engage in activities (FG4). While attending the DT class, students

experienced greater learning of teamwork and collaboration, exchange of ideas, discussions, creativity, and innovation. As FG 6 and FG 7 remark:

> "There is an opportunity for creating new things using our creativity and innovation and can watch and experience during the prototyping and testing phase".

> "Teaching happens outside the box. There is a higher level of collaboration amongst the learners".

The second learning experience for them is skills development such as creativity and communication skills. They shared that the process of idea generation during ideation puts them under test of their potential. For example, FG3 expressed:

> "It enhances our communication skill because the activities demanded the generation of more ideas through asking questions and cross-fertilization of ideas. For example, in Biology class, when we learned about invasive species, my friends came up with a new set of ideas that I even didn't realize". Similarly, FG 5 emphasized that "it is a good approach, learner-centered, and offered hands-on experience".

The third learning experience for them is empathizing with others. FG 5 indicated that in Biology class when we learned about muscle movement, we got to interact with the students with special needs at our school. When we found them using a wheelchair, we could empathize with their real problems. We could enter into their shoes, therefore, we tried in our project to develop prosthetic limbs for them to use. Further, they mentioned that they learn how to interact and feel about others.

The overall findings from the focus group discussions indicate students have experienced new learning which enhances their thinking ability, interest, and motivation to learn. To sum up the findings, the participants' voices about the lessons, expressed that they found the lesson interesting because it allowed them more interaction and generation of varying ideas, excited to learn new things, and motivating (FG 1, FG2, and FG4). Students also prefer the lessons to be taught using DT steps in the future.

4.4 Opportunity and challenges of effective implementation of DT

Teacher participants have the same opinions regarding the implications of DT in the teaching and learning process. The prominent opportunities voiced by the participants are integrating DT in teaching helps to cater to the development of 21st-century skills of the students: self-learning, collaboration, creativity, communication, and excitement, problem solving. The finding indicates that another positive aspect of DT lesson shared by the participant is it provides students an opportunity to explore beyond the textbook curriculum which is a self-oriented learning process.

The challenges encountered by teachers in the implementation of DT in teaching are identified. First, the time and resources (Teaching –learning materials) are considered as an issue in use of DT in the classroom effectively. All the participants mentioned and agreed that one hurdle is time and resources. The finding indicates that the lack of time and resources are a major setback in teachers' efficient implementation of DT lesson.

Additionally, choosing relevant topics that best suit the DT principle was the challenge that emerged for the participants. Besides, teacher participants argued that DT cannot be used for teaching all the topics given in the curriculum and completion of a lesson embedding all 5 phases of DT during one period becomes a challenge. To exemplify these claims, the participant expressed; "the lesson seems very interesting for both teacher and students, however, some lessons cannot use all the components of the DT. The last two components that couldn't be used in the lesson were due to the shortage of time or due to inability to comprehend and use the concepts" (T1). Further, T2 expressed that "students were apprehensive about this new teaching skill. They had a problem understanding the motive of it all". These findings of challenges encountered indicate that both teachers and students need to be well-oriented with the concept of DT.

Therefore, the findings from this part indicate that teachers are of the view that time, resources, and lesson topics are considered to be the main constraints in the effective implementation of the DT principle in classroom teaching learning.

5. Discussion

This section discusses the key findings of implementing DT in the school. The discussion is presented with key findings of lesson observations supported and validated through interviews, focus group discussion, and relevant literature on Design Thinking.

Analysis of lesson and teaching observations revealed the following four key findings. These findings contributed to the understanding of processes and outcomes; students' and teachers' perspectives and experiences, and challenges of implementing DT principles in the teaching and learning process in the higher secondary classrooms in Bhutan.

5.1 DT lessons facilitated engagement by providing an opportunity for students to express their voices and opinions

The study by Kwek (2014) found that DT helped to foster collaboration, gave them voice and choice, and allowed for powerful engagement. The present study's findings found that while engaging in the DT activities in the classrooms, there is an active engagement of students in groups, and students expressed that they receive equal opportunity to express their views regardless of high or low academic performance in the class. The same findings were reported in the previous studies (Gompel, 2019; Cupps, 2014; Kwek, 2011). The observation results revealed that during ideation and prototype steps, students were actively engaged in discussion, brainstorming, writing, drawing, and sketching their ideas. In the same way, students expressed that they preferred active learning activities rather than passive learning activities in the classrooms.

During the focus group discussion, student participants mentioned that active learning and engagement have happened during the class. Students expressed that their interest and concentration in the class are enhanced due to active individual participation and there is no room for sleeping as it happens in other lessons due to less opportunity for students to engage in activities (FG4). Similarly, this finding relates when teacher participants also voiced throughout the interview that there is a high level of motivation and excitement developed in the students during the whole process of DT activities in the classrooms. Besides, motivation and excitement, teacher participants expressed that DT activities keep students engaged meaningfully throughout the class. The finding of the current study agrees with Kolk (2012), that as

an instructional tool, it can be used to allow students to express their ideas without constraint while engaging in design activities.

From this finding, it was understood that the DT approach can offer the freedom for students to learn through active engagement to share and voice their opinions and ideas. This indicates that teachers must create a platform for our students to perform activities that enables them to explore their potential and confidence.

5.2 Students engaged in collaborative learning while participating in DT activities

The findings from the observation of the conduct of the DT activities involving the five stages of DT by teachers revealed that students experienced greater learning of teamwork and collaboration, exchange of ideas, discussions, creativity, and innovation. The activity occurred during the whole process of DT and engages students to practice working in groups, brainstorming, and ideation, creating prototypes, and sharing. Student participants expressed that during the activities, "there is an opportunity for creating new things using our creativity and innovation and can watch and experience during the prototyping and testing phase" (FG 6); "Teaching happens outside the box and there is a higher level of collaboration amongst the learners" (FG 7). This current finding agrees with the ideas of Carrol (2015), Kwek (2011), and Scheer et al. (2012) who argued that DT motivates students for exploration and problem solving, being open to ideas, allowing them to be innovative and creative. Furthermore, within the educational context, the characteristic of DT focuses on collaboration and iteration which is relevant to learning theories within education, developmental psychology, and social psychology (Hennessey & Wilfrid, 2020).

5.3 Popular DT Steps Used by Teachers

The observation findings revealed that teachers made good use of the "ideation" and "prototype" stages of DT while organizing classroom activities. It was common for all the teachers in organizing and imparting lesson objectives in the ideation and prototype stages. The common methods used by teachers to carry out ideation were: discussion, brainstorming, listing and writing, drawing, and sketching the ideas on post-it papers. Similarly, prototyping activity methods included such as constructing a simple prototype model, drawing and sketches, and writing. For example, a few prototypes designed by

students consisted of: "*making a cooler model using the thermodynamic concept* (in Lesson 1); "a *sketch of mind mapping on the chart paper* (in lesson 2); and "*concept sketches to minimize the impact of wastes and sewages.* The current study results corroborate with the idea proposed by Dam and Siang (2020) that in the context of education, the DT model describing "prototype" is about bringing conceptual or theoretical ideas to life and exploring their real-world impact before finally executing them. Further, a prototype can be a cardboard box or a sketch model, a particular gadget, or a role-playing activity (Ambrose & Harry, 2010). Therefore, the common materials used in the development of prototypes included papers, cardboard boxes, chart paper, markers, wooden planks, and other available materials. Students used those materials to design the models, sketches, or concept maps to represent their ideas for the problems identified. However, the pattern of conducting the lesson activities followed is common to all the teachers.

It was revealed from the observation notes of the teachers' use of the DT process in the classroom that teachers mostly focused on engaging students in ideation and prototype stages to provide them with hands-on activities to let students actively engage in the learning process. Across the lessons, students were observed actively enjoying the ideation and prototype activities. During the interview, both teacher and students expressed that the ideation and the prototype are fun and interesting and these two steps were well received by them. In accordance with the present result, previous studies have demonstrated that students learn best when they take an active role in the education process, discussing what they read, practicing what they learn, and applying concepts and ideas (Davis, 2009; Smart & Csapo, 2007). Besides, with the help of the design processes, students can develop their thought processes, and that can increase their interest in the lessons (Kwack, 2014).

From the findings, it may be concluded that there is evidence that the DT process in teaching and learning motivates and develop an interest in students to learn. With facilitation from the teachers, students show excitement, curiosity, and interest while carrying out the DT activities through active engagement and collaboration to generate ideas and create prototypes. Therefore, it can be recommended to the teachers that DT can be used to engage, develop interest and fun, and promote a student-centered learning environment with a series of activities such as interviewing, observation,

writing, drawing, creating, and finding what they can do with their learning through ideation and prototype.

5.4 Teachers Perception in the use of DT in Teaching and Learning

According to the literature, the end purpose of the DT approach is for creativity and innovation, empathy and user-centeredness, prototyping and experimentation, and multidisciplinary collaboration (Lor, 2017, p. 59). Further, the nature of the design process also provides collaboration, teamwork, and communication (Kolodner, 2002). The finding of this study is considered relevant in fostering skills of collaboration, innovation, creativity, communication, thought process, prototyping, and experimentation in the learning of students through a DT approach. Findings revealed that both teachers and students perceived and experienced the DT approach as one strategy to teach and learn higher thinking skills.

Further, the finding suggested that one significant outcome of implementing DT in the classroom teaching is relevant to 21st-century demands to cater to the skills set such as creativity, critical thinking, problem-solving, and innovations. Additionally, the teacher participants expressed, that knowledge of DT prepares students for the future. As one participant voiced; " I found that DT is one such strategy that grooms our children more practically in connection with the demands and challenges of the real world" (T3). These findings from the teachers' experience agree with the literature on DT which describes that in education DT is regarded as design-based learning (Dolak et al., 2013, p.2). Further, DT is believed to be a catalyst for innovation and bringing new things into the world (Meinel & Leifer, 2011). These findings further support the findings of previous studies, in which DT pedagogy helps students prepare for collaboration and leadership skills needed for success in any career field (Cupps, 2014); and DT increased student motivation by allowing students to feel successful and confident in their learning (Campos, 2011). Similarly, DT can build the capacity for students to understand the process of learning itself (Carroll et al., 2010). Further, DT helps to foster collaboration, gives them voice and choice, and allows for powerful engagement (Kwek, 2011).

Furthermore, while students were asked to provide feedback on the lesson as a whole, all the student participants mentioned that they enjoyed the activities and it was interesting to learn through such a teaching method. The study also revealed that students experienced greater learning while engaging in DT activities. Student participants shared the process of idea generations they went through during ideation phase which challenges their potential. This corroborates the study of Carrol et al. (2010) which described DT, as applied in education, as a learning process that focuses on building the creative confidence of students and where students engage in hands-on projects that focus on building empathy, promoting a bias toward action, encouraging ideation, and fostering active problem-solving.

6. Conclusion

In general, overall findings suggested that engaging in DT helped students to think creatively, which resulted in the development of new knowledge and new ways of thinking that can be incorporated both in teachers' instructional strategies and the students' approaches to learning. Therefore, the findings of the study unveiled that using DT enable lessons to become more exciting and empower teachers to be innovative. It also facilitates them to plan lessons and organize learning activities for students to promote creativity, innovation, and problem-solving skills.

Based on the positive findings of the study the following recommendations are proposed to create enduring impact on the educational front:

Short-term goal: The teacher participants for this study are now empowered to use DT in their teaching, and learning and assessment, with the knowledge and skills developed it enables them to employ the approach when appropriate to subjects they teach. Since use of DT as a teaching-learning strategy has the potential to develop fundamental skills required for students such as critical thinking, creativity and problem solving skills, orientation and workshop on use of DT can be planned and provided by the Ministry of Education to the teachers of secondary schools.

Mid-term goal: The empirical evidence has exhibited positive bearings on students' learning therefore, curriculum designers and policy makers could adopt it as one of the key teaching- learning -strategy and plan to imbed DT as an approach across secondary school curriculum. Further, to promote DT as one of the primary

teaching-learning approaches in an educational setting it would require teacher training colleges to rethink and consider the institution of DT as a teaching- learning approach for the teacher trainees in their training.

Long-term goal: DT, with its emphasis on equipping students with the tools and capacity for innovative and creative thinking, offers great promise to make progress towards the vision of *Royal Kasho on Education reform*, 2020. As such, this study provides information that broadens the understanding of the integration of the DT approach in the classroom in the Bhutanese context, and its impact on twenty-first-century skill development.

Finally, the study being limited to only one sample school it is recommended that further research on DT can be undertaken to pave the way forward and build foundation on the implementation of it in classroom teaching in Bhutanese secondary schools. Nonetheless, despite the overarching positive findings revealed by the study, it also revealed teacher competency, time, and resources are the prevailing implementation hurdles that require attention from relevant stakeholders, schools, and individual teachers if this approach to teaching is to move forward. The sample was limited to one school only, therefore, results cannot be generalized across all the higher secondary science classrooms.

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