(RE)POSITIONING SCIENCE EDUCATION FOR THE SELF AND SOCIETY:

AN AUTOETHNOGRAPHIC INQUIRY

Aagat Awasthi

A Dissertation

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AN ABSTRACT

of the dissertation of *Aagat Awasthi* for the degree of *Master of Philosophy in Education (STEAM Education)* presented on January 22, 2023, entitled *(Re)positioning Science Education for the Self and Society: An Autoethnographic Inquiry*

Abstract Approved:

…………………………………….	…………………………………
Prof. Bal Chandra Luitel, PhD	Asst. Prof. Binod Prasad Pant
Dissertation Supervisor	Dissertation Supervisor

I grew up in an environment that encouraged me to look at science as a local entity and embodiment of indigenous knowledge and for my parents and grandparents, this knowledge of science was so important that it impacted their day-to-day life and the activities they performed. I also became part of this 'knowledge-transfer chain' and this was my first exposure to science education. However, during my school, I often felt a missing link between the science education I was learning at school and the world I was living in. The teaching of science was textbook-based, disconnecting students from their lives and intimate realities (Bajracharya & Brouwer, 1997). From what I experienced, school education has not fully succeeded in cultivating interest in the minds of students like me for exploring nature and their environment. I also began to view science as the most significant subject in school, and I developed the belief that science is superior to all other subjects as I was growing up. This perception was attributed to the social standing, prestige, and potential career path connected to the study of science. My impression

towards science developed primarily due to my family environment, social networks and the community (Fabiansson, 2015).

I was able to reflect on my educational journey and deepen my understanding of the world thanks to my participation in the MPhil programme, with a focus on science education in particular. I gained theoretical understanding and practical insights that helped me to better understand the various STEAM education lenses. This opportunity also gave me a foundation for (re)connecting my past experiences of science education with new worldviews and inspired me to start this research inquiry. I concentrated on re-establishing the connection between science and everyday life in my research and made an effort to look into the space provided in science education for students to reflect on their social contexts. As a method of inquiry, I found autoethnographic design (Adams et al., 2016, 2021; Creswell, 2012; Ortiz-Vilarelle, 2021) to be the most appropriate for my particular study. I explored my lifeworld and investigated the value of science education to me as an individual, as a professional, and as a social being through my personal-professional as well as societal lived experiences. My narratives are divided into three themes: science education as/for personal (ir)relevance (Chapter Three), Science education as/for professional (ir)relevance (Chapter Four), and science education as/for social (ir)relevance (Chapter Five). In the process of unpacking my experiences, I realised that the teaching of science was decontextualised, textbook-based, didactic, and encouraged rote learning (low level of cognitive achievement). My study unfolded the need for transformation from technical interest in teaching and learning practices to emancipatory interest; reconceptualisation of curricula from subject-centric to thematic transdisciplinary approach; and harmonisation of learners' engagement across cognitive, affective, and psychomotor learning domains, allowing students to develop reflective and critical awareness. These insights provided me with the opportunity to crystalise my vision (Chapter Six) and deepen my engagement in STEAM education.

………………………………… January 22, 2023

Aagat Awasthi

Degree Candidate

This dissertation entitled *(Re)positioning Science Education for the Self and Society: An Autoethnographic Inquiry* presented by *Aagat Awasthi* on January 22, 2023

APPROVED BY

………………………………… January 22, 2023

Asst. Prof. Binod Prasad Pant

Dissertation Supervisor/Acting Head of Department

………………………………… January 22, 2023

Prof. Peter Charles Taylor, PhD

External Examiner

………………………………… January 22, 2023

Prof. Bal Chandra Luitel, PhD

Dissertation Supervisor/Dean/Chair of Research Committee

I understand and agree that my dissertation will become a part of the permanent collection of the Kathmandu University Library. My signature below authorises the release of my dissertation to any readers upon request for scholarly purposes.

………………………………… January 22, 2023

Aagat Awasthi

Degree Candidate

DECLARATION

I hereby declare that this dissertation entitled *(Re)positioning Science Education for the Self and Society: An Autoethnographic Inquiry* has not been submitted earlier for the candidature of any other degree to any university.

………………………………… January 22, 2023

Aagat Awasthi

Degree Candidate

DEDICATION

To my ancestors who treasured and transmitted their limitless experience, knowledge and skills

To all teachers who dedicate their life to transform others' lives

To all learners who aspire for emancipation and transformation

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I am grateful to my parents, my grandparents and my ancestors who provided a pathway for intergenerational connection and a vast source of knowledge that has been a part of my day-to-day activities. I could not have undertaken this journey if I did not have the opportunity to observe my grandparents (who are no more with us) and my parents practising their knowledge and learning from their stories.

I owe a great deal of gratitude to my parents and in-laws for their support, kindness, and encouragement.

I want to express my gratitude to my wife Prakriti for the support and encouragement she provided in my life, in my career, and in undertaking this research as well as to my daughter Ribhu who inspired me to bring new insights during the narrative generation process of this research. Without their help, it would not have been possible for me to complete this work.

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ABBREVIATIONS

AC	Alternating Current
CBO	Curriculum Based Objectives
CBS	Central Bureau of Statistics
CDC	Curriculum Development Centre
DNA	Deoxyribonucleic Acid
DOS	Microsoft Disk Operating System
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GRE	Graduate Records Examinations
ICT	Information and Communication Technology
IELTS	International English Language Testing System
LPG	Liquid Petroleum Gas
MB	Megabyte
MPhil	Master of Philosophy
NPR	Nepali Rupees
OBE	Outcome Based Education
PBS	Project Based Science
QBASIC	Quick Beginners All-purpose Symbolic Instruction Code
RNA	Ribonucleic Acid
SDG	Sustainable Development Goal
SEL	Social and Emotional Learning

SLC	School Leaving Certificate
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics
TOEFL	Test of English as a Foreign Language
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNESCO MGIEP	United Nations Educational Scientific and Cultural Organisation – Mahatma Gandhi Institute of Education for Peace and Sustainable Development

CHAPTER ONE

THE PROLOGUE

I have always been curious about the science and technology that surrounds me. I try to keep myself updated with the latest information on scientific and technological advancements. However, when it came to studying science and technology at school and university, I was always faced with challenges. Science, for me, had mostly been a subject about rote learning and memorisation, and I never could relate the science I was learning to my real-world situations. In this research inquiry, I explore my experiences of having to live in two science worlds: ‘the science that I study’ and ‘the science that I experience in the everyday world’. As I begin my inquiry, in this first chapter, I recall my memories and present here an outlook on my learning experiences (from school to university), experiences from my professional lifeworld and present-day moments, which sets a scene for the birth of this research inquiry. I discuss the theoretical lenses that I use as referents (cf. framework) for this inquiry. The chapter also presents some current issues in science education, leading to the resulting statement of the problems, the purpose of the study inquiry, the research questions, and the delimitations of the study.

Understanding My Selfhood

In the spring of 1988, I was born in Kathmandu, the capital city of Nepal and was raised here. On top of that, I must consider myself lucky that I was born into a family that has been extremely supportive of me with proper guidance for my education by affording to send me to some of the ‘top’ academic institutions in the country. Fortunately, my parents were living in the capital city of the country (of course, with a lot of struggles at the time to earn a living). I had great support from my parents to help me out with my studies and facilitate my learning. My parents told me that they had bought me small wooden blocks with *Ka*, *Kha, Ga*….[1] which helped me with my first exposure to the Nepali alphabet. I had early access to educational toys that allowed me to learn and explore from a very early age and I still have kept a few of them safely.

My mother played a major role in allowing me to understand the world. As we say, ‘*Pahilo Shikshak Aama, Pahilo Vidyalaya Ghar*’ [Translated as: Mother as the first teacher, Home as the first school], the knowledge I received from my family, especially from my mother was immense. From what I heard from my parents; I was already learning the Nepali alphabet through my interaction with the blocks. As I spent most of my time with my mother growing up, I also learnt to interact and communicate with my neighbours and a wider community. As I grew up, I learnt to stand, learnt to walk, and learnt other life skills to become more independent.

Figure 1: The stereo cassette player which turned into one of my early learning toys (Photo: Self)

I was told that, in 1988, when I was about four months old, my father had to go out of the country for his studies, and when he came back in 1990, he had brought with him a stereo cassette player. The stereo, however, could not survive long – it had several falls from my hands and even forced open some of its function buttons. I used to break down things to explore them from the inside. I loved to throw things under the bed and bend over to observe

[1] *Ka, Kha, Ga* (written as ‘क, ख, ग’ in Devanagari script) are the first three consonants in Nepali writing system.

them rolling and bouncing back from the wall (and for this exploratory behaviour, my relatives nicknamed me *Kupre*[2] - some even like to call me to date.

In 1992, when I reached the fourth year of my age, I was admitted to Nursery[3]. My parents did a lot of effort in finding a ‘good’ school where I could enjoy learning. While deciding about a school, my parents had to also think of their affordability. I still remember the first day I joined the school – it was difficult to be separated from my parents for the first time and be with a group that I had never interacted and met with before – all new faces. However, going to school at this age was all about playing games – new toys to play with, stories, music, and dance. Each day, I was learning something different. Some days were about the alphabet, and numbers, while other days were about colours, animals, fruits and many more. We used to have an indoor play with wooden blocks and bricks. However, most of the time, I had to be limited within the four walls. There were some hours for outdoor sports activities, like playing football with classmates as well. At least until the early grades, the examinations were all about drawing and colouring, and when it came to results, I was in the top positions.

As I moved to the primary level, I had to be limited within the classroom for a greater number of hours than I used to during my nursery or kindergarten. There were long hours of classes, which involved either repeating out loud what the teacher just said or reading out loud from the textbook. This means I had to compromise myself with fewer hours of outdoor activities. Further, I was now into studying different subjects,

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[2] *Kupre*, in the Nepali language, refers to a person who bends over.

[3] Nursery is one of the stages in early childhood education and development in Nepal. The stages are, generally, divided into Playgroup (30 - 36 months of age), Nursery (36 months of age), Lower Kindergarten or LKG (48 months of age) and Upper Kindergarten or UKG (60 months of age).

each allocated with certain minutes every day based on the timetable. Several textbooks were introduced to guide my everyday classes – at least one for each subject – and teaching learning was often accompanied by flex posters on the walls. The teacher would often point a long stick to certain images or text lines on the posters and again I had no other options than to repeat out loud.

"*Why do I have to sit in the classroom the whole day? Why cannot I go outside and play?"* – the thought that kept coming every single day. "*What is the purpose of those large playgrounds when most of the time, you are limited indoors?"*

My parents' quest for finding a good school for me never came to an end. The school where I started my schooling was a primary school. Though there were discussions about the school's possible upgrade to a secondary level soon, my parents already had plans to put me in another 'good' school – I had just reached grade three, but, well, this was about my better 'future'. *"What would the new school be like?" "Will the new school have a bigger playground?" "Will I have less homework to do?"*

During the new academic session in 1997, I got transferred to another school in grade four and another one in 1998 in grade five. The quest for a 'good' school was everlasting, until the last school transfer I made in 1999 for my grade six, from where I appeared for the SLC (School Leaving Certificate) examination in 2004. For my parents, a 'good' school required big infrastructures, spacious playgrounds, trained teachers, caring staff, and well-equipped facilities – science laboratories, computer labs and so on; and the schools I attended had the prestige of being 'good' schools.

While I very much appreciate my parents' efforts in getting me to a good school, I often used to ask my parents why they moved me from one school to the next. And their response would always be "*We wanted to get you to a good school for your better future.*" Even I have always been grateful to my parents for their efforts in providing me with good education and feel proud of getting the opportunity to study in esteemed institutions in the country and being called an alumnus of my alma matters. All these were to provide me with a favourable environment for getting good grades in SLC. All through the school level, it was all about "*You are a good student, you need to get a distinction in SLC.*", "*What if I do not get a chance to study science?*".

In 2004, after succeeding the SLC in the first division, I passed through the 'iron gate' (as everyone says). Probably I was not able to meet the expectations of parents and teachers who were expecting me to score a distinction, but for me, it was more like "*What next? At least, I can now study science.*" For that, I had to now get into a 'good' higher secondary education institution for my higher secondary education. As I waited for my SLC examination results to be announced (which would generally take around three months), I, along with many school batchmates, had already joined bridge courses and entrance preparation classes – to prepare for grade 11 entrance examinations. With my results, I was able to get admission to one of the higher education institutions popular for science. Deep inside, I was excited that I was becoming a 'science' student. I had always thought that science in higher education was all about curiosity, exploration, and discovery – unravelling the mysteries that I see around me.

Two years passed by; I found no variation in how the classes were being delivered. Throughout my school years, in every school, after delivery of the content, I had the same experience – the teacher would refer to the prescribed exercise work provided at the end of the textbook – some of the questions were assigned in the classroom, and with the end of the class, remaining questions were to be completed as homework. This experience was not limited to one subject, but to all. Some of the questions were marked as ‘important’ for their potential chances of being asked in an examination. There were additional homework tasks – to memorise the definitions and formulae for the next class. I always faced difficulties (until today) when it comes to rote memorisation. I always had fear when the teacher would ask me for a verbatim recall from the earlier classroom or homework and when I was unable to do so, I had to face punishments. My fear remained mostly during my science and mathematics classes, which had zillions of theories/theorems, definitions, formulae steps, and figures to memorise. As I moved up the classes, I had difficulty scoring better marks in the examination of my inability to memorise what has been provided in the textbook and/or in the teachers’ notes. During the examination, most of the preparation included learning the notes by heart and memorising the steps of different numerical problems.

With the completion of my grade 12 (majored in Biology), most of my friends opted to go for preparation classes for the medical entrance examinations. Unlike most students, I never regarded a medical degree as being a piece of cake for me. I enjoyed learning biology but did not dare to pursue a medical degree as I always thought studying medicine was all about learning by heart – from every bone to all the muscles to all the nerves in the body and whatnot – I already had enough of it during school. I had this perception observing my cousins and relatives who were in the field.

What could be something I could get enrolled in? Sometime in 2005, during one of the biology classes in grade 12, I was introduced to ‘Biotechnology’, which encouraged me to take this new field as one of the options for me to pursue my bachelor's degree. In 2006, I also succeeded in getting enrolled in one of the reputed universities for the biotechnology course. From the brief introduction I received in grade 12, I had an impression that biotechnology could improve the quality of human life through innovations in health, environment, agriculture, and whatnot, I was so excited that I had dreamt that I could change the world with my future knowledge in biotechnology. Above that, during orientation, I was also informed that the course introduced was adapted from one of the most prestigious universities in the world. Wow! What do you need more?

During the four years of my bachelor's degree, I had learnt about different tools and techniques in biotechnology and the prospects – the array was vast from engineering drawing to computer programming, from microbiology to animal science to plant biotechnology, from biochemistry to immunology, from environmental science to chemical engineering. We were the fourth batch to be enrolled on the course and as we approached the third and fourth years, we started to hear complaints from our seniors that the scope of biotechnology in Nepal was limited. This may be true as well, as we could see many of the seniors had started going abroad for further studies immediately after their graduation. By the time I reached the third year, several questions would come to my mind. *What next? Will I get a job? What if the job hunt is not as easy as my seniors say? What am I going to do then? What am I going to do with the degree certificate I had been conferred with? Should I also plan to go abroad as others are doing?*

With all the new confusion in mind, in 2011, I completed my bachelor's degree. The case was a bit different for me here. I was offered a job at a newly established biotechnology firm in Kathmandu. The firm was looking for someone good at computer programming skills and supporting them with the bioinformatics setup and fortunately, I had the skills that the firm was looking for, in addition to a biotechnology degree, and I joined the firm. While I was working there, in 2012, I received a scholarship for my master's degree and moved to India for two years.

The Turning Point

After I returned to Nepal in 2015, I had an opportunity to work with another biotechnology research organisation. In addition to my knowledge of biotechnology, my skills in web designing and other computer skills again gave me an edge there in getting associated with that organisation – as they were also looking for someone who could be able to support them with the branding and their website. Here, in addition to providing ICT (Information and Communication Technology) and website support, I was also involved in community-based education for environmental awareness and advocacy. This was the first time I was taking my knowledge to the community. This is where I realised that what I had studied as a science during my school and university was so much disconnected from the community. The indigenous knowledge and skills available at the local level never became a part of the discussion during my science education journey. My engagement in this project ignited my interest to work in the field of community-based science, capacity development, and empowerment. And this experience led to me think: *Why is our science education so disconnected from our own family and community?*

In the middle of 2015, I received an opportunity to work at an international organisation that globally works with governments for education and science policies, strategies, and plans. This opportunity enhanced my capability and deepened my interest in and passion for sustainable development through education. I also started to realise the urgent need of preparing students with the necessary knowledge and skills to tackle twenty-first-century challenges and problems (Harari, 2018; Taylor & Taylor, 2019). I also started to wonder *why the teaching and learning processes in our schools do not have much connectedness to the community and society that we live in* (Aikenhead & Ogawa, 2007; UNESCO, n.d.).

In 2019, with my engagement in Master of Philosophy (MPhil) in Education programme (with specialisation in STEAM Education), I was able to strengthen the connection between my graduate degree in science and professional experience in the field of education. It allowed me to deepen my knowledge of the world and provoked me to critically reflect on my trajectory of education, with a particular focus on science education. The MPhil course provided me with a critical lens to look into the teaching-learning process, curricula and assessment process, and a perspective basis for (re)connecting my past for the pursuit of science education, with new worldviews. During this journey, I was introduced to different theoretical premises of education, such as Vygotsky's sociocultural theory (Vygotsky, 1978), Knowledge Constitutive Interests (Habermas, 1971), Bloom's Taxonomy of Educational Objectives (Airasian et al., 2001; Bloom et al., 1956; Krathwohl et al., 1964) and was able to link these educational theories with my lived experience as a student of science and technology. Here, I experienced a unique relationship between how I entered the world of education and how I was getting connected to the emerging reality of STEAM education. With my academic engagement, I began to critically reflect through questions like:

Why is science regarded as one of the critical subjects in school?

Despite one's interest, why a student like me must struggle in learning science at school and beyond?

What is the purpose of learning science? Is it just to provide pure scientific knowledge or empower learners to find solutions to everyday problems?

What could be done to increase the participation of students in science?

Taking a Plunge

With my engagement in MPhil, I was also making a shift in my academic discipline and my practice: from a scientific researcher to being a social science researcher (education research to be specific). The most challenging part of this academic journey was to undertake this inquiry as part of my dissertation, as I had to completely switch my research approaches and logic able to fit within a new paradigm for me.

During my bachelor's and master's degree courses, I undertook two research projects as part of my dissertations:

1. Isolation and Characterisation of Actinomycetes from Surrounding Soil of Medicinal Plants (2011)
2. Investigation on the Effect of High-Frequency Non-Thermal Electromagnetic Radiation on Enterobacteriaceae (2014)

In both research projects, I was asked by my department to identify a subject of my interest and to meet with my potential supervisors for their possible interest in taking me into their existing research activities. After a discussion with my potential supervisors, they offered me to work under them on a part of their existing project and join other undergraduate, graduate, and doctoral students who are working on different aspects of the same core research. The supervisor, along with other members provided an induction on the project, along with the expected results and an update on the results so far. I was also provided with some relevant papers on related studies and a brief on different procedures and techniques to be applied to undertake the experiments under the project. While some of the procedures and apparatus were the first time for me, for some, I already had some competence to work on. All the experiments and the procedures involved were tightly designed and controlled ones and I would interpret the result from what I observed based on the expected outcome of the experiment – no further analysis based on my belief. Any further interpretation may have led to scientific misconduct. As cited by Taber (2020), both of these projects were:

"largely deductive, with a tightly defined research question that was framed through a very specific theoretical perspective drawn from the literature (perhaps needing an early judgement about which of a number of theorists to follow), with the consequence that it was predetermined how the data should be understood, and how results would arise from the analysis" (p. 4)

In contrast, the research approach I was required to take for my MPhil dissertation was a very different one as I was embarking on research which was a new area for me. After I identified a potential topic for my research, my supervisor advised me to go through different papers to help me develop an understanding of my topic. Based on diverse papers, I also prepared a research plan and a methodology to guide my research. Compared to my scientific research activities, I was more autonomous regarding the scope of my research. The research process was very open-ended, and the inquiry had an evolving design. I also had to be very creative in terms of data interpretation and find suitable literature to back up my belief. As presented by Taber (2020), this research project for my MPhil dissertation involved:

"more exploratory approach indicated, where the way data were to be understood would emerge later from a more open-ended process with aspects of conceptualisation deferred until later in the process in the light of the ongoing analysis" (p. 4)

Despite the struggle I had to face initially; with support from my supervisor, I began to delve into several pieces of literature and came across different theories that could provide me with possible answers to my inquiries. I situated between different theories, as my theoretical referents (Luitel, 2009; Pant, 2015) and discussed the learning behaviour of students in science subjects and how the local construct and knowledge system could influence the understanding of science topics in a classroom. To carry out this inquiry, I have drawn upon theoretical premises like local cosmologies, with a focus on the local indigenous/contextualised knowledge systems, Vygotsky's sociocultural theory, Bloom's taxonomy, Habermas Constitutive Interest, leading to social justice and science for all, and transformative learning.

Local Cosmologies

What we call science is a cosmological manifestation resulting from our age-old knowledge system, tested, and proven by ancestral wisdom and intergenerational transmission of lived experience. Our cosmologies comprise knowledge about our existence, physical and spiritual reality, physiological needs, survival skills, health care and rearing practices, foods and food habits, sanitation, clothing, protection, and art of living together, etc. Science is inherent to these knowledge systems that our ancestors cumulated from time immemorial. Local cosmologies are the depositories of Nepal's knowledge and wisdom, drawing on the evidence and lived experience through our interactions with nature and living beings (Luitel & Taylor, 2008).

Typical to many children who were the first-generation of any family to be Kathmandu-born, my parents were the first in their family to have come to Kathmandu city for their further studies and being able to earn a degree here. Being born and raised in Kathmandu, while I had early access to educational toys and learning materials, I also had opportunities to learn from my parents about their life experiences in rural settings and the indigenous knowledge they possessed. I grew up in an environment that encouraged me to look at science as a local entity and embodiment of indigenous knowledge. My parents had received their knowledge based on ‘indigenous science’ through an inter-generational transfer of knowledge from one generation to the next through daily social and cultural events (Nakashima et al., 2017; Ogawa, 1995). For my parents, this knowledge of science was so important that it impacted their day-to-day life and the activities they performed. This knowledge was well preserved within them despite living in the city for a long time (Kolawole, 2015). Subsequently, I also became a part of this knowledge-transfer chain, which may be was my first exposure to science education.

Relating science to Nepal’s traditional and ethnic knowledge systems and practices may be more meaningful than the knowledge gained from outside sources (Awasthi, 2004). Local knowledge and technologies are being utilised in our communities for a very long time and local knowledge also forms a foundation of one’s identity. Being a family following Vedic traditions, I experienced a lot of *puja* rituals in my home, and I was always briefed by my parents on the ‘science’ of all these rituals and their significance to nature and oneself. The ‘indigenous science’ knowledge I received from my parents was vast – including, but not limited to cleanliness and hygiene, how we prepare/cook food, what/how we eat, and home-based/herbal remedies for health care.

The local knowledge system, on the other hand, also contains elements of pseudoscience (Thagard, 1978). For example, there exist beliefs about the existence of supernatural forces, attributing to certain illnesses or natural phenomena, which are not supported by scientific evidence. Such beliefs are often at odds with scientific knowledge, especially when used to justify harmful practices. While some social beliefs and practices in our local knowledge system tend to promote pseudoscience, it is not always the case, and much of our local knowledge can also coexist with scientific knowledge. It is, therefore, crucial to scrutinise pseudoscientific beliefs for the confirmation of their scientific credibility.

During this study, based on my lived experiences, I explored the incorporation of Nepal’s local knowledge systems and local cosmologies into the science teaching and learning process, making local cosmologies a source and repository of science that is locally appropriate, relevant to learners’ lives, and ‘subject of everyday life.’

Glocalisation

As I was born and raised in an urban setting, my source of knowledge was not limited to local and indigenous knowledge transfer through my parents. As I grew up, with my day-to-day engagement with the school textbooks, local markets and television, modernisation and Western worldviews started to have a bigger influence on my activities and my preferences. Over time, in the name of globalisation, there has been a major change in the sociocultural construct of society (Bencze et al., 2012) and a rise in *comprador intelligentsia* who undervalues local practices and knowledge for being too primitive to fit into the modern day education system (Fanon, 1963; Luitel, 2009; Said, 1995). It is common for developing countries like Nepal to have economic and cultural changes with the process of globalisation (Raikhan et al., 2014). Further, with the emphasis on education as a mechanism for economic growth, it is also influencing and shaping the globalisation of science education (Stacey et al., 2018). With this, curriculum reforms in school education are focused more towards producing globally competent citizens who can actively participate within the globalised markets (Luitel & Taylor, 2008; Sellar & Lingard, 2014) and science teaching taking into account cultural and economic globalisation processes (Bencze et al., 2012).

While globalisation opens opportunities to developing countries (Sharma, 2014), globalisation is also seen as a hegemony of foreign worldview that imports and legitimatises Western modern worldview. In a country like Nepal, having a diverse culture and knowledge systems, there is a risk that indigenous knowledge systems are threatened by globalisation-influenced science knowledge and the community may lose some cultural identity (Bencze et al., 2012; Nakashima et al., 2017).

Local and indigenous knowledge systems are so much benefitting that we continue to use them for our day-day-to activities and some, it is part of their livelihoods. As local problems demand local solutions (Kolawole, 2015), it is inevitable that local knowledge systems are better suited for it and are also economically and environmentally sustainable over imported technologies. However, some aspects of local knowledge and technology may benefit from technological advancement due to modern science (for example: using various standardised extraction technologies for commercial purification of compounds from traditional medicinal and aromatic plants). We cannot get away with the prospects of communication and collaboration that globalisation opens a door to and thus for knowledge and technology exchange as well as commercial opportunities. This can also help in (re)innovation of some of our traditional technologies. Hence, there is a need for an inclusive view of globalisation within science education that acknowledges cultural practices and local knowledge of communities (Luitel, 2009). I have incorporated a transformative vision of glocalisation within science education which can be seen as a dialectical space where there is "a continuous interplay and interactivity between globalisation and localisation" (Luitel, 2009, p. 334). This will help in overcoming both the exclusive view of the hegemonic worldview and the romanticisation of indigenous knowledge systems (Gevelt, 2019).

Social Constructivism

I grew up observing the sociocultural practices of my parents and those of my uncle and aunts in the neighbourhood who continue to promote their traditional community knowledge originating from their village and my learning during the early stage of my life was primarily through my exposure to and interaction with these sociocultural values and practices. This is in line with the central assumption of Vygotsky's sociocultural theory (Vygotsky, 1978) that interaction with other people and culture is the foundation of learning and following this, the information is integrated on an individual level. Vygotsky's theory emphasises the role of interactions between individuals and the environment in which the individual grows up and therefore, rather than viewing learning as solely a product of an individual's cognitive processes, this theory suggests that learning involves adopting the behaviours and conventions of a particular culture or group. Further, social interaction with 'knowledge holders' (or based on Vygotsky, the 'More Knowledgeable Other') in society allows an individual learner to better understand the local culture and context and adapt the knowledge to the individual and societal needs.

During my infancy, my interaction with my mother and observing her eating, allowed me to also develop my skills to eat as my mother does. As I grew up, I started to learn to cook and the sequence I follow while preparing food is often reflective of how my mother cooks. When I make errors in the process of cooking, it was easier for me to get support and instructions from my mother, and I can manage to do better than the previous time. Most of my learning from before the time I started to go to school occurred in an unintentional setup of a collaborative learning environment and this allowed me to internalise many life skills and problem-solving strategies by observing and interacting with my parents and other members of my community. But my learning at school was primarily happening through rote learning, and textbook- and lecture-based approaches, and there was limited space that allowed collaborative learning through interaction with my community and the 'knowledge holders'.

Nepal is a culturally diverse country, and the local/indigenous knowledge it holds is vast. To allow the learners to internalise the knowledge that exists in our society and enable them better to serve societal needs, there is a need for better social interaction involving collaborative dialogue with knowledge holders. In this study, I explored the curricular space provided for knowledge construction through interaction within the learners' sociocultural environment settings and how sociocultural contexts are brought for discussion in the classroom for a better understanding of the subject and social awareness (Mohapatra, 1991).

Learning Domains

The Taxonomy of Learning Objectives or Bloom's Taxonomy – both old and revised (Airasian et al., 2001; Bloom et al., 1956; Krathwohl et al., 1964) – constitutes three hierarchical models for classifying educational learning objectives based on the cognitive, affective, and psychomotor learning domains. When learning occurs holistically, it is not limited to the study of facts and dissemination of information, and its recall (learning in the cognitive domain), but also prepares the learners about attitudes, emotions, and feelings (learning in the affective domain) and support development of fine motor skills (learning in the psychomotor domain) associated with their cognitive understanding.

From what I experienced, most of my learning of science at school and university has centred around the cognitive domain and the curriculum design, classroom activities and assessments are structured with a focus on the cognitive learning domain. Examination-driven learning has emphasised rote memorisation as the primary technique for knowledge acquisition and the ability to recall the content of any subject determined a learner's success more than anything else. This led to learning being limited to the lower order of the cognitive domain. I have made further discussion on my experiences from school and university as a science learner in Chapter Three.

Further, learning at school and university also provided limited opportunities for psychomotor development towards a higher order. The practical session was about following a sequence of steps as provided in the practical guidebook ('Set' level of the psychomotor domain) and following instructions from the instructor (‘Guided response’ level of the psychomotor domain) (Simpson, 1972). The time allocation for learning any scientific skills was so limited that there was no opportunity for further development of proficiency in any of the scientific skills I was required to master (‘Mechanism’ level of the psychomotor domain). According to the Fitts and Postner (1967) model of human performance, skill acquisition occurs in three stages: cognition, integration, and automation, which could also be applied to scientific skill acquisition. After the learner intellectualises any task and executes it during the cognitive stage, the learner proceeds to the integration stage, where they further refine their skill and gradually be competent with the appropriate use of motor skills based on the scenario. With adequate practice, the learners can perform their skills in an automated way with minimal cognitive input (Shaker, 2018). But due to the limited allocation of time for each practical/experimentation session, I did not receive an opportunity to further advance my scientific skill to a level that was essential for my professional settings. I have further discussed my experiences from my professional setting in Chapter Four.

The affective domain is often undervalued when it comes to teaching and learning science. While science learning is important, they have received far less attention than the cognitive dimensions. Science is regarded as a subject of recitation of formulae, theories, facts and information in which feeling and affection do have any existence (Alsop & Watts, 2003). But, when it comes to science education, for learning to occur, the affective dimension is a necessary condition (Perrier & Nsengiyumva, 2003). Attitude and motivation play a positive influence on learning behaviour, thus promoting active participation, and fostering achievement in science education. Additionally, it is also important for science learners to be socially responsible and aware of social and cultural issues. I have discussed some of these experiences in Chapter Five.

As I developed a vision of STEAM education in Chapter Six, I have presented science as a subject of social interaction that provides a space for children to think about their environment and surroundings and make them aware so they can contribute towards solving the local and global issues. I have also highlighted the importance of social and emotional learning to promote interpersonal skills among learners.

Knowledge Constitutive Interests

The theory of ‘Knowledge Constitutive Interests’ was also fascinating to me (Grundy, 1987). According to Habermas (1971), humans are preconditioned with cognitive interest for their survival and this interest stimulates the generation of knowledge about the physical and social world and the exercising of political power (Amador et al., 2015; Edgar, 2006). This knowledge is linked to different actions as these interests are “anthropologically deep-seated” (Edgar, 2006, p. 11).

Technical knowledge constitutive interests are those aspects of knowledge linked with manipulation of the physical environment and it was prevailing in most of my classrooms. From my experience, there is also a relationship between knowledge and power, where as a student, we were often considered naive by our teachers and there was a domination of teachers in classroom interactions and the teaching-learning process – a power imbalance between the teachers and students. Further, behaviourist learning theory was prevalent in classrooms with “drill-like practice and the transmission of facts and principles” (Agarkar & Brock, 2017, p. 94), with an authoritarian and teacher-centred model of teaching (Stewart, 2012). When I, as a student was not able to meet expectations from teachers – for example, when I fail to make a verbatim recall from the textbook or the teachers' lecture notes, I often had to face punishments like scolding, nagging, public shaming, spanking and 'hen punishment'.

While the technical interest is limited to an understanding of the environment for the formulation of laws to have control over that environment, the practical interest allows the understanding of the environment to be able to communicate with it (Habermas, 1971). This allows communication with each other to have a shared understanding of the world as a meaningful place. Guided by practical interest, in a classroom, teachers and students are engaged in sense-making activities. The generation of knowledge is through the meaning-making process and is associated with historical-hermeneutic science (Grundy, 1987). The curriculum guided by practical interest facilitates the meaning-making and interpretation of knowledge, but from my experience, the learning was primarily through textbook-based subject matters and memorisation of facts and rote learning. The practical interest was also much of an interest to me as it allowed sharing of narratives and meaning making based on my lived experiences and my environment where local knowledge and values played a major role in building on my prior knowledge.

Further, the emancipatory curriculum interest aims at developing students and teachers as individuals who are free of influences from disempowering forces in society (Grundy, 1987). As I developed a vision of STEAM education in Chapter Six, I was guided by the emancipatory interest paradigm. In this practice, the teacher and students are involved not only in "reflective deliberation, personal judgement-making and interpretation" (Taylor & Campbell-Williams, 1992, p. 7) of curricular contents but also bring into discussion the existing social contexts. Teachers and students also share authority and control in the social construction of their knowledge. The emancipatory curriculum practice also allows the development of critical consciousness among learners to reflect and be critically aware of any social inequalities in society and environment, and mindfully act for their mitigation (O'Sullivan et al., 2002; Taylor & Taylor, 2019).

Science Education, Society and Science for All

From what I have experienced, science in the school curriculum is looked upon as a subject that provides scientific knowledge as a preparation for the students who later go on to study different science subjects at the university level (Fensham, 2008). Hence, science education has been primarily introduced as a medium to generate pure scientific knowledge among students – understanding of scientific facts, principles, theories, etc. (DeBoer, 1991). However, science education should not be limited to promoting only scientific knowledge, but rather also towards developing the competency and ability of the learner to become scientifically and technologically well-informed (Fensham, 2008) and to engage in real issues of the society and socio-political actions (Hodson, 2003). With contextualised science education, every learner "should be able to confront, negotiate, and make decisions in everyday situations that involve science" (Sadler, 2011, p. 1). Even though I have been learning science at school and university, in many real-life situations, I have not been able to apply my scientific knowledge to find solutions to problems I have encountered that involve my knowledge of science and technology. In Chapter Three, I have discussed some of the problems I encountered.

The Perth Declaration on Science and Technology Education (2007) also conveys that the current science and technology education has not been able to address present societal issues of the twenty-first century. In my vision of STEAM education, I have looked at science education through a lens of equally benefitting everyone in society, not only the students who plan to engage in science professionally and have explored the role of education in preparing students who can participate in the discourse of society.

Transformative Learning

There is a need for science education to have a transformation from being a subject that delivers only pure scientific knowledge to become a subject that also allows learners to be “critical self-reflective thinkers” (p. 1080), which can be only achieved through the incorporation of transformative learning theory in science education (Taylor, 2015). Mezirow has viewed transformative learning as “the process of using a prior interpretation to construct a new or revised interpretation of the meaning of one’s experience in order to guide future action” (Maiese, 2017, p. 211). I have looked into the engagement of learners in a science classroom through the framework of five ways of knowing, as advised by Taylor (2015): cultural-self knowing, relational knowing, critical knowing, visionary and ethical knowing and knowing in action. This enables us to understand our situatedness in the context of our culture, identity and beliefs; question any assumptions and beliefs in the surroundings on if they are accurate or (dis)empowering and critically reflect on the local/indigenous knowledge systems (Taylor, 2015). It further allows science education towards becoming more human-centred and focused towards supporting learners to be future responsible citizens. As I develop my vision for STEAM education, I explored the practice of glocalisation as a transformative vision in science education in Nepal, that allows the incorporation of local knowledge and practices into the classroom (Luitel, 2009).

Statement of Problem

Science as a course was mainstreamed into the Nepali education system after 1951. It, however, was, from then, delivered using the lecture method and consisted of drills and rote memorisation (Nepal National Education Planning Commission, 1956). Nepal National Education Planning Commission (1956) envisioned and recommended the science curricula of Nepal be localised and connected to “nature that surround the child” (p. 91). However, since the process of formal curriculum development started in 1971, the curriculum has always been centrally designed based on the ‘one fits for all’ model, without giving much space to the contextualised curriculum (Nepal, 2014).

The current decontextualised nature of curriculum materials and textbooks (UNESCO & Kathmandu University, 2008) have disconnected students from their local environment and knowledge system – leading to their low participation and underachievement in science education. As observed by Luitel and Taylor (2005), the problem lies in the curriculum development process that is designed centrally without recognising the local contexts and contents.

The curriculum and textbooks influence the learning of science in classrooms (Shrestha, 2015). Teachers are presented with a ‘centrally designed standardised’ curriculum and a set of recommended textbooks to be strictly followed. Teachers are not just faced with too many contents that are required to be covered within the allotted time, but the time allotted is inadequate to allow coverage of the targeted contents. The teachers, hence, get very little time for the individual attention of students (Majoni, 2017). Due to these constraints, teachers are forced to practice rote learning as the primary way of learning and ask students to memorise factual knowledge. Because of this view of curriculum as reproduction and rote learning, there is also a chance of reproducing hegemony and inequalities existing in society (Brookfield, 1998).

By utilising their knowledge and skills of science, teachers need to customise students' curricula to make them locally appropriate and relevant to their lifeworld and livelihood. This leads to making science a 'subject of everyday life' with a focus on cultivating their interest in learning science. In Nepal's current context, most students feel burdened by the contents of science due to their disconnections and aridity.

As a student, I could barely relate the science I learnt and the science problems I observed to my everyday life (Burbules & Linn, 1991). An ideal teacher is required to promote individual students to actively construct knowledge through a discovery learning approach and it requires teachers to accept all students' ideas as equally valid (Matthews, 1992). Meaningful learning takes place in a classroom when teachers can design or adapt curricula to meet the needs of their students (Strauss, 2016).

Moreover, a study by Wai, Lubinski and Benbow (2009) on cognitive predictors of STEM learning in children suggests that competency in the language (awareness of phonetics, knowledge of letters and vocabulary) also affects learning in Mathematics, which could also apply to other STEM subjects like science. This is very critical in the context of Nepal where students come from diverse linguistic and social backgrounds, and speak more than 123 languages (CBS, 2012). Further, before the promulgation of the Constitution of Nepal (2015), the Nepali language was promoted as the only official language and this lingua franca caused non-Nepali speaking learners to be unable to understand the class, resulting in low achievement and dropouts (Awasthi, 2004). Nepal National Education Planning Commission (1956), however, is also to be held responsible for promoting monolingual practices in Nepal, not realising the importance of multilingualism in education, and with this, the school curricula advanced with disconnection from cultural values (Dastgoshadeh & Jalilzadeh, 2011) belonging to non-Nepali speakers. Further, the introduction of English as the sole medium of instruction for teaching subjects like science has culturally decontextualised science education in Nepal (Luitel & Taylor, 2005). There is a further risk of decontextualisation in science education with the recently endorsed National Education Policy (MoEST, 2019) which promotes the use of the English language for science education.

Under the federal governance system, the local governments have also been provided with the authority to design and implement local curricula (Local Government Operation Act, 2017). It is therefore important for us to make a rethinking in science teaching and curricular design to contextualise its content and construct by bringing a shift in the existing policies and practices for teaching science. Ultimately, the teaching of science needs to witness a departure from a centrally designed course and imported contents to locally constructed science programmes and everyday-associated curricula. The introduction of locally constructed curricula would also allow teachers and students to get engaged in a process of integrating and getting deeply engaged with local and ethnic knowledge. This also helps reduce existing gaps in educational policies and pedagogical practices, as well as address social injustice and inequalities.

Purpose of the Study

The purpose of this study is to reflect on my own experience of learning science and understand the inter-relations between the knowledge of science and the lived experience. My focus in this study is to relink science with our day-to-day functioning to make students feel that science is not a separate entity or subject but is a manifestation of our understanding of the environment and everyday happenings in our lives. Further, I would also explore the space allowed in science education for the learners to be self-reflective on their local knowledge and social construct to allow social change and improvement in society.

Research Questions

My overarching research question is: **How (de)contextualised was my journey of science education and how can science education be (re)constructed?**

Subsidiary Research Questions

1. How have I experienced learning of science at home, school and university?
2. How applicable has the learning of science been to my personal, professional and societal lifeworlds?
3. How can science education be (re)constructed to respond to personal-professional and societal needs?

My Positionality in the Study

My research is primarily informed by my learning experiences at home, school and university. This study embodies my experiences of learning science in educational institutions where, in general, a minimal level of basic physical infrastructure was in place. Since I have spent most of my life in Kathmandu and its periphery, my personal, professional and societal lifeworlds are mostly limited to urban settings that shaped my lived experiences as well as my narratives. The meaning-making process (Chapters Three, Four and Five) and envisioning (Chapter Six) in this inquiry have been influenced by my (re)orientations that evolved during my learning journey while engaging in the MPhil programme.

While objectivity is equally important in science education as it helps to ensure that research is based on solid evidence, I have placed greater emphasis on subjectivity throughout my dissertation to highlight its important role in science education as it allows value judgements as well as different perspectives and insights to advance our understanding of the world. It is also important to recognise that (ir)relevance I have discussed at the personal, professional and societal levels is a subjective construct that can change over time and may be influenced by an individual's changing values, goals, and experiences.

Chapter Outline

Chapter One, ‘The Prologue’ sets the stage for the beginning of this research inquiry. I reflect on my past experiences and offer here an outlook on my educational journey, experiences from my professional lifeworld, and current moments. I go over the theoretical frameworks that I refer to in my discussion of this inquiry. A few current issues in science education are also discussed in the chapter, which leads to a statement of the issues, the goal of the study inquiry with the research questions and the delimitations of the study.

Chapter Two, ‘Research Methodology’ highlights the methodology I use to conduct the research. I start the chapter by going over my philosophical presumptions, then I go over the research paradigms that my research is based on, the autoethnography I use as a research methodology, how I generate stories, the various logics and genres I use, the quality standards I assure, and ethical considerations I made throughout the process.

Chapter Three, ‘Science Education as/for Personal (Ir)relevance’ is in response to the first research question as well as the second research question's ‘personal lifeworld’ part. Addressing the first research question, I narrate my personal experiences of learning science at home and during my formal education in Nepal. I, further, investigate whether the science education I received was meaningful and applicable to me. In response to the ‘personal lifeworld’ part of the second research question, I discuss how helpful science education was for me in my everyday activities.

Chapter Four, ‘Science Education as/for Professional (Ir)relevance’ responds to the second research question's ‘professional lifeworld’ part, where I discuss the relevance of the knowledge and skills I acquired during my science education, in the context of my professional life.

Chapter Five, ‘Science Education as/for Social (Ir)relevance’ addresses the ‘societal lifeworld’ section of my second research question. I discuss the value of science education to societal well-being and explore how useful and applicable knowledge and skills acquired through science education are in addressing and resolving issues in society.

Chapter Six, ‘Imagining the Future(s) of STEAM Education’ outlines my vision for (re)conceptualising STEM education with a discussion on some key elements. The chapter is in response to the third research question and is based on my learning through recent academic engagement and my personal-professional experiences.

Chapter Seven, ‘Recollections and Reflections’ is the concluding chapter of this dissertation. I reflect on my research journey, followed by my concluding reflections on the research questions, methodology, and theoretical referents I used. I also discuss my future direction and any implications the study might have.

Summing Up

The chapter gave a general overview of my research inquiry. I highlighted some of my most memorable educational experiences from home, school, and university as well as from my professional life. To relink science learning to our daily functioning, I reflect on my own science learning experiences throughout this inquiry. The four theoretical notions of the sociocultural theory, the taxonomy of learning objectives, the theory of knowledge constitutive interests, and the theory of transformative learning will serve as the foundation for this investigation, along with concepts such as local cosmologies, glocalisation, and science for all. I also discussed a few of the problems I saw in the field of education, with a special emphasis on science education. These discussions formed the basis for my overarching research questions, which I used to develop four subsidiary questions that would cover every aspect of the investigation.

I will go over the research methodologies I used in the following chapter.

CHAPTER TWO

RESEARCH METHODOLOGY

Chapter Overview

In the previous chapter, I discussed the birth of my research agenda, the theoretical lenses that I use, current issues in science education, the statement of the problems, the purpose of the study inquiry, research questions I articulated and delimitations for this research. In this chapter, I highlight the methodological design that guides my research inquiry. I begin the chapter by discussing my philosophical assumptions, followed by research paradigms that my research is based on, autoethnography that I employ as my research methodology, the narrative generation process, multiple logics and genres I use, quality standards I assure in the process, and ethical considerations.

My Philosophical Assumptions

My philosophical assumptions constitute axiology, ontology and epistemology, with a view to aligning them with my research process. Recognising the centrality of axiological foundation in my autoethnographic inquiry, I have placed it at the beginning of my philosophical premises.

Axiological Assumptions

My value-based assumptions about science education triggered my quest for knowledge and provided me with a firm foundation for embarking on this journey. The nature of my autoethnographic inquiry is value-laden (Creswell & Poth, 2017). The values I uphold are emanated from the cosmological constructs instilled in me through the intergenerational transmission of knowledge. My parents, in particular, and family as well as society as a whole played a part in constructing my knowledge of science at the subconscious and conscious levels. These values have contributed to my learning, unlearning and/or relearning of science in informal and formal settings at home, school and university.

Further, my lived experiences in science education have ignited my desire to explore how my values manifest at my personal, professional and societal levels. My trajectory of learning science appears to have been shaped by the values I embodied. My acquisition of science at home was founded on local/indigenous knowledge and belief systems whereas the pedagogy of science at school and university was primarily prescriptive (Pajares, 1992). I have experienced a missing link between the two operating systems that shaped my trajectory of science education.

This inquiry is thus an attempt to understand the continuum of the makings and manifestations of values in science education at home and school/university with regard to my personal, professional and societal engagements (Kennedy & Cram, 2010).

My values about science and science education have influenced my paradigmatic, methodological and theoretical choices (Zaidi & Larsen, 2018). The research design and inquiry processes have been shaped by my value-laden worldviews. The ethical boundaries and bonding in my research have been defined by the values I have enshrined (Ermine et al., 2004).

Ontological Assumptions

My research used relativist ontological orientations (Denzin & Lincoln, 2005) as it provided me with a basis for recognising multiple realities and allowed me to explore juxtaposing views and positions. The realities I have experienced regarding learning/experiencing science education vary at different stages of my journey – as a science learner, as a working professional, as a member of a society and as an MPhil scholar. As I was learning science at school, I always understood science as a subject of factual knowledge that required a learner to follow rote learning and memorisation of the formula, theories and definitions by heart. I looked at science as being a subject of social status and linked my success with my future ability to study science for my higher studies (see Chapter Three). As I joined professional work, I found the knowledge and skills imparted from the school and university were not adequate for real-world situations (see Chapter Four). With my engagement in MPhil, I was also able to look at science education from a social constructivist perspective, which allowed me to understand the need for school science to have better connectedness with the local knowledge and learners' everyday situations, to allow learners to better serve the society. My narratives reflected my lived experiences and made the real representation of these multiple realities by using multiple research logics and genres.

Epistemological Assumptions

I have generated knowledge based on my personal experiences and analysed them through a subjective lens. My study employed knowledge generated through interfacing my own personal-professional experiences. The knowledge in natural science is generated based on empirical evidence, and the rational nature of science provides space for logical reasoning. From my experience, my teachers seemed to employ only rationalised pedagogy primarily based on didactic and textbook-based teaching. With my engagement in MPhil, I learnt that to engage students in the learning process, it is important to generate knowledge by linking learning with the learner’s environment and community. This also applies to teaching and learning science by bringing into discussion learners’ experience of science at home based on their local/indigenous knowledge system.

Epistemologically, my position is transcendental idealism (Kant, 1998). The concept of transcendental idealism was introduced by Immanuel Kant in the eighteenth century and according to this theory, rather than knowledge being seen purely as an objective body of information, the knowledge is actively constructed by the mind that also structures and organizes sensory experiences into meaningful knowledge. Corresponding to Kant's idea that our subjective experiences and mental processes shape our understanding of reality, in the context of science education, I believe that knowledge should be generated by connecting it with the learner's environment and community, rather than relying solely on didactic and textbook-based teaching. Incorporating learners' personal experiences and local knowledge systems into science education open ways for a more meaningful and relevant learning experience.

As I develop my vision of STEAM education (see Chapter Six), I have utilised empirical inputs (from teachers and learners) for rationalised teaching of science. Using empirical inputs from teachers and learners for rationalized science teaching entails incorporating both teachers' and students' experiences and observations into teaching and learning processes. This involves real-world scenarios and examples from learners’ experiences as well as engagement in hands-on activities. Further, rationalized teaching encourages students to reflect on their experiences and critically evaluate scientific concepts and theories as well as debunk any myths and misconceptions that they believe in by use of logical reasoning.

Research Paradigms

I have applied the multi-paradigmatic research design space (Luitel, 2019) by drawing on the paradigms of interpretivism, criticalism and postmodernism. I concentrated on interpretivism, criticalism and postmodernism. Interpretivism was employed to adapt a relativist ontology for multiple interpretations of a single phenomenon to gain a deeper understanding of the subject matter. Further, criticalism provided a theoretical base for understanding a socially constructed reality (Pham, 2018) in view of science education in Nepal. The paradigm of postmodernism allowed me to give a literary turn to the knowledge generated.

Interpretivism

The interpretivist paradigm has enabled me to construct knowledge through a dynamic and evolving process of interpretation and understanding while engaging in the inquiry. I used micro and macro level connections during the memory reconstruction process by ensuring that my interpretation is informed by a diverse range of perspectives and sources and that it takes into account both my lived experiences as well as cultural and social context. As new insights, perspectives, and understandings emerged, I was able to embrace them in the research process. I was flexible and accommodating, letting the insights shape and guide my understanding. Through the process of interpretation, I was able to construct a deeper and more nuanced understanding of my experiences as well as make reflections on my personal-professional journey to unfold the cultural and local knowledge perspectives, connecting them to everyday science classroom activities.

This provided me with a basis for adapting relativist ontology, offering opportunities for multiple perspectives and interpretations of science education experiences, rather than relying on a single, subjective viewpoint. Interpretations representing locally constructed realities (Taylor, Taylor, & Luitel, 2012) added value to deepening my understanding of science-related matters.

Criticalism

The paradigm of interpretivism is not enough for me to understand the difficulty faced by students in studying science subjects, based on my own experience, which is largely textbook based, disconnecting students from their lives and the environment they live in. The paradigm of criticalism helped me understand the problem faced by the students in understanding science as a subject due to its decontextualised nature from their everyday life and how teachers can facilitate making science a ‘subject of everyday life.’ Further, criticalism allowed me to explore the interests being (under)served by present-day science education (Taylor et al., 2012) and the incorporation of social justice. Until we recognise socially constructed reality as an integral part of science education, the holistic dimension of science cannot be attained. Therefore, criticalism is a crucial research paradigm for this study.

Postmodernism

In the paradigm of postmodernism, during my research, I was on a quest for postmodernism in science which tries to find a balance between nature and knowledge (Taylor, 2014), in contrast to the ‘conventional science’ that only accepts a singular truth. While undertaking this inquiry, the paradigm has allowed me to present autobiographical narratives based on my educational experiences, analyse the relationship between my past and present experiences and practices, and envisage the future of science education based on these insights (Henderson & Gornik, 2007; Pinar, 1975). In this paradigm, I was also able to present my qualitative data texts in the form of narratives, metaphors, stories, etc., giving them a literary turn (Taylor, 2014). This allowed me, as a researcher, to become "the mirror to the world under analysis" (p. 5), reflecting real representation of the lived experience, thus addressing the crisis of representation (Denzin, 1997). Further, as I develop my vision of STEAM education, I am guided by my currere approach to science teaching and learning where learners are provided with comfortable space to share their lived experiences.

Critical Autoethnography as the Method of Inquiry

To allow myself to respond to the issues I have identified and the research questions I have articulated for this inquiry, autoethnography research was the most appropriate method. Autoethnographic design is a qualitative research method where the elements of autobiography and ethnography are combined (Creswell, 2012). While undertaking this inquiry, I have reflected on my journey based on my lived experiences and studied its relation to my culture's prevailing beliefs and principles. This allowed me to explore my contemporary phenomenon in the real-life context as a science learner, individual, professional and social being. I have narrated my stories of myself based on self-reflection of my journey (Ellis et al., 2010) and also made a theoretical inquiry through the use of various policy documents, reports, curricula, textbooks and teaching learning materials. As I commenced with my inquiry, I wanted to explore myself and critically examine my personal-professional accounts (Taylor et al., 2012). I have shared the values of critical orientation in qualitative research (Carspecken, 1996) for this research which enabled me to focus on cultural self-knowing with reference to my learning and critically reflect on my assumptions and beliefs. Further, this allowed me to reconceptualise my professionalism and commit to transforming science education policy, curricula and/or pedagogical practices.

Critical Autoethnography as Transformative Research Methodology

Critical autoethnography as a research methodology upholds individual experiences within a broader cultural context and enables the researcher to challenge prevailing narratives and power structures while critically analysing their lived experiences and biases (Ellis et al., 2010). While employing this methodology, I, as a researcher, am taking on dual roles of subject and observer, using my lived experiences as a starting point for further inquiry into wider cultural and societal issues. The critical autoethnography allowed me to engage in self-reflection and self-exploration (Ellis et al., 2010) and challenge the dominant narratives around science education through the sharing of my lived experiences. In doing so, I experienced a transformative awakening of myself, which fostered my capacities and awareness at both the personal and societal levels (Qutoshi, 2015), contributing to the inception of a more inclusive and equitable vision for science education.

Writing as Inquiry

I got engaged in writing from the very beginning of my research. I had my lived experiences and drafted a few narratives based on my own experience in response to my research questions. I recollected my memories and presented the lived experiences I had gone through as a learner (Chang, 2016; Gautam, 2018), as a working professional and as a social being. It was for the first time; I was reflecting on my entire life from my early stage to the present time. As I got myself engaged in writing, I started to find newer connections to my experiences and one narrative led to the other, building new knowledge (Werder, 2016). Then, I made thoughtful reflections on my lived experiences (Rai, 2017) and critically reviewed my narratives to arrange them under different themes. I narrated my lived experience, using multiple genres and logics (stories, dialogues, metaphors). I made notes based on my readings of scholarly journals (Rai, 2017) and as I got involved in writing, I reflected and discussed the narratives, with reference to the theories that I had chosen as my theoretical referents. I presented my experiences and reflections in an 'intellectually honest' (Bruner, 1960) form for simplifications that avoid distorting that essence.

I retrieved and recalled past events and experiences through memory reconstruction by linking them to both broader and overarching macro, and specific and detailed micro contexts (Wang et al., 2017). Both macro and micro-level connections played an important role in the process of memory retrieval and reconstruction - macro-level connections allowed me to remember significant events and occurrences, as well as cultural and social context, while micro-level connections helped me to remember specific details, such as who was present or what was said. Further, as I made connections between my personal experiences and the larger cultural and social contexts in which those experiences occurred, the macro connections allowed me to situate my memories within those contexts, and to understand how my experiences were shaped by broader social and cultural forces.

Given that my mother tongue is the Nepali language and having to juggle between two languages (English and Nepali), it was challenging for me to narrate my experiences and write this inquiry solely using ‘native speaker’ dialects in the English language (Canagarajah, 2012). Hence, I employed interlanguaging and translanguaging as a means to reflect my bilingual experiences and identities (García & Wei, 2014; Pavlenko & Lantolf, 2000). Within most of the vignettes and narratives, I have switched between the two languages (interlanguaging) and used together elements of both of these languages (translanguaging), as a way to communicate effectively and express the complexity and diversity of my experiences in a more authentic and nuanced way (Canagarajah, 2012).

As I made this inquiry, I looked into how the science education I have received from school to university has been relevant to me. Van Aalsvoort (2004) has viewed relevance through the connection in personal, professional and social settings and with reference to this, I have explored, through my personal-professional as well as societal lived experiences, the relevance of science education to me as an individual, as a professional and as a social being. I have divided my narratives into three themes: Science education as/for personal (ir)relevance (Chapter Three), Science education as/for professional (ir)relevance (Chapter Four) and Science education as/for social (ir)relevance (Chapter Five). Based on my learnings during my MPhil and the insights I derived from these narratives, I developed my vision for STEAM Education (Chapter Six).

To guide myself in the process of unpacking my experiences based on these themes, I developed a timeline of my experiences (Chang, 2016) as a source to craft my narratives of my lived and present experiences, which I have presented in the table below.

Table 1

Chart for Narrative Development

Inquiry Theme	Representative Chapter(s)	Research Question(s)	Source and Timeline of Data
Science education as/for personal (ir)relevance	Chapter Three	How have I experienced learning of science at home, school and university?	From the time of early childhood to the present (1992 – present)
Science education as/for professional (ir)relevance	Chapter Four	How applicable has the learning of science been to my personal, professional and societal lifeworlds?	From the time of completion of under graduation to the time of joining MPhil programme (2011 – 2019)
Science education as/for social (ir)relevance	Chapter Five		From the time of completion of under graduation to the present (2016 – present)
Imagining the future(s) of STEAM Education	Chapter Six	How can science education be (re)constructed to respond to personal-professional and societal needs?	Emerged during my MPhil and the process of this inquiry (2019 – present)

Multiple Research Logics and Genres

I have used multiple research genres and logics to allow the space for multiple pluralism (Rai, 2017) and identify paradoxes existing in classroom practices and during the design and delivery of science education in Nepal.

Dialectic Logic and Genre

Within the postmodern research paradigm, with the use of dialectic logic, I was able to explore different opposing views and represent them with equal consideration (Taylor et al., 2012). Through this dimension, I have created a balance in the tension between what I believe and what I experienced (Luitel, 2009). Additionally, I have taken a synergetic approach in developing the titles of my chapter such as Science education as/for personal (ir)relevance (Chapter Three), Science education as/for professional (ir)relevance (Chapter Four), Science education as/for social (ir)relevance (Chapter Five).

Metaphorical Logic and Genre

Similarly, the metaphorical logic was useful to provide a visual image of something that I, as a researcher, might have observed or experienced. Through the use of metaphors, any complex construct which is very abstract can be communicated to anyone to give them a representative image of the observance or experience (Taylor et al., 2012). For example, I used metaphors like *tuppi kasera* (see Chapter Three), *thulo mache* (See Chapter Four) and others throughout my inquiry.

Narrative Logic and Genre

The narrative logic allowed me to reflect on my lived experience through the use of personal memoirs and events, thus giving representations of the multiple realities within a complex construct, thus addressing the crisis of representation across this dissertation (Denzin, 1997). By employing narrative logic and genre, I was able to create engaging and meaningful research that could effectively communicate my experiences and insights to the readers.

Non-linguistic Genre

I have used non-linguistic genres like photographs, and cartoons which allowed me to represent the lived experience and "foster thoughtfulness in the reader" (Taylor et al., 2012, p. 381). This form can be seen throughout the narratives to support the readers in the meaning-making process as anticipated by the particular environmental and social context in which I was positioned.

Quality Standards

I have been honest with my narratives and experiences. I have maintained the quality standards of my research by fulfilling the requirement of the research protocol and integrating theories with methodological choices followed by interpretation and self-reflection.

Verisimilitude

I have developed narratives that are based on my personal experiences. To make my vignettes as realistic as possible, I provided a thorough description of the context and the environment. I presented my stories through dialogue (direct speech) and in multiple voices so that the readers can find them to be very representative and engaging (Pant, 2015) (see Chapters Three, Four and Five). I used multiple logics and genres to maintain the realness of the environment and my lived experience, and thus maintain verisimilitude (Luitel, 2009).

Generativity

My research reflects the lived experiences of teaching and learning science and the applicability of science learning in real-world situations. I have used vignettes and narratives based on my lived experiences, which the readers can relate to their own experiences or apply in their personal and professional contexts (Ellis et al., 2010). Further, as I reflect on my lived experiences and beliefs, this allows readers to generate new insights and understanding, and raise questions on the existing construct of science education (Barone & Eisner, 2012).

Pedagogical Thoughtfulness

I have ensured pedagogical thoughtfulness in my research to inspire the readers. Through my narratives, I believe that other science education learners and educators would interpret my experiences within their context, and make a reflection on their teaching and learning process to bring required changes to the pedagogical process and (re)construct science education as equally benefitting everyone (Qutoshi, 2019).

Critical Reflexivity

The use of criticalism as a research paradigm allowed me to have critical reflexivity as a key quality standard for my research. The critical reflexivity allowed me to be self-reflective on my lived experiences on practices of hegemonic ideologies (Taylor et al., 2012). In the process, I employed three phases of critical reflection (Brookfield, 1994; Pant, 2015). First, I identified my beliefs and practices, for which I developed various narratives and stories. Then, I critically examined my beliefs and assumptions as well as my experiences and identified any hegemonic and disempowering forces in those experiences (see Chapters Three, Four and Five). This enabled me to embark on a transformative journey and allowed me to develop my vision of STEAM education, which I think is more empowering and transformative (see Chapter Six). Like me, I hope that the readers would also embark on a critical reflective journey inspiring a change in their approach to teaching and learning in science education.

Ethical Consideration

I have taken into account the principles of beneficence and non-maleficence to ensure that I conducted this autoethnographic inquiry responsibly and respectfully.

My narratives, in this autoethnographic inquiry, involves diverse people, places and context. I was aware that I needed permission to disclose any details involving any person in this inquiry. I made an effort to use fictitious names for the individuals and places to ensure anonymity for the protection of identity and confidentiality. I was mindful of any sensitive or private information that I included in my narratives and considered whether it was necessary and appropriate to include it in my research. In the case of my parents and relatives, I obtained their informed consent and permission, while I was writing, to include any stories that involves them and to keep the information (Denzin & Lincoln, 2018). It was also important to be transparent about my relationship with different people in the narratives, particularly when it included my family members, to ensure that the research is conducted ethically (Ellis & Bochner, 2000).

The study intends to discover new information that would be helpful to society, science education, and the education sector as a whole and is not intended to hurt anyone or find out information at the cost of any people or the community.

Summing up

I covered my research methodology in this chapter. I started by talking about my philosophical assumptions. Then I talked about the various research paradigms I used for my research, including interpretivism, criticalism, and postmodernism. I used interpretivism to consider various interpretations of a single phenomenon. Criticalism gave me a theoretical framework for comprehending a socially constructed reality in the context of science education in Nepal. The postmodernist paradigm allowed me to give my qualitative data texts a literary spin by presenting them as narratives, metaphors, etc. By incorporating these three paradigms, I used the multi-paradigmatic research design space (Luitel, 2019). Because it allows me to reflect on my lived experiences, I used an autoethnographic design, which I found to be the most appropriate method of inquiry for my particular study. Later, I emphasised the various research logics, genres, quality standards I had employed, and ethical considerations.

I start responding to my research questions in the following chapters. In Chapter Three, I make inquiries based on the first research question and the ‘personal lifeworld’ part of the second research question.

CHAPTER THREE

SCIENCE EDUCATION AS/FOR PERSONAL (IR)RELEVANCE

Chapter Overview

In the previous chapter, I discussed the methodological process of my research inquiry. In this chapter, I address the first research question and the 'personal lifeworld' part of the second research question. My personal experiences of learning science at home and during my formal education in Nepal – from primary school to a bachelor's degree in biotechnology – prompted me to pose the first research question. In the context of personal (ir)relevance, I discuss my connectedness to the science education I received and its significance in my personal lifeworld. I explore whether the science education I received was relevant to me and meaningful.

Here, I develop narratives under various sub-themes to address the issues of school science not being connected to learners' homes and social contexts, which results in decontextualised learning: '*Setting the scene: Scientific knowledge at the home/school interplay'*, '*Blurring out the experience: 'Padera janincha''*, '*The More Knowledgeable Others: My parents and grandparents*', '*Embarrassment with my urban-centric understanding*', '*Real World Learning*', '*Visualising in the textbooks*', '*Natural science without naturality*', '*Science projects as (in)active construction of knowledge*' and '*Washback effect in science education*'. Additionally, I address the 'personal lifeworld' part of the second research question in the next sub-theme '*My sciences in my everyday life'* and talk about how useful my science education was for me in my day-to-day activities. Some of these themes have emerged based on the intensity and proximity of my grandparents' and parents' knowledge of science and their occupational connection, geographical situatedness and societal engagement.

Setting the scene: Scientific knowledge at the home/school interplay

Being born in a Brahmin family, the Vedic culture has been influential in my beliefs and traditions. I often observe my parents and grandparents listening to and chanting Vedic *mantras* (line verse) and hymns. While these hymns are religious and consist of worship of gods, they also provide information on health, well-being, recuperation and different sciences (Wujastyk, 1998). I grew up hearing stories of *Panchatantra* and *Dantya Katha* (fables) from my parents and grandparents. Each story used to have a moral lesson and provided me with knowledge on survival and well-being in every aspect of my life (Bajracharya & Brouwer, 1997). I always observed them listening to and reading through *Paurarik Katha* (or mythological stories). Whenever a protagonist of the story would either be in trouble or would be doing something wrong morally, there would be some moral presented through a character either representing a god/goddess or some mythological figure. My grandfather used to tell me that these mythological stories provide him with the required skills and knowledge to live a healthy and happy life. These stories also had some influence on me – there were characters I would be influenced by or some I would be fearful of. I also experienced a lot of *puja* rituals in my home. My father always gave me a briefing on the 'science' behind all these rituals and their importance to the environment and oneself. As highlighted by Bajracharya and Brouwer (1997), such stories have created a society that greatly values the environment and the significant roles that numerous plants and animals play in it. The knowledge of 'indigenous science' I received from my parents had its focus on a biospheric aspect of learning, and our traditional rituals show that there are “many possible connections between traditional Nepalese culture and a well-rounded science education” (Bajracharya & Brouwer, 1997, p. 432).

Further, I grew up observing my parents and grandparents following many routine activities that they said to have learnt from their fore-parents. Every morning, I see my mother waking up early in the morning and sweeping and mopping the floor. Sometimes when I was still a child, I even asked her if it is important to clean the house every day. She told me that her parents had taught her, citing different cultural significances and she continues to do so until today. She finds the knowledge sourced from her mother to be more practical and applicable. Most importantly, this knowledge from her mother also had religion and social connectedness. Even on the days, she was not feeling better, she forces herself to at least wipe clean the main door area, the kitchen and the front yard, else I have seen her having that fear and guilt on the days when cleaning these core areas of the house could not be performed.

Learning about tidiness and cleanliness has been part of my school curriculum since early grades and this has made me aware that I need to keep my home and surroundings clean. However, I do not consider myself being as sincere and responsible as my parents and grandparents are/were.

“Can you clean the front yard today? It is getting dirty.”

“Do we need to do this today? I will do it tomorrow.”

“You were so different when you were a child. You always wanted to keep everything tidy.”

This is the complaint I always hear from my mother, whenever I come up with excuses for her request for some cleaning work at home. But most times, I do not feel too determined towards house cleaning. From what I hear from my mother, I was much different when it comes to cleanliness and tidiness when I was a child, in contrast to what I am today. As a child, I had a practice of keeping things in place and keeping things clean. “You have not been so responsible after you have grown up.”

This is not a one-time statement I get to hear from my mother. Her concluding comments on this behaviour of mine often always carry a similar message and, she utters on a similar pitch and tone. Her statements had often made me rethink how I have changed regarding some of my behaviours and habits unlike how I was as a child.

Then as a child: *Did I have the influence of my mother and grandparents that I learned to keep things clean and tidy?*

And later as I grew up: *Why were the school and the science lessons not able to keep up my motivation towards cleanliness?*

Blurring out the experience: *‘Padera janincha’*

It was sometime in 1992, I got admitted to the ‘Children School’, which was my first school where I studied until the third grade. When I must recall my early grade classroom space today, I can still remember those walls that were colourful and with pictures painted all over. There were also several posters hung on the wall. There were pictures about learning animals, birds, vegetables, fruits and many more. Whenever it was time for a learning activity, the class teacher would also utilise different learning materials like soft toys, wooden blocks etc. Though limited, my learning would often be accompanied by field visits and excursion trips from the school. This allowed me to contextualise my learning to the environment I live in. The fruits, vegetables and animals that I use to learn at my early grades were something I could observe or interact with at my home or around. I always looked forward to these trips as I could have so much fun outside. Who would not have loved to skip school at times? I do not know if this desire was out of my boredom within the four walls of the classroom, but as a child, I did enjoy learning outside the classroom, which involved exploration and discovery.

But as I reached higher grades, I started to find the school to be more burdening. One of my scariest moments in the classroom used to be those first few minutes when my teacher used to ask me to synthesise the 'take-away' of the earlier class – most of the time, this would include the definitions, theorems or formulae. I was among most of the students who could never satisfy the teachers with the definition or the explanation that was presented in response.

"Why don't you study what I have taught you? How would you score marks without knowing the definition?"

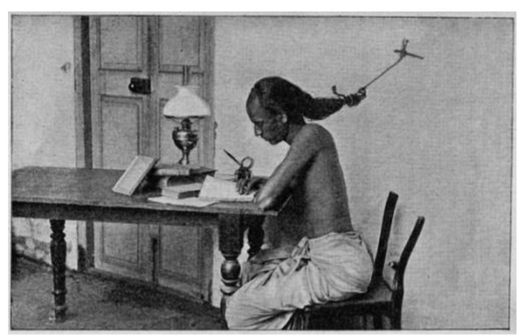

Figure 2: 'Image: Student of University of Madras. Preparations for Exams (Working Hard, They Tie Hair to Nail in Wall to Prevent Falling into Sleep)' (1905)

The culture of teaching was more as depositing the teacher's ideas into students (Luitel & Taylor, 2005) and I was always told to study 'टुप्पी कसेर' [*Tuppi kasera*, translated as 'by tying your lock of hair'] which would mean that I needed to study day and night and put on a lot of efforts. This phrase originates from the traditional practice of Brahmins, during their study, who used to tie their hair locks to wall hooks so they rote learn a vast quantity of *slokas* and *mantras* without falling asleep. *Were my teachers suggesting I follow the same practice of rote learning?*

It was sometime around 2000 while I was in grade seven, Mr T used to be my chemistry teacher in school. I always felt he was the most hard-hearted person. He presented himself as being the strictest teacher of all. Every time he entered the classroom, he would have a long stick with him (it was a hockey stick!) and on entering the classroom, would directly head to the classroom platform stage and put down his stuff on the teacher's table on the front. Every one of us would hurriedly stand up from our seats and greet “Good morning, Sir!”. As he directed everyone to sit down, my heart would start beating out of my chest. “What if he asks me a question today.” Just then, he called my roll number, and he goes:

“Roll number 4, what is the chemical formula of propane?”

“Methane, Ethane, what is next? Oh God, please help me!”

I went mum to his question. I tried to look at the whiteboard for any possible traces from his class yesterday. He arrived just next to me and pulled my ear.

“*Science padna kaa sajilo cha ra, tuppi kasera padnu parcha*” [Translated as: “It is not easy to study science, you need to study hard”].

Mr T was commenting on my inability to reproduce what I was taught the other day. I could feel my ear canal stretching and with it the pain within me that I could not respond to his question.

“Next class, I will spank you with this stick and throw you out of class if you can’t remember!”

Every day, after I reached home from school, I would take a break and have to get back to studying. I would check my school diary to recall the homework I have been assigned for the day and then check the class routine for the next day, so I can prioritise the subjects that are scheduled for the next day. Still, it would take me at least 2-3 hours to complete my written homework. The written part would usually comprise exercise questions from the textbooks that would require me to adapt the texts from either the teachers' notes or textbook texts and make them fit the question asked. Then after, I had to find time to memorise the notes as provided in the class. I would have faced similar consequences from teachers like Mr T. I would try repeat-out-loud and take repeated notes to make sure to learn everything by heart. I would have to prioritise subjects like science because of the fear of Mr T. In case, I was not able to know the contents of the earlier class by heart, the fear would always remain inside me:

“Hope, sir does not ask me today again!”

As I inquire further about my experiences, it takes me to another incident I faced during grade nine (sometime around 2003) with my physics teacher Ms C. Ms C wrote down on a whiteboard Newton’s first law of motion:

“Newton's first law states that….” “Students, write this down exactly the way I have written it. This is a very important question.”

The whiteboard was so reflective that I was not able to see some of the writings.

“Why are the texts so tiny? Or is it my eyes that are not able to read anything? Could it be the same for others as well?”

I have been diagnosed with short-sightedness from an early age and even with a big-fat frame on my eyes, I still face difficulties with my vision. I tried to peep into my friend, who was sitting next to my desk.

“Oi, can you show me what you have written?”, I mumbled to my friend sitting at the other desk next to me.

Just then, Ms C, in her angry voice, calls on my name “If you cannot even copy properly from the board, what are you good at?”

Towards the end of her ‘recitation’, every one of us started to compare our notes with one another and try to correct any errors made. There were plenty of blanks left in between the words in my note copy as they were not readable from the whiteboard.

“You should learn these laws by heart. These are ‘sure questions’ in the SLC [School Leaving Certificate] examinations.”

Even before we could cross verify our notes, Ms C, continues, “Now write the second law – ‘Newton's second law states …’. I must complete both laws in today’s class, otherwise, I will not be able to complete the course in time.”

She had almost reached the bottom corner of the board, but I had just reached somewhere in the middle. Just then, the bell rang indicating the end of our 45-minute class.

“I will ask tomorrow what I have taught you. These are very important for your exam. There could be a surprise test as well,” informs Ms C as she exits the classroom.

Even before I could copy the notes entirely from the board, I had not realised our Nepali teacher had already entered the classroom. He calls out my name to let me know that I had to stand up to greet him. As everyone greeted him, he had already started to dust off the notes from the earlier class.

The science subject constituted a set of plans with contents sequenced for students to know. Like Ms C, the teachers had to allocate a specific duration of time to teach students with each set of contents and would have to deliver essential knowledge based on the prescribed textbooks and the curriculum. Several lectures used to be assigned to each of the topics in the curriculum. The teacher was required to accomplish the job of delivering those contents as per the schedule and students could ‘acquire’ necessary knowledge within the specified time. Because the teacher had to follow a fixed and standardised pattern, they never got much flexibility to perform “differentiate teaching” (Rushton & Suter, 2012, pp. 48), as a result, the student-centred methodology never governed the classroom and was not able to address the need of every individual student, including me. As the major focus of each class was to prepare the students for examination, the teachers were focused more towards making sure the students acquire what was ‘just’ necessary. Due to limited time for interaction on the issues, limited attention was given towards the abrupt curiosity coming from many students. These questions used to be either tagged as ‘out-of-topic’ or ‘unnecessary’ questions and in worst cases, the students were punished for being ‘too curious. This practice never recognised unintended outcomes, which demotivated students in their ability to further learn, explore and develop new understanding.

The next day, Ms C took her first few minutes to ask us to synthesise the ‘take-away’s of the earlier class:

“Ramesh, tell me Newton's second law.”

“Hmmmmm…”. Ramesh went silent and turned pale.

“Why don’t you study what I have taught you yesterday? How would you score marks without learning it?”

Next was Mahesh who also tried his best to convince Ms C and gave his interpretation of the second law.

“No, Mahesh, you will not get full marks with this. You all should know these laws by heart.”

I was at my desk with my head down, trying my best to avoid Ms C’s attention towards me. Luckily, I was not asked that day – I had not even studied the notes as I was not able to copy the notes to my copy entirely.

“I am going to ask all of you again tomorrow. Those who will not be able to tell me these laws will have to stand up at the last bench for the entire class or get out of the class.”

Every morning was quite stressful moments for me – especially on the days when I had rote learning to do for the class. I remember some of those days when I used to create a fuss in the morning to find some excuses to go to school. Every day, with the last bell, it is just an end-of-class for the day, but I still had a list of assignments tasked for the home in the evening. Rote learning has always been my weakest domain and it becomes a herculean task when I have to rote learn something. I am only able to memorise any subject content only when I can build it based on my declarative knowledge (Pals et al., 2018) or develop a pictorial representation (Akaygun & Jones, 2014) or relate to my surroundings and everyday life (Burbules & Linn, 1991).

The psychologists Jean Piaget and Lev Vygotsky are largely credited for the research and theories that underpin constructivist theories of learning. According to Piaget (1952), children develop ideas about the working of a natural world by interacting with that world. When an event in their environment challenges their preconceived notions and cannot be satisfactorily accounted for by the explanations they have at their disposal, they may develop new ideas. (Howes, 2002).

Piaget (1952) described two processes by which new information is added to existing schemata: assimilation and accommodation. When an individual encounters new information, they try to fit it into their existing understanding of the world, a process known as assimilation. If the new information does not fit with their current schema, they may experience cognitive disequilibrium, a feeling of discomfort or confusion, and to resolve this discomfort, they may modify their schema to incorporate the new information, a process known as accommodation. This allows them to achieve cognitive equilibrium, a state of balance and understanding. This cycle of assimilation, cognitive disequilibrium, accommodation, and cognitive equilibrium occurs whenever an individual encounters new information and attempts to integrate it into their existing understanding of the world, and it is through this process that learning occurs (Agarkar & Brock, 2017).

In case of my inability of memorising, the next day, before going to school, I would have the greatest fear that I could be punished by my teachers for not being able to complete the assigned tasks:

“What if the teacher asks me any question tomorrow?”

"What if I am the only one who will not be able to provide the teacher with a satisfying answer", and I used to look for excuses to skip the next class of that subject.

Some days, I would find excuses with "I am feeling sick today", "I am having stomach pain today", "I feel like having a fever today", …… On other days, I would feel like crying out loud as I left my home for the bus stop or as I get into the bus. "I do not want to go to school. Why do I have to go to school?"

"You must go to school. How can you become a *thulo manche* [Translated as: a big person] without going to school?"

"But you are the one who said my grandfather never went to school. How come they know so many things, without ever going to school?", I would complain to my parents.

"*Ki parera janincha, ki padera janincha*" [Translated as: Either you know by experience, or you know by learning]

The More Knowledgeable Others: My parents and grandparents

For my grandparents and parents, the knowledge they had received from their fore-parents was so important that it impacted their day-to-day life and the activities they performed. The 'indigenous science' knowledge they possessed was based on oral traditions influenced by spirituality and philosophies, which moulded their traditional ways of being and provided the knowledge pathway that informed future generations' heritage, knowledge, and modes of existence (Ormiston, 2010). The knowledge they possessed was vast – including but not limited to cleanliness and hygiene, preparation and preservation of food, and home remedies for health care. My first exposure to science education was by observing my parents and grandparents as I became part of this ‘knowledge-transfer chain’.

Agricultural technology and my grandfather as a traditional knowledge holder and practitioner

My grandfather (paternal) lived through his life in a village in Baitadi, a district in Sudurpashchim Province of Nepal. My grandfather had earned respect in the village for being an astrologer, but his passion was not limited to preparing aesthetic-looking *china* (birth calendar). He also had equal love towards agriculture, and he used to grow different local plants and crops in the village. He would regularly travel to Kathmandu to live with us for a few months. When coming to visit us, I used to be quite excited to open the pouches and bags that he used to bring, filled with the produce from the village. Sometimes, he would go: “This year, I could not bring you much *Maas* (black lentils) as last year. The yield did not go as expected.”. My grandfather would share the problem with my father the problems he faced with the yield. Maybe he was expecting some advice from my father, but he was the one already having better ways to mitigate for the next season's harvest.

It was sometime in 2004. My grandfather came to visit us at our home in Kathmandu and as we were having some chats, I heard about *Paani Ghatta* (Water mill) from him – I was around 14 years of age then. My grandfather, as he hands over a bag to my mother, said “I have brought some flour so you can have some *rotis*.”

“These days we do also get some good quality flour in the nearby mill. It must have been difficult for you to make and bring this from so far away,” my mother said.

“No, No. We had some wheat in the storage, and I got this milled at the *Pani Ghatta* before it goes bad.”

“What is a *Paani Ghatta,* hajurbuwa [grandfather]?”, my curiosity kicked off.

I had been to the local mills accompanying my mother a few times and observed the machine producing a fine powdered form of the grains. But *Paani Ghatta* was something new to me. “The mill here runs from electricity, but Paani Ghatta is run by a flowing stream of water,” elaborated my grandfather.

As I was making this inquiry, I started to delve into how my grandfather and our ancestors despite not earning a formal science degree, were able to understand and utilise a stream of water to run a mill and use it for grinding grains and cereals. While my grandfather was explaining to me how he mills the cereals in the *Paani Ghatta,* he was aware of the power the running water carries. But never did he utter a single theory and principle related to potential and kinetic energy or the transformation of energy or the law of conservation of energy.

It was around grade six when I was about 12 years of age, I had been taught some theories related to energy and the conversion of energy from one form to the other. But, as my grandfather was explaining to me about the Paani Ghatta, I was not able to relate it to my learning at school. This made me wonder: *Shouldn’t I have been able to relate it to my learning at school when my grandfather was telling me about Paani Ghatta? Why was my school science not able to connect me to my local knowledge and contexts?*

While I was a good student then, my learning was just limited to rote learning and my understanding was limited to replicating those for the examination purpose. I had a limited understanding of how my knowledge could have been utilised in my daily life settings. Most importantly, I have realised the discussion within our classroom also did not incorporate traditional knowledge and technologies. Science education at school was guided by decontextualised pedagogy, in which teaching was just about concepts and definitions, without any linkages to the local contexts and knowledge systems (Luitel, 2009). While electric turbines and electric mills were used as examples during the lectures, *Paani Ghattas* never became a part of our discussion in the science classroom (at least until I was studying).

Food technology and my mother as a traditional knowledge holder and practitioner

My thulo-mummy and thulo-buwa (who are my mother's elder sister and brother-in-law) live in Chitwan district, which falls in the southern lowland Terai part of the country. During my winter breaks, I, along with my mother, used to visit them and spend most of my vacation days with them.

One fine morning, I hear some grinding noise coming from the kitchen area. I guided myself into the kitchen and observed my mother and thulo-mummy. My thulo-mummy was holding a rope ('*Neti*') and pulling it back and forth, thus turning a rod ('*Madani*') dipped into a vessel ('*Theki*').

Me: "Mummy, what are you doing?"

Mother: "Making some ghee [clarified butter]. You can have some fresh ghee with rice for lunch today."

I always loved having dal-bhat with some ghee.

"See here, as you turn this rod, *Nauni* [butter] would get separated from *Mohi* [buttermilk]. You just need to heat the *Nauni* later to make ghee", explained my thulo-mummy. That day I was able to closely witness the process of butter/ghee and *Mohi* making.

For us in Kathmandu, ghee was often purchased from a local dairy and at times, sourced from our relatives. Some years back, my mother had started to collect *tarr* [milk film] in a separate container. After observing her doing this a few times, I asked her why she is collecting the *tarr*. “I want to try making ghee using the blender.” “What? You can make ghee in the blender?”, I asked her with surprise. “Let me try. I will attempt once this container fills up with *tarr*. Probably after a few days.” she responded as this was her first time trying out a new method.

One fine evening, my mother was excited that she was able to make some ghee at home and was happily offering us to try it out over dinner. I was quite astonished by the knowledge and skills my mother holds. During this time, I was already a graduate with a degree in science and technology. And, it was only quite later, that I came across on the internet, the working principle of this age-old butter-churning process. To my surprise, it was the same centripetal and centrifugal force I had studied during grade seven, but I had earlier never been able to relate it to something I had studied in my school. On the other hand, my mother was ingenious to utilise her indigenous skill using modern technology. At times, when my mother is out of home, I try to churn out the butter from the collection of *tarr,* but it never turns out well. While I may hold better knowledge of the working principle (theoretical) of how butter gets separated during churning, my skills (applied) are limited in comparison to what my mother and thulo-mummy possess.

Despite not having formal academic qualifications of any kind nor any formal training in science and technology, I consider my grandparents to be the possessor of a vast array of knowledge and skills. Even for my parents, the primary source of knowledge had been their parents or grandparents, most of which still guide their day-to-day routine activities. They considered their knowledge as a ‘way of life’ (Aikenhead & Ogawa, 2007). At times, I get lost in thoughts about whether the education I have received has been able to make me as knowledgeable and skilful as my grandparents or my parents were. Saying so, I am not denying the importance of education and getting to school and university for earning academic degrees, but here I am trying to critically make a reflection on how our education system is preparing learners. *Has the science education from my school and university helped me in my daily life? How have the ‘products’, like me, out of the current education system been able to contribute to the betterment of society?* Unlike our ancestors, who have been able to utilise various scientific knowledge (as local/indigenous knowledge) as part of their different activities in day-to-day life, *why has our education system not been able to impart similar skills and knowledge that are more relatable and applicable in our daily life?*

Embarrassment with my urban-centric understanding

It was sometime during March 2003; I was travelling with my parents to my relative’s home in Terai for a family function. On our way, one of my relatives asked me, pointing to the farmers harvesting the wheat in the field:

“Yo k ho thaha cha?” [Do you know what this is?]

“Yo k garirako, la bhana ta” [Tell me what they are doing.]

I feel like I am being harassed when these questions are asked of me because the tone often suggests that they are aware of my ignorance because of the changes that I may have never seen or observed as I was born and raised in a metro city.

“Achel ka sahariya bachcha haru lai ka tha huncha” [These urban kids do not know] is the comment I hear next when I stay mum.

I used to spend most of my time at school and my learning was happening through lectures and textbooks at school. But, at times, I have great memories of going out with my parents to various natural and historical sites for me to observe and enjoy – venues like the botanical garden, parks and zoo during the weekends and out of Kathmandu visits to national parks, monuments and heritage sites during longer vacation. I also had the opportunity to go on tours with my parents that helped me experience learning outside the school, classroom and books – an opportunity which I rarely received in school. Often, I was able to visually observe what was else just limited to texts and pictures – close encounters with wild animals like tigers, and rhinos at national parks, and experiencing the sounds of animals and birds at a zoo were always great experiences. On top of this, I used to spend my vacation days in Chitwan with my thulo-buwa and thulo-mummy, which provided me with great opportunities to experience life outside urban areas. But still, when I must face questions like the above, I feel my learning journey has been so disconnected from pristine Nepali culture and tradition and feel regret at times.

Real-world learning

This takes me to my class sometime around my first grade in 1995, we were being taught about animals. With a long stick, the class teacher pointed to the pictures of animals on the wall.

Miss: [Pointing to a picture of an animal on the wall poster] “Have you ever seen this animal?”

All students: “Yes Miss!”

Miss: “What do call it? Who can say?”

All: “Elephant, Miss!”

(I looked through other pictures in the posters and could recognise most of them with their names.)

(After a few rounds of animals….)

Miss: “Who can tell, what is this?” (Pointing to the next picture on the poster)

(I immediately raised my hands in a race to be the first one to answer)

Me: “Miss! Miss! Miss! It’s a buffalo!”

Thanks to my visits to Chitwan and my interactions with thulo-buwa and thulo-mummy I came to know about the existence of buffaloes and their importance to humans. My thulo-buwa and thulo-mummy had reared a few buffaloes for milk. I even used to feed the buffaloes together with my thulo-buwa and milked it a few times.

It was during the winter of 1997, I was in Chitwan for my winter vacation stay. I heard from my thulo-buwa that there will be local villagers coming for a ‘दाँइ’ [pronounced as: dãi] the next day. This was the first time I had ever heard of this word.

“What is दाँइ, thulo-buwa?”, I curiously asked.

“Why don’t you observe by yourself tomorrow?”

My thulo-buwa rather decided that my curiosity remains until I observe it directly with my own eyes. As it passed around seven in the morning the next day, the villagers started to gather around the open field. They started to arrange the paddy crops in a large circle around a central pole.

“These paddy plants were harvested some months back and were left to dry on the field before they could be threshed,” informed thulo-buwa.

Now, I could make sense of why the crops were left casually on every field I see around. After the crops were arranged to some height, 2-3 oxen/bulls were tied to a central pole and the animals would trample on the crops and circle around, thus threshing the crops and separating the paddy grains from the hay. After a few hours of work, the hay is collected and stacked for later use as fodder for the buffaloes. For someone like me who was brought up metro area, the process was spectacular to witness with my own eyes. *Would I have been able to experience this had I not been to Chitwan during my breaks?*

Rice has been part of my curriculum at different times – in some grades, rice became part of my lessons as a cash crop, in the next grade, as a monocot, in others as an annual crop plant, and as a nutritious food, but never I learnt from my school how it forms a part of the Nepali culture.

It was during grade 2; I learnt about domestic and wild animals. All I knew about the oxen and the buffaloes was that they are domestic animals. I was aware of what domestic animals were – when I was asked: "What is a domestic animal? Write the names of three domestic animals.", my answer was limited to: "Cow, buffalo, and ox are domestic animals, and they live in our house. Cow and Buffalo give us milk. Ox is used in farms."

At school, I never had to be aware of the importance of these domestic animals – why humans adapt and raise these animals or how these animals have been playing such an important role in our human life. There were animals, the images of which were just limited to books.

As I reached higher grades, I had begun to experience dissociation from the surrounding I live in and day to day phenomena I observed. I was required to construct my knowledge primarily through textbooks and lectures from my teachers, and there were very limited contents for which I could experience or observe within my surrounding.

The above experience made me realise the importance of our social interaction and engagement in the environment in learning and takes me to one of the magical experiences I had recently experienced with my daughter. As I was halfway through my MPhil journey, I and my wife were blessed with an adorable little girl. I have been closely observing her growth every day and as a father, it is quite an emotional moment to observe how my daughter has been learning new things each day.

It was during November 2021; my sister-in-law was getting married and we, including my then one-and-a-half-year-old daughter, were all attending the ceremony. As the wedding ceremony was getting over and everyone had begun bidding goodbye before leaving. Our daughter, who was patiently observing and enjoying most of the ceremony, had now started to respond to every '*Namaskar*' from our relatives. Out of nowhere, she had learnt to greet/respond with a '*Namaskar*' to everyone she meets. She must have observed the attendees greeting '*Namaskar*' to each other and must have realised that she also needs to do the same as a greeting.

In the case of my daughter, she learnt a new skill through observational learning, closely observing the invitees to the party, which is in line with the philosophy of learning as being a social activity (Dewey, 1986). Then, a question strikes me: *How often* *was I, as a student, encouraged to construct my knowledge through such engagement in the environment?*

Visualising in the textbooks

It was in the year 1998, I was studying at 'Neighbourhood Academy' and this school had been recently established and then had limited infrastructure. We were the first batch of fifth graders. We had a science teacher Mr P, who was young, still enrolled as an undergraduate student himself and was new to teaching science.

Mr P: "Good Morning!" (With a rolled-up poster in his hands, he enters the class)

Students: "Good Morning Sir!"

Mr P: "Today we are going to learn about animal and plant cells."

(He then rolls downs two posters and hangs them on the nail over the blackboard. The posters had illustrations of animal and plant cells.)

Mr P: "We cannot observe these cells through our naked eye. We need to use a microscope and we can see images something like this over the microscope."

One of my classmates, K (stands up from his seat and in his inquisitive voice): "Don't we have a microscope in our school, sir?"

Mr P: "We do not have one now. But you can just visualise these images provided here and in your textbook." (Mr P then starts to point out different parts of the cell and say out loud the functionalities of each part.) "Okay, now write down as I say."

(All we could do was agree to him and continue listening to him.)

How can we construct knowledge without being able to observe or experience it? Should we be 'doing science' (Murphy et al., 2017) *or 'studying science'?* Having to experience this was demotivating to study science and I also felt that being a student in a low-resource school (at least during the time of my study here) with limited or no access to a basic science laboratory set-up and equipment like a microscope can further add to the challenge in learning science. On one hand, subject like science is regarded as difficult subjects at school, and on the other hand, when there is a limited support mechanism for the knowledge construction in science, the only way the students can rely on is the notes provided by the teachers and those available in the textbooks.

During the same year, on another regular day at school, Mr P was on leave and the school principal decided to take over as his substitution. One of my classmates took this as an opportunity to share his feelings. He raised his hands to grab the attention and stood up from his seat.

M: “Sir, why we do not have a science lab in our school? We have been studying different types of animals, but how can we learn without getting to see their features? It is not just clear from pictures in the book.”

Principal Sir: “We are already in the process to buy the lab materials. As you know, we are still setting up the lab. For now, it will be more than enough if you just study hard what science sir has taught you.”

I was in Grade 5 then, but, coming to this day, whom should I see the fault in? While I was not able to get an opportunity to learn science in a more engaging and meaningful way in this school, I can also understand the challenges that the school administration may have faced regarding the management of the resources. I may have been among the lucky ones that I was able to shift to a different school with better facilities, but there are still so many students who have not been able to learn due to a lack of resources in the school, especially when it comes to learning science and are purely limited to rote learning from textbooks and lecture notes.

Natural science without naturality

It was sometime during 1996, I moved to a new school, which had a much bigger infrastructure than the previous one I had studied at. Every week the school had dedicated about two hours of science practical classes aimed at providing a hands-on understanding of the subject we were studying as a theory. The science laboratories were well equipped. During one of the classes on vertebrates and non-vertebrates, we were taken to a biology laboratory, where I was able to observe different animals. “A sea horse, look at that”. There were so many species of animals I had never seen or heard of. This took me to the flashback of the conversation we had with the school principal of the previous school I was studying. This school at least had a resource to have a well-maintained collection of the species in glass containers, but this may not have been the case for all the schools.

Those moments of being at a science laboratory were always a moment of delight – I would feel like a sorcerer when I can work on so-called dangerous materials like acids with a white coat on. For me, during my school and university days, practical classes were mostly about visiting the science laboratories and playing with the chemicals and equipment. But, coming to this inquiry, I started to wonder why it is called the ‘natural science’ when most of our learnings in science are limited to textbooks, lectures and simulated laboratory works. Isn’t ‘natural science’ supposed to be a subject of natural phenomenon, where we should have had more opportunities to explore the phenomenon, we have studied in a natural setting?

There is so limited space in our curriculum that allows the students to explore the connection of what we learn as science to society, human life and the environment and experiment in the natural setting. The 'natural science' that we study at school (biology, chemistry, physics, geology, astronomy) are supposed to deal with the physical world and natural phenomenon that occurs within. In contrast, from what I experienced; the school education was not fully able to cultivate interest in the minds of students like me for exploring the environment. I often felt a missing link between the education I received and the world I am living in. Often the teaching has been textbook-based, disconnecting students from their lives and intimate realities (Bajracharya & Brouwer, 1997).

Science projects as (in)active construction of knowledge

It was sometime during 2000, a science exhibition was organised in the school as was the case every year, to showcase the students' engagement in science. This was an opportunity that the school had provided students to do project-based science (PBS) by participating in science exhibitions and project works. PBS involves the learner in the active construction of science concepts and principles by conducting investigations in collaboration with others (Crawford, 2014). We had to design science projects and showcase them to the teachers, parents and other visitors. I teamed up with my other classmate and we planned to demonstrate the production of hydrogen gas. We had just studied about the gas and the distinct 'pop sound' that the gas produces when lighted was fascinating to us. We felt that it was also easy to showcase to the visitors. For the experiment, we used sulphuric acid and zinc – the same chemicals that were showcased to be producing hydrogen gas in the textbooks. I had a firm belief that zinc could react with the acid, producing hydrogen gas, but never realised to generalise the metal-acid reaction concepts to other likely substances (Bajracharya & Brouwer, 1997).

The science laboratory works throughout my school and university level were task-based and I had to follow the instructions in a prescribed manner, as given by the instructor or provided in the practical manual (Connor et al., 2015). I had to maintain a practical file – for each experiment, we had it documented as well. Except for the results observed, I had to maintain a note based on a standard format provided for the documentation of the experiments performed – a background, procedure, expected results, observations and conclusion. Except for the observations, all the other contents were a copy-paste from the practical book or classmates. And during a practical examination, from the dissection of the plants and animals to the experiments of chemical reactions, all I had to do was to rote learn all the steps and replicate it at the practical examination. It was just one of these experiments that would be asked during the final practical examination – from a total of about 10-15.

This made me ponder: *Why is it called practical classes when I must rote-learn the procedures as I have done in the theoretical classes? Were the practical sessions really helpful for me to understand the theoretical ideas?* During the practical classes, students are anticipated to learn theoretical concepts through different exercises and due to conventional design, often does not allow the learners to link their observations to scientific ideas (Abrahams & Millar, 2008). From school to university, the science practical remains as projects defined by the instructor and that uses prescribed methods. There are a set of instructions provided and as a student, I was supposed to follow the steps provided and conduct the experiment. This type of task project allowed minimal student motivation and skill development and are part of traditional instruction in most curricula (Connor et al., 2015).

Washback effect on science education

"Ramrari pad hai pad aile, SLC ma first division aayena bhane science padna paidaina. Ani k gari khanchas bhawisya ma?" [Translated as: "You must study well now, else if you do not get the first division in SLC, you will not be able to study science. Then, what would you do in future?", to be read in an authoritative tone of voice]

I always felt that studying was all about examinations. Well, I always felt that pressure from my parents, family and society – "I need to get the first division in my SLC. What if I do not get a chance to study science?". During SLC examinations, I had the pressure that I need get at least first division in the SLC examinations – a result with distinction was always expected. While preparing for the examinations, all I did was practice the 'sure questions' and 'important questions' again and again, putting my all efforts into rote learning all the definitions, the same would go for any theories/theorems, their proof and everything that I was required to study as part of my curriculum. I even bought some question banks to prepare from. These question banks used to have a collection of past question papers from the last few years, along with a complete step-by-step solution to each of the questions. During preparations for the examination, my focus would be towards improving my ability to replicate answers, provided as a 'solution'.

Instead of being the means to formative feedback and testing of my preparedness for real-world situations (Archer et al., 2021), assessments and examinations were mostly about the test of my verbatim recall. After sitting for examinations, I never had the confidence within me to tell if I had done my papers well. For many questions, I would lack the capacity to ‘rewind and play back’ the answers exactly as prescribed, and I would not have an idea how the evaluators would grade my answers. From theoretical to practical examinations, as mentioned by Cobern (1994), I was one of the students who practised “cognitive apartheid” (p.588). The scientific knowledge I obtained from education was accumulated for occasions like school examinations but had no use in my everyday life (Cobern, 1994).

My sciences in my everyday life

It was in September 2015; Nepal was imposed an economic blockade, severely affecting the supply of petroleum products and LPG (liquid petroleum gas) cylinders and causing a fuel crisis in the country. About two years back, while purchasing a washing machine for our home use, we also received an induction cooker as a freebie. We did not know what to do with the cooker. At the store, we were told that induction cookers are quite an energy efficient at cooking, but we had to purchase induction-compatible utensils for them to work, which were not cheap at all. My mother suggested that we just store it for now as it was of no use, and we were quite comfortable with gas stove cooking. The economic blockade went on for some months and we were almost out of our gas supply. There was news in the media about Nepalis making use of induction cookers as an alternative to gas stove cooking and it was then we thought of putting back the induction cooker we had to work. My mother was not in favour of buying a whole set of new utensils again. “No more pressure cookers please!”. I thought of going to the internet to learn what makes induction-compatible cookers different from the ones being used with gas stoves. I found out that it was ferrous material (iron) on the base of these cookers which makes them suitable for induction cooking. “Ah, what about the cast-iron

Karai we have?” I placed the *Karai* over the induction cooktop and magic! Tada! That was the eureka moment for me.

It was during grade 10 (sometime during 2004), I studied Faraday and electromagnetism, but never I was able to make a connection between the principle of electromagnetic induction and the induction cooktops. Thanks to the blockade, I made a realisation of one of the topics I had learnt so hard for my School Leaving Certificate examinations.

With this new insight out of much-lamented knowledge, my mother and I were able to make use of all the already-available utensils in our home. The principle on which induction cooking is based is called electromagnetic induction, the process discovered by Michael Faraday – something that I studied in grade 10.

Figure 3: My mother made some 'Sel-rotis' during Tihar of 2015, using induction cooktop and traditional cast-iron cookware (Photo: Self)

Under the cooking top, there is a coil of copper wire and when an electric current (alternating current or AC) is passed through it, the resulting oscillating magnetic field induces an electrical current on the bottom surface of the pot placed. This will then warm the pot up and thus cook the food inside. Based on this principle, any cookware that has some form of ferrous material (iron) will work and any of our traditionally hand-crafted cast-iron utensils are all compatible. We have traditionally produced cast iron cookware for ages and most Nepali households already possess utensils like Karahi and Tawa - and they are the ones that work the best with induction cooktops and are less expensive too! We were even able to make some '*sel-rotis*' during the Tihar festival.

For most of the contents we learn at school, we are not able to find a connection to our day-to-day living and hence the knowledge we gain tends to get disregarded eventually. During the Nepal blockade, most were spending a lot of money to buy so-called 'induction compatible' utensils (Bhatta & Bhandari, 2015). Because we were not able to properly utilise the scientific knowledge we had received from school, we were also falling into the traps of the market and business houses who utilised our ignorance to promote and sell 'induction compatible' cookware.

* * *

It was sometime around August 2016; my mother asked me if I could accompany her to the local plant nursery to get some *Sayapatri ko Phool* (marigold flower). My mother loves maintaining a flower garden in the front yard of our home. Utilising the small open space we have, my mother has been creative in utilising the plant pots to create a small, yet beautiful flower garden. After getting some plants from the nursery, my mother suggested that we should be transferring the plants to pots the same day. I decided that I should also be helping my mother to get the work done quicker, as it was already starting to get dark. As my mother prepared some pots for the repotting, I helped her with the others.

"Are you sure you can do it?"

"Yes, yes, I can do it."

"Make sure you add sufficient fertiliser as well." "Look, this is the way", my mother wanted to be assured that I do the task well.

On the other hand, I had that confidence with the knowledge I had acquired from the Plant Biotechnology course during my undergraduate and graduate level. I did not even bother to look at her demonstration. "*Huss, Huss*" [Translated as: Sure, Sure]

A few days passed by and almost all that I had planted had started to wilt while the plants that my mother had grown were all lively and perked up.

Where did I go wrong? In my context as a science student, the impartation of scientific knowledge and skills at school and university is limited to classrooms, laboratories and examinations. The question arises: *How much are we prepared for real-world problems? As a science student, do I/we possess the required skills to come up with solutions to the day-to-day problems I/we face?*

Summing Up

I addressed the first research question and the 'personal lifeworld' part of the second research question in this chapter. At home, the indigenous science knowledge that my grandparents and parents possessed focused on the biospheric aspect and had strong ties to daily life. The discussions further elucidate that the prevailing pedagogical practices of science education at school and university are disconnected from home and the local knowledge system in terms of its construct and contents and learning processes. Science by nature constitutes applied aspects of learning. However, the focus of science education appears to be confined to the rote memorisation of factual information and the didactic approach to teaching. Science education does not seem to have established a dialectical relation with an individual learner. In the final sub-theme, I addressed the second research question's 'personal lifeworld' section by providing narratives based on my experiences and discussions reveal that that science education at school and university has not prepared students to address science-related problems they encounter daily.

In the next chapter, I address the 'professional lifeworld' part of the second research question.

CHAPTER FOUR

SCIENCE EDUCATION AS/FOR PROFESSIONAL (IR)RELEVANCE

Chapter Overview

In the previous chapter, I responded to the first research question and the 'personal lifeworld' part of the second research question. In this chapter, I address the 'professional lifeworld' part of the second research question and discuss the relevance of science education to me in my professional settings. Here, I talk about the professional (ir)relevance of the science education I received, which refers to the extent to which the knowledge and skills I learned in science education are relevant, applicable and useful in the context of my professional life. I develop several sub-themes '*Becoming a Thulo Manche', 'Saving myself from a brain drain', 'Being Competent: Knowledge vs Skills' and 'With science at my heart: Transitioning from a scientific researcher to a social science (education) researcher'.*

Becoming a *Thulo Manche*

"*Pachi thulo bhayepachi k banne? Doctor banne ki engineer?*" [Translated as: "What do you want to be when you grow up? Doctor or Engineer"].

"Khai, doctor ki ta engineer" [Translated as: "Maybe a doctor or an engineer"] would be my immediate response.

I always had to face this question whenever I met my relatives and mostly during every Dashain festival as part of a blessing. It felt to me that I had to be either a doctor or an engineer 'to save the nose'[4] of my family. Subjects like science and mathematics were also regarded as the most important subjects at schools, and so were for my parents and my relatives.

During the internal tests and examinations, the percentage I would score would matter the most, the next would be my achievements in Mathematics and Science. "How much did you get in mathematics?" "What was your score in Science?". During primary and secondary school education, I scored at satisfactory and good levels but was mostly not outstanding level. My parents had identified some private tutors to whom I used to visit for additional tuition classes during grades 9 and 10 in subjects like Science and Mathematics. It was so important for me to get a good score at least in the two subjects (of course, with a first division overall), for me to qualify for the science stream in 10+2[5], which further opens my door towards a science and engineering degree for my under-graduation level. It is not just my parents, but some other relatives and neighbours have high regard for those in science professions. Getting into science for higher education was something to show off and a means to become a '*thulo manche*'[6].

Here, I try to recall one of the representative conversations I faced. It was sometime around March 2004, and it had just been a few days since the 'iron-gate' SLC examinations had been over. I was quite relaxed that the examinations were over, and I could take some good rest. Just then, someone rang the doorbell at my home.

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[4] 'To save the nose' is used here as an expression on contrary to a popular Nepali idiom: 'नाक काट्नु' [transliterated as: 'to cut the nose', meaning: to bring dishonor to someone].

[5] 10+2 refers to an additional two years of higher secondary education after the completion of 10 years of school education. With the endorsement of the Education Act (Eighth Amendment) in 2016, the two years of higher secondary education has now been part of secondary education.

[6] *'Thulo manche'* resonates with Dor Bahadur Bista's fatalism (Bista, 2020).

"*Ko ho?*" [Who is it], my mother called out from the top floor terrace.

"*Ma aako*" [It's me], responds neighbour aunty Mrs D.

I unlocked the door and "*Namaskar Aunty*", I greeted.

"*Kasto bhayo SLC? K padne aba? Science padne ta hola ni!*" [How was your SLC? What will you study next? I am sure you will be studying Science."]

"*Khai aunty, sure bhako chaina.*" [Not sure, Aunty]

"*Ka testo bhanera huncha, buwa ko ijjat ko lagi ni Science padnu parcha.*" [How can you say that you should study science at least for the prestige of your father.] "*Dai haru lai hera na, Euta aile doctor paddai cha, arko engineer*" [See my sons, one is studying doctor, another is studying engineering] "*Maile bhaneko chu hai timi ni doctor wa engineer hunu parcha.*" [I have told you; you should also be either a doctor or an engineer.]

"*Huss Aunty!*" [Sometimes, I feel it is wiser to end a conversation with a "*huss*" than continue putting up your thoughts.]

I had just appeared for the SLC examinations, and I already had been receiving advice from my relatives and neighbours that I need to take forward Science at my higher secondary level. Some wanted me to be an engineer while some would prefer me to be a doctor. It was since my school days, subjects like science and mathematics always looked like the superior subjects and I also had an impression that I needed to perform well in these subjects for a better future. *So, was this a matter of social status and prestige for me and my family?*

Here, I may sound like I am objecting to taking science as a career. Hence, a little disclaimer in advance: the purpose of this chapter is to document my dissatisfaction towards how we have been prepared at school and university and how we are communicating the purpose of learning science at the school level. There is no doubt that science needs to be valued by society for its potential to benefit human needs, society and the environment. The purpose of learning science at school and university, however, should not be limited to learning facts as 'inert knowledge', but to support learners personally and functionally as literate citizens, even for students who do not enter the field of science or engineering for their higher education (Hofstein et al., 2011). But I always had an impression that I needed to do well in Science and Mathematics to secure my way towards taking science for 10+2 which will allow me to later get a STEM degree and have a decent job. I followed this path with the belief that I will have a secured future. After SLC, I joined 10+2 with a major in science and later joined a university for my bachelor's degree in biotechnology.

Saving myself from a brain drain

As I reached my third year of my bachelor's, I started to explore my possibilities after my graduation. One fine day, I joined my other classmates who were having a casual talk with one of the seniors who had come to visit the department. The senior *dai* was among the pioneer batch of biotechnology from my university.

"What are our scopes after graduation?", one of my friends asked him.

"Oh, it's very limited. A few of our friends have got a job in some companies. But most of us, we are preparing for GRE [Graduate Records Examinations] to go abroad for further studies. There are a lot of opportunities in biotechnologies abroad and we also have a chance to get a scholarship.", he responded with some frustration.

“What about those who are doing jobs here? How is the pay?”, I added to the conversation.

He named a few companies. “Most of these are pharmaceutical companies, where we could give a try. But they prefer those with degrees in pharmacy over ours. Another one is a multinational company, where their work is mostly on bioinformatics. There is also a biotechnology company that has recently been opened.”

Laughingly he added, our bachelor’s degree does not end here at this university. The fifth year of our 4-year course happens at XYZ International Education Institute. As I was towards the completion of my bachelor’s degree, most of my friends were already starting to join the same institute for their GRE[7] preparation – the same institute as mentioned once by our senior *dai*. Some were also taking preparation classes for their TOEFL (Test of English as a Foreign Language)/IELTS (International English Language Testing System)[8] examinations. One of my classmates called me and informed me that he and a few others are also joining preparation classes:

“Are you planning to join us for the preparation classes?”

“No, I do not have plans yet to go abroad for my studies. You can join the classes.”

“*Yaha ta Scope nai chaina* [Translated as: There is no scope (of biotechnology) here]. And we have no other options than to go abroad for further studies.”

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[7] Many graduate programs in the United States, Canada, and a few other nations require applicants to take the GRE, which is a standardised test.
[8] For non-native English speakers, the TOEFL and IELTS are international standardised assessment of English language proficiency.

“Maybe if my plans change, I can join you all as well. But not for now. When are your classes starting?”

“From next week. Almost everyone has already joined the classes. We are the last ones to join from our batch.”

There was a reason for me to not join the preparation classes yet. I always wished that I could work for some time in the country to gain the necessary experience after my graduation and only then opt for a higher degree of education. While this experience would have allowed me to gain additional skills and knowledge necessary for my professional settings, it would also have helped me to identify some specialised areas that I could take forward for my higher studies. The primary purpose for me to go abroad would be in attaining further academic qualifications and professional experiences. I never wanted to have a long-term stay in other countries and return after gaining an academic degree and some professional experience. Thanks to my father who has been successful in conveying this important message to me. I was always exploring some specialised areas which would allow me to serve the nation.

Amidst the job hunt, I received an opportunity to work for a biotechnology-based company. This opportunity mainly came through another senior *dai* who was providing bioinformatics support to the company. After working for two years, he was going abroad for further studies, and he was looking for someone who could replace his position. The position required someone with proficient ICT skills able to provide similar support as he was doing and provide support in developing digital content. *Dai* approached me and asked if I could be interested in the job. I immediately said yes to the opportunity. There were limited opportunities, and I was not in a position to let this opportunity slip away.

D*ai* was aware of my digital skills including website development, photo and video editing and creative designing, as we had closely worked together in a student club on a few projects.

It was when I was in grade three, my father got a personal computer for his professional work, which I have a faint memory of – a Windows 3.0 device with not more than 4 MB (megabyte) of Random Access Memory with a monochrome monitor and used MS-DOS (Microsoft Disk Operating System) commands for operation. The device made me fascinated with the computer world. Later with other upgraded versions of the computer device, I started to learn different tools and QBASIC (the first programming language I had started to learn, later introduced myself to applications, like Adobe Flash, Adobe Photoshop, and Windows Movie Maker to name a few. With the 56k dial-up modem speed, I used to search the internet for samples and download it as my reference to learn the new and advanced levels.

As I reflected on this recollection, it made me realise that in addition to the degree I had, the supplementary skills I possessed helped me give an edge in receiving this job. van Laar, van Deursen, van Dijk and de Haan (2020) also suggest that the use of ICT is widespread in the workplace, and qualified ICT-proficient workforce with twenty-first-century digital skills such as information digital skills and creative digital skills are in high demand.

I supposed that biotechnology was a new subject and there were very few institutions that had opportunities for biotechnology students, like what was experienced by the senior *dai*. I also thought it to be reasonable for some years to have limited opportunities for graduates. Some new institutions were being established. As these establishments were new, they did not have ample number employment opportunities open to intake graduates for their career growth, but I was also being hopeful that the opportunities would be there for all the graduates. But I believe that for the graduates of the university within the country, there should already be existing market demands or ample opportunities for the graduates to be engaged and the expertise of those could be utilised for the benefit of society and the country. Hence, at times I also considered it to be okay for my friends from the Biotechnology stream to look for opportunities abroad as there were limited opportunities in the country. But the issue with graduate students' escape from the country is not limited to just the stream I was in. I have so many of my friends and relatives who are graduates of other science and technology streams who follow the same trend of "*Yaha ta Scope nai chaina*" and make their best efforts to move to developed countries. In large part, because of social pressure, many graduates in the country want to attend a prominent university abroad, in a hope of finding employment after graduation (The Himalayan Times, 2021). Given the difficulty of getting work in the country, this is understandable.

Fazzino (2017) also observes the issue with science curriculum that has not been able to incorporate necessary skill set necessary for the twenty-first century. Most employment, fifty years ago, required specific technical skills and with a strict, textbook-driven curriculum that prioritised rote learning, schools were able to train students for these kinds of occupations. However, given the digital age, we now live in, automation is taking the place of many sectors. The abilities we require for these jobs have changed along with the needs of the workforce.

Science is about curiosity, innovation, and cooperation and there is a significant link between twenty-first-century skills and science education. Science, when taught with an emphasis on skills, helps build critical thinking, problem-solving, and digital literacy. “No longer is there much value in rote-learning the first twenty elements of the periodic table, as facts like these can be so easily accessed by a single google search” (Fazzino, 2017).

Even for me, I believe that my digital skills allowed me to secure a job immediately after my graduation, else I could also have been one looking for study opportunities abroad for possible job security after some years. After a year of work, I received a scholarship opportunity to pursue my master’s degree in India. While a part of my brain wanted me to spend some additional time exploring a potential area in biotechnology in which I can build on my expertise and receive academic experiences later, the other part wanted me not to slip away from the opportunity that had come to my hands. With the hope that more opportunities would come following my master’s degree studies, I planned to join for my master’s study.

Being ‘Theoretically’ Competent: Knowledge with(out) Skills

As I discussed in Chapter One, the laboratory classes were mostly guided. And during practical examinations, I had to go through our practical files and make sure I know very well all the procedures and theories of the experiments. These experiments were included in the curriculum to provide us with basic knowledge and skills on different tools and equipment that we must be acquainted with to undertake any biotechnology-related studies. In addition to a detailed theoretical lecture in the classroom, each new technique/tool was allocated about one or two 3-hour classes. While these experiments in the classroom were supposed to be hands-on, it was usually some groups of students that were formed for the experiments. So, these experiments were more for demonstrative purposes than to build a particular skill.

It was during the fourth semester of my under-graduation level in 2018. I particularly remember a practical class on electrophoresis in molecular biology laboratory session during my fourth semester. Electrophoresis is a technique that allows molecules like DNA (deoxyribonucleic acid), RNA (Ribonucleic acid) or protein molecules to be separated based on their size using an electric field. We had 37 in our batch, separated into two groups. For a group of 17, we had two sets of gel electrophoresis apparatus (8-9 for each apparatus). After setting up the apparatus, an agarose gel is prepared and placed in a chamber, which is filled with buffer. The agarose gel is prepared in such a way that they have wells within them. After the set-up is ready, we were required to use a micropipette to load a tiny load of DNA samples into the wells. There were about 10-12 wells in each setup, and we had to take turns performing a hands-on loading of the sample into the wells. 10-12 wells to load for a group of about 8-9. The loading work is not easy if you are a first timer – identifying the perfect location of a well and pipetting out the samples perfectly into the well without damaging the well or overflowing the samples into other wells. None of us was able to successfully load the samples perfectly and we just had a chance to have hands-on for the technique.

“Isn’t the time too limited for us to learn this technique?”, one of our group members asked.

“Yes, but this is just to give you an idea of how the process works and to demonstrate to you what has been taught in the theory class. I think sir will be teaching it next week. You will get used to it when you do your research in the fourth year.”

During the fourth year, my dissertation research did not involve any gel electrophoresis techniques and the knowledge and skills in the process were based on what I had learned from my one session of the practical session.

It was sometime in 2012 after I joined the organisation after my bachelor’s degree, I was asked by one of my colleagues (who had been working in the lab for the past 2-3 years) if I know gel electrophoresis. I said “yes” because it would have been a shame for me to not know about gel electrophoresis as it was one of the widely used laboratory techniques while working with DNA and RNA samples. My colleague asked me to help her out with the process and it was for the first time after my university laboratory session, I was holding the apparatus. I followed the procedure book and succeeded in preparing the gel. But when it was time to load the samples into the well, my hands were shaking. I could not keep a stable hold of the micropipette and it punctured the well. I tried my luck for another well and had the same challenge. As several samples were to be loaded into the wells, I started to get more nervous and started to lose confidence that I might be able to do better in loading into the new well and if I damaged yet another well, it may have been insufficient for the samples. I asked my colleague if she may continue loading and that I can learn it the next time. I had theoretical knowledge of what gel electrophoresis is and the procedure behind it. I had aced my molecular biology laboratory examinations. But, while performing at a professional workplace, I realised I needed to upgrade my technical skills as well.

Though I initially thought I had some level of competence in these techniques, after my experience at the workplace, I realised my competence was not sufficient for me and had to put on effort into building on my competence. Later with support from my colleagues, I was able to build on my confidence to work on the process and update my competence in using the technique and apparatus. However, the competence I achieved later in my workplace should have already happened at my university before I completed my degree. As I shared earlier, I was fortunate to have gotten an opportunity to work in this institution that evaluated me based on my supplementary skills as required to fulfil the responsibilities demanded by the position. But for others, from what I observed at the institution, at least a basic competency in techniques and apparatus was a must when entering the workforce in fields like biotechnology, but unfortunately most of the fresh graduates, despite having a solid theoretical understanding of these techniques, faced with struggles while doing it. In addition to the basic theory and practical knowledge, from my experience, it is important for universities to also develop desirable competencies among graduates that are required by employers in the field (Assamoi, 2015). Oh and Lee (2010) have also highlighted this growing concern about the mismatch between college graduates' skills and the requirements demanded by businesses. Other than job-specific skills, it is also important to be able to develop interpersonal or social skills (Oh & Lee, 2010). However, the university placed less emphasis on soft skills during the four years to boost my career prospects and as a student, I was also more oriented towards getting better grades in examinations (Gautam, 2016).

With science at my heart: Transitioning from a scientific researcher to a social science (education) researcher

After two years of study in India, I returned to Nepal. The struggle for opportunities remained the same. I did not have expected much to change within two years. However, in these two years, I was still in connection with some of the institutions that were working in Nepal and continued to be associated with some of them. After my return, I had an opportunity to work closely with one of those research institutes and this association also came through my support to them in developing their website and digital materials. The organisation was undertaking a community engagement activity to take scientific knowledge to support the community. My further engagement in this programme deepened my interest towards community engagement and environmental awareness. As I was involved, I received an opportunity to work in an international organisation for a project on climate change education. It was only when I joined the organisation, I started to learn about social development perspectives, which I was not much aware of. We are often told about the importance of science and technology as tools for social development, but I started to realise that we were just being trained to be experts on our 'technical subject' without much awareness of the 'social' aspects of science and technology. As a scientific researcher, I had never considered the issues of gender and social inequalities in any of my scientific activities. My engagement in this international organisation provided me with a new lens to see social development and to rethink how as a science and technology student, I could be more socially sensitive and responsive.

Summing Up

In this chapter, I responded to the ‘professional lifeworld’ part of the second research question. According to my experiences, I was destined to pursue my career in science and become a *‘thulo manche’* after earning a first division in SLC out of respect for my parents and relatives. I started to stress as I approached completing my undergraduate and wondered what I should do next. The fact that most of my friends were already getting ready to travel abroad was regrettable. The university was unable to encourage the graduates' interest in using their knowledge to address local and national needs. I had a similar learning experience at the university to what I had in school. The university did not give much thought to the value of graduates developing desirable competencies and necessary skill sets. The discussions reveal that the knowledge and skills gained through science education at school and university have not succeeded in preparing learners for their professional life. Science education needs to be professionally relevant to ensure that students can apply their learning to their future careers and make a meaningful contribution to their chosen fields. This can be achieved by ensuring that the curriculum is closely aligned with the needs and demands of the various professions and by providing opportunities for students to gain practical experience and apply their learning in real-world settings.

In the following chapter, I'll look into how science education has affected my ability—or our ability—to act as responsible citizens and contribute to society's advancement.

CHAPTER FIVE

SCIENCE EDUCATION AS/FOR SOCIAL (IR)RELEVANCE

Chapter Overview

In the previous chapter, I discuss the relevance of science education to me in my professional settings. In this chapter, the construct of social (ir)relevance refers to the extent to which the knowledge and skills learned in science education are socially responsive, as well as applicable and useful in addressing and solving problems that affect society as a whole. Here, I develop two sub-themes '*Valuing local knowledge, advocating justice'*, and *'Disregarding science, fearing divinity'* to respond to the 'societal lifeworld' part of my second research question. I talk about how important science education is to the welfare of society.

Valuing local knowledge, advocating justice

It was in December 2014; I joined the team from the research institute and travelled to a village in Kavre district in Nepal to provide training to the community members on herbal plants and herbal gardening. We had prepared a list of common herbal plants in Nepal, and I designed a presentation on these plants along with their importance to the community. As I started with my presentation, the community members were uncomplainingly listening to the presentation. As I showed an image of a plant, I was asking the participants if they are aware of it – I wanted to check their knowledge. As I moved towards the end of my presentation, I realised the participants were quite aware of most of the contents in the presentation, except for some 'too scientific information' that I had deliberately included for my presentation, like the optimum temperature and humidity required for the plants to grow. After the training session, we had plans to tour the village to explore different plants in the area and requested some of the community members to accompany us around. During the exploration visit, it was the community members who were providing us with detailed information about the plants and how they have been using them. There were so many plants that we were not aware of or never heard of, but the community members who were with us had so much of knowledge and information than what we had presumed and the whole community had been utilising those plants during different types of sickness in themselves or their cattle.

While making this inquiry it made me question if I was being too egoistic with the scientific knowledge I possessed. I, as a product of a modern education system, have been oriented in a way that those not in possession of a formal degree are to be called illiterates. In doing so, we neglect the indigenous/local knowledge they hold and instead regard our modern 'scientific' knowledge to be superior. We overlook the fact that illiterate individuals are illiterate only until modern educational models are used to assess their knowledge (Maila & Loubser, 2003). The scientific knowledge we are offered at school and university has been designed as part of the modern education system, hence it lacks the social context (Rhulani Ubisi et al., 2019) and the indigenous/local knowledge system gets very limited space in our science curriculum.

For a science and technology graduate like me, I have always understood that "good science" (p. 169) refers to high-quality research that is accurate, dependable, and reproducible, is based on good laboratory practice and that can provide a firm basis for future researchers to build on, but for a society, the science becomes a ‘good science’ only when it can serve in the benefit of the society (Bird, 2014).

It is undeniable that the progress and development in the field of science and technology have changed our lives – from development in the field of energy, transportation and communication to innovations in health like immunisation and antibiotics (Miedema, 2022). But being in developing countries like Nepal, I must access consumer products and innovations that are designed for the global market, and often they do not meet my requirements and expectations. Science and technology need to understand the local needs and introduce appropriate scientific technology and innovation to boost the productivity of local technology and knowledge that is better suited to our needs. As I discussed above my experience working in a local community in Kavre, I was taking my knowledge established based on my universal science that I had modelled during my university study, rather than complementing the local knowledge with my scientific knowledge. Now, I feel that I was being colonial (Sidik, 2022) without much regard for the local knowledge system.

Further, the school and university curricula are often adapted from the international curricula, and this is promoted as being a benefit for learners to join that course or the institution. While joining my university for my undergraduate study, I was informed by one of the faculty members during the orientation that the syllabus and the course plan for the degree were adapted from one of the prominent universities in the world. At that time of joining, I was much attracted to this fact but then, later, I started to realise the issues and subject contents were so much disconnected from local relevance and needs. While some references were made to the local context, the curriculum did not provide space for thoughts on how the scientific knowledge could be utilised for the betterment of the local knowledge systems and it felt like being forcefully fitting into the standard curricular design.

As I shared in Chapter One, my final year project for my undergraduate degree was identified based on my consultation with my then-supervisor who allowed me to research a part of his ongoing study. The research was primarily designed as an effort to fill in the existing knowledge gaps in the scientific community. While the research was focused on flora and microflora found in Nepal, I was never required to consult the local community for the needs identification of my research and discuss with the community how my research impacts/supports the community. I only visited the local community once to gather my required data, along with some medicinal plants as samples and without much interaction with the community, returned, and never went back to the community again. As I am making this inquiry, I have noticed the science education I received was colonial and extractive (Sidik, 2022) in nature towards the local community and society, and in recognising the vast array of local knowledge available our society holds.

From my experience, the science education, we are being offered is limiting in serving the national needs and priorities. In addition to my experiences, I have been coming across several reports that indicate a similar situation regarding our science education. 66% of the total population in Nepal is involved in the agriculture sector (FAO in Nepal, n.d.). Although national policies suggest Nepal is an agricultural-driven economy, there are reports of decreasing share of GDP (gross domestic product) from the agricultural sector, which was 66.9% in 1970 to 25% in 2018 (Prasain, 2021). Pun (2019) reports that agricultural education in Nepal has not been able to provide proper training to the graduates and generate skilful graduates who could come up with technological innovations for the betterment of the agricultural sector of the country. One of the concerns is the existing theory-based education in universities, that too is not catering to the national needs, which may be one of the factors impeding the upliftment and commercialisation of sectors with cultural and economic importance, like agriculture, ayurvedic medicine (The Himalayan Times, 2021), in the country.

Further, as shared in Chapter One, I had an opportunity to work at an international organisation. At the start, I was involved in a project on climate change education that primarily targeted schools and communities towards improved understanding of the impacts of the climate crisis and empowering them as agents of change. As I started to engage myself in development projects I started to get acquainted with perspectives on sustainable development, social inclusion and gender equality. While I had heard about these perspectives, I realised then, I had never really internalised the concept before I started getting engaged in these development projects. I understood the mainstreaming of societal issues, including but not limited to, girls and women, and geographically/economically marginalised communities were so important to identify the needy population and to provide equitable benefits to the community members. While the developments in science and technology are always as seen a means towards social development, I have also realised that without an in-depth understanding of these perspectives, innovation through science and technology may instead further lead to inequalities and risk it towards elite capture of the technology.

Disregarding science, fearing divinity

It was one fine evening in June 2018, a group of five or six students in their school uniform were walking down the street some meters in front of me and they were so much having fun with one another, blocking halfway on the 14-foot road. I could see one of them also holding a packet of instant noodles and they were sharing as they walked the street. Just then, one of them crumpled the packet and threw it into the roadside drain. For me, it was saddening to see. I started to think if these school students were to be blamed for their civic sense behaviour. Or it is the school science education that has not been able to provide the students with applicable knowledge to be able to apply their scientific knowledge to societal issues (Hofstein et al., 2011). From my experiences, I also see the design of the school science curriculum is more responsible because of its primary focus on learning facts.

Figure 4: School students throwing wrappers on the road (representative artwork created with the help of Artificial Intelligence)

On one hand, university-level science and technology education should be able to train future professionals in science and technology to have ethical responsibilities towards society for the betterment and sustainable development. On the other hand, science education being delivered at the school level should also not be limited to ‘inert knowledge’, rather it should be able to develop non-cognitive skills (UNESCO, 2015a) like critical thinking among the learners and help them become socially responsible citizens, as well as attaining scientific literacy for all students (Hofstein et al., 2011).

Solid waste management remains one of the major challenges in Kathmandu. The situation gets worse when the municipal garbage collection is disrupted for some weeks and at times, for months. During these times, people start to throw their waste by the roadside or at a street corner and you could see roadsides getting piled with garbage. Often, this becomes a common sight in Kathmandu. The local community leaders and environmental activist have been making efforts in advocating public to not throw waste on the roadside as it may lead to health hazards as well it causes a foul smell for passer-by and the local community. Many of the walls on the roadside even have advocacy slogans painted, along with legal warnings: “Throwing garbage is strictly prohibited. In case someone is found throwing garbage, they will be fined NPR [Nepali Rupees] 5,000 to NPR 100,000”, but these efforts have also not discouraged people from throwing garbage on the roadside. One of my neighbourhood areas also had a similar problem and it used to be an unpleasant sight while passing by that area.

Figure 6: A common sight in Kathmandu: Dumping trash where it is prohibited to do so (Photo: blessedhero, https://twitter.com/ronbupdates/status/1557625974363136001)

Figure 5: Placing images of Hindu deities as an innovative fix to stop people from throwing waste (Photo: Self)

Sometime in 2020, while getting to the office, I observed a homeowner in my neighbourhood directing a mason to an appropriate location to place a ceramic tile on his compound wall – the tile had printed images of Hindu deities. I could hear him complaining to his neighbours about someone from a different neighbourhood coming at night and throwing out garbage bags right outside his compound at that corner, and others also followed by, littering the corner. I could sense he was annoyed about this and was installing those tiles to curb others from throwing garbage bags outside his home. While I walked down the road as I reached my office, I started to ponder if his idea would help keep the corner clean. To my surprise, from that very next day, I never saw garbage bags getting piled up as they used to before. Ojha (2019) also reports a similar innovative fix implemented by local communities in Kathmandu which has helped in stopping people from throwing garbage in open spaces.

The topics like the cleanliness of the surrounding (Grades 1-3), solid waste management (Grades 6-8) and environmental pollution (Grades 9-10) have been part of the school science curriculum, but I experienced and observed that these topics are only "connected to the context of being part of 'school science'" (Hofstein et al., 2011, p. 1460) and because learners do not have space to discuss on the social and personal relevance of these topics, the existing issues in the society and the power science education can play in tackling these issues, as well as busting social myths and taboos, are never realised.

Between 2015-2021, I was engaged in different projects on girls and women's empowerment through education. It was a concern that many female students were missing out on school during their menstruation, and when paired with the inability to catch up on lost courses and extra family tasks, they were forced to drop out. In Nepali society, menstruation has been surrounded by a deeply rooted cultural and religious belief that regards females during menstruation as being ‘impure’ or ‘untouchable’ and more than 89% of Nepali women are reported to face some type of restriction and isolation during menstruation (Mukherjee et al., 2020). Menarche typically occurs unexpectedly, leaving girls with little or no understanding of what is going on. As per scientific knowledge, menstruation is seen as a natural biological process by which the uterus loses blood and tissue as part of the menstrual cycle to prepare her body for a possible pregnancy and the topics on menstruation have been part of the school level curriculum (in Health, Physical and Creative Arts, Grades 6-8). But, being a subject of social taboo, menstruation is not often brought into discussion in classrooms by teachers and this leads to girls living with fear, shame, anxiety and other major health consequences caused by menstruation.

There are numerous cultural and religious taboos and customs, including those related to menstruation, which is often grounded in claims lacking empirical proof but are conveyed as if they are backed by scientific evidence. It is essential to educate students about the widespread presence of pseudoscience (Padma, 2017) in our communities and encourage them to critically assess evidence, ask questions, and draw conclusions based on sound scientific knowledge (Martin, 1994).

In this context, teachers are often trapped in the “reflexive loop” (p. 295) (a process that involves picking evidence, adding personal meaning to it, creating assumptions based on their interpretations of the data, drawing conclusions, adopting beliefs, and finally acting), which happens within a “mental model” (p. 295) (one’s understanding of the world) – are influenced by the popular or existing social belief and make choices based this assumption in the classroom. In this situation, teachers of science and health education need to be capacitated on critical reflective teaching practices (Larrivee, 2000) through teacher professional development programmes. This involves both critical inquiry and self-reflection. Critical inquiry involves the moral and ethical consideration of classroom practice, while self-reflection allows teachers to investigate their cultural context and personal values and both concepts have been merged to coin ‘critical reflection’.

Hofstein et al. (2011) further suggest that science education should incorporate teaching/learning resources that allow the incorporation of socio-scientific themes, to enhance the development of cognitive and meta-cognitive domains among learners. However, as science education is primarily didactic and factual content oriented, and the assessment calls for the test of verbatim recall; it often separates values from facts, making science education more of a knowledge issue than of social concern. Where social issues (and environmental issues like climate change) are included as part of science education, it should not be limited to providing factual information, but most importantly, helping learners internalise the gravity and complexity of these issues (Jones & Davison, 2021).

Summing Up

In this chapter, I addressed the ‘societal lifeworld’ part of the second research question and talked about how important science education is to the well-being of society. According to my personal experiences, the science I studied in school and at the university gave local issues and knowledge systems very little room, which left students lacking the knowledge and attitudes necessary to be critical thinkers and responsive to societal problems. The discussions reflect that while the role science plays in society is well appreciated, science education has not been able to equip learners with an understanding of ethical and social responsibilities. Secondly, science education has not been able to help learners develop the skills and attitudes needed to engage critically and responsibly to challenge existing societal assumptions and taboos.

In the next chapter, I develop my vision of STEAM education through which I attempt to address the issues I experienced as a science learner.

CHAPTER SIX

IMAGINING THE FUTURE(S) OF STEAM EDUCATION

Chapter Overview

In the previous chapter, I responded to the ‘societal lifeworld’ part of the second research question. Based on my learning to this stage and my personal-professional experiences, and responding to the third research question, I develop this chapter to present my vision for (re)conceptualisation and implementation of various activities towards improving participation, achievement and continuation of students in STEM education. I employ the construct of imagination and futures in envisioning STEAM education to enable learners with the skills and mindset needed to be creative problem-solvers and leaders in the 21st century. Here, I discuss three key features of my vision: *‘Towards emancipatory practice in teaching and learning of science’*, *‘From interdisciplinary to a transdisciplinary approach to STEAM Education’*, and *‘Valuing science of learning for learning of science’*. Guided by these three features, I also design a sample STEAM Plan: Community resilience in addressing the disease epidemic.

Towards emancipatory practice in teaching and learning of science

It was sometime around October 2019; I was among the nine students from MPhil in Education (STEAM Education) programme attending the course on ‘Curricula in STEAM Education’. The course was designed to provide us with the conceptual tools needed to investigate various conceptualisations of curriculum and the chance to develop a critical understanding of our pre-existing conceptions of curriculum and how they have been shaped historically by social, political, and economic forces. The course facilitator

Mr Transformist asked each one of us to reflect on our teaching and learning experience and curricular practices in science and mathematics. Later, Mr Transformist facilitated a critical discussion based on a paper on ‘Three Fundamental Human Interests’ (Grundy, 1987), also drawing on our experiences. This enabled me to develop a creative understanding of an ideal representation that supports the development of emancipatory educational approaches.

My earlier understandings of teaching and learning science echoed my own experience of the science lessons I took in school. This was also the case for other learners in the course (some of whom had shared their experiences as students and others as teachers themselves) who have experienced and gone through the ‘teacher-centric’ education system and felt that most teachers are not able to internalise the new approaches to teaching and learning in practice (Bentley et al., n.d.). Traditional theories have shaped “the way classrooms are built, the way courses are taught, and the way the students’ knowledge is assessed” (Bodner et al., 2001, p. 1108).

However, in developing my pedagogy I would like to provide space for the learners in science education to be self-reflective on their local knowledge and social construct to allow social change and improvement in society. I would like to promote science as being transcendental idealist (Kant, 1998), where science can be seen as a manifestation of locally constructed knowledge proven by local practices and its applicability to respond to day-to-day needs (empirical value), as well as allow learners to critically reflect on their experiences and debunk any myths and misconceptions that they believe in by use of logical reasoning (rational value).

I believe my transformative orientation will allow me to challenge the existing coercive power-dominated pedagogy by the teachers (Cummins, 2000). Learners will be provided with a space to make a critical judgement of the issues and the contents being delivered in the classroom under transformative pedagogy. To engage students in innovative activities in the classroom, a conducive environment needs to be created for constructing new knowledge through dialectical and discovery learning approaches (Matthews, 1992). As an educator, teachers need to play the role of facilitator, providing constructive feedback to promote student-centred learning in the class (Hunter-Doniger & Sydow, 2016).

I plan to guide my pedagogy with emancipatory interest (Habermas, 1971) and bring into discussion the existing social contexts through the development of critical consciousness among learners. This allows them to have a deeper personal and cultural understanding of who they are (Baldwin, 2019; Taylor, 2015), and further be critically aware of the hegemonic practices, social inequalities and any oppression existing in the society and challenge the status quo (Danish & Gresalfi, 2018). My pedagogy in science education would empower learners to be self-reflective on their local knowledge and social construct to allow social change and improvement in society.

When I go back to reflect on my school and university days, I realise our education is mostly guided by technical interest (Grundy, 1987; Habermas, 1971) and is focused on delivering subject matters. Students and teachers have more interest in grades than overall learning (Rahmawati & Taylor, 2015). In some cases, practical interest (Grundy, 1987; Habermas, 1971) does shape teachers' engagement in the classroom and there is very limited space for open discourse allowing learning to be guided by lived experiences.

The constructivist approach to the classroom would promote teachers to actively participate in classroom discussions and construct knowledge through critical inquiry-based learning, rather than just the theoretical knowledge gained from lectures (Danish & Gresalfi, 2018). The learners' responses would help drive lessons, shift instructional strategies, and alter content as necessary and as relevant (Gross & Gross, 2016; Kompf, 1996). The guiding questions raised by the facilitator will help drive learners' interest and to explore their practices through critical self-reflection, thus generating my interest in the course. The inquiry-based learning will promote learning through lived experiences and allow learners to engage in applying understandings to address day-to-day problems arising in their personal and professional practices. Further, learning needs to also occur through the conversations happening between the learners and teachers (Gross & Gross, 2016).

The emancipatory curriculum practice will promote the development of critical consciousness to allow reflection and be critically aware of the social inequalities around us. Recognising that learners' knowledge results from the social construct, it is important to recognise the social aspects of learning and cognitive development (Sharma et al., n.d.) and hence, the curriculum needs to incorporate local contexts and contents (Bentley et al., n.d.). The course should not just adopt a cognitive perspective, but also a sociocultural perspective (Danish & Gresalfi, 2018). This will contribute to raising awareness about the critical dimensions of education. Through a transformative perspective, realising the power of education for changing society, the critical reflection would allow challenging the social, political and economic contexts (Rushton & Suter, 2012). It would allow one to be self-reflective on one's own experience and contribute towards addressing problems prevalent within the professional practice (Qutoshi, 2019).

From interdisciplinary to a transdisciplinary approach to STEAM Education

It was sometime during November 2017; I was attending a meeting between the then Ministry of Education, and education development partners. One of the discussions was on the government plans for the revision of the National Curriculum Framework and the integrated curriculum for grades 1-3. Being a newcomer to the education sector, I had a limited understanding of notions of curriculum and curriculum development. My engagement in the follow-up meetings gave me knowledge of the curriculum development process and a better understanding of the national and international practices in curriculum development.

Traditionally, the curriculum is organised around a separate subject area (Beane, 1995) and the students are provided with a set of contents as guided by the curriculum to achieve the objectives set by the curriculum. My learning at school was also guided by the same notion of the curriculum. Different subjects are taught by different teachers, and they are delivered in a way that they are not linked to each other. Students do not get the wider context of what they are learning. Students are not able to understand the impact of one subject over other and how they are interlinked. Learning becomes fragmented. The contents within the subjects are designed by subject experts, most having their interests and purposes, and the purpose is to deliver technical knowledge. A set of plans with contents are sequenced for students to know. Students are not able to find the real-life purpose of studying what is being taught under each subject. This leads to decontextualisation, and the students' knowledge is based on acquisition, memorisation, and rote learning of each specific content knowledge.

We do not hear the students in their beginning years of schooling saying they are bad at mathematics, or they find science boring. But as they reach higher grades, they start to feel that way because of the subject-based educational model. Integrated learning involves combining different subjects or areas of study in a way that helps students see how they are related to each other and relevant to the topic being studied (CDC, 2019; *Educators Say Integrating School Subjects into Interdisciplinary Approach Has Benefits*, 2017). Beane (1995) suggests integrated curriculum is a real paradigm shift in the education system, promoting technical knowledge as 'means' of education rather than as an 'end' in itself. Curriculum integration centres the curriculum based on real-world issues and lived experiences rather than "mastery of fragmented information within the boundaries of subject area" (Beane, 1995, p. 622). Guided by practical curriculum interest (Grundy, 1987), in a classroom, teachers and students can involve in sense-making activities. This allows the engagement of students as active learners and helps develop students' transdisciplinary abilities including critical and creative thinking, personal and social capabilities, ethical understanding and intercultural understanding (Babaci-Wilhite, 2019; Taylor & Taylor, 2019). The teachers, as facilitators, can engage students and themselves towards "reflective deliberation, personal judgement-making and interpretation" (Taylor & Campbell-Williams, 1992, p. 7) of curricular contents and bringing into discussion the existing social contexts. In this way, emancipatory curriculum practice can also be made possible through an integrated curriculum, the teachers can play a major role in the development of critical consciousness among the students that allows them to reflect and be critically aware of social inequalities.

Radziwill, Benton and Moellers (2015) showcased how art-integrated STEM projects could "foster creativity and new ways of thinking" (p.4). The addition of “A” to STEM, making it STEAM, recognises the role of aesthetics, beauty and emotion, and also adds an affective component to STEM concepts (Bush & Cook, 2019; Silk et al., 2019). As highlighted by Taylor and Taylor (2019), I agree that there is also a need for science education to foster interdisciplinary collaboration between STEM and arts to “create interdisciplinary STEAM curriculum spaces for designing transformative pedagogies that develop students’ disciplinary knowledge/skills and awaken their creative self-consciousness, elevate their moral/ethical and spiritual awareness,” (p.1) and empower them to practice sustainable practices.

Leaping further, as I envision STEAM education, I would also like to employ the transdisciplinary space (Liao, 2018).

Learning in transdisciplinary space: Thematic indivisibility

It was sometime in February 2019; it had just been a few weeks since I had begun my MPhil journey. I was gradually learning about various STEAM education perspectives – thanks to the course ‘Lenses of STEAM Education’ introduced during the first semester. I was also researching various academic papers to get ready for my portfolio writing and I learned about the transdisciplinary approach to curriculum integration (Liao, 2018). I, then, started to consider the limitations of interdisciplinary and multidisciplinary approaches to curriculum integration. While the interdisciplinary approach focuses on bringing together two or more disciplines to address a specific problem or issue, it does not necessarily address the problem in a holistic or integrated way. The multidisciplinary approach, on the other hand, involves multiple disciplines working independently on a problem, without necessarily seeking to integrate their perspectives. As we aim to empower learners in addressing complex real-world problems or issues (for example: addressing issues of climate change) requiring a multifaceted approach that takes into account multiple perspectives and approaches, a transdisciplinary approach is particularly useful.

The transdisciplinary space, according to Nicolescu (1997), differs from interdisciplinarity because of its goal, as “the understanding of the present world, which cannot be accomplished in the framework of disciplinary research” (p.8). In the transdisciplinary space, students do not categorise what they are learning as science, technology, engineering, mathematics or art, but they get engaged across all subjects and even go beyond (Liao, 2018). The learning task is designed based on a theme of study to support the learners with a holistic understanding of any processes or issues. When discussion of any issue or process is fragmented across different subjects and delivered through different teachers (which was also my learning experience), the learning also becomes fragmented, and learners are not able to apply their knowledge in their day-to-day life.

Transdisciplinary pedagogical practices are challenging to implement in Nepal due to existing teacher recruitment policies and processes, and subject-based teachers’ habitus. Schools and educational institutions are structured around traditional subject-based teaching and learning. To respond to the need for transdisciplinary approaches, teacher collaboration and teamwork are fundamental. A multidisciplinary team of teachers, educators and stakeholders with diverse backgrounds and expertise needs to be employed to design lesson plans, by integrating multiple subjects and perspectives, for a comprehensive and holistic understanding of thematic topics. When learning tasks are designed from the perspective of ‘thematic indivisibility’, it can engage students to apply their understandings, leading towards innovation to address local as well as global issues (Liao, 2018) including areas specific to the Sustainable Development Goals (SDGs) (Kioupi & Voulvoulis, 2019; Taimur & Sattar, 2019; UNESCO, 2017).

Valuing science of learning for learning of science

When developing learning tasks, it is important to take into account the achievement of a learner across all three domains of learning: Cognitive; Affective and Psychomotor (Airasian et al., 2001; Bloom et al., 1956; Krathwohl et al., 1964). From what I experienced, learning in science has an emphasis on the development of low-order skills of the cognitive domain, as learning primarily involves rote learning of factual information. On top of that, science education at school and university has not been able to fully contribute to the development of psychomotor (see Chapter Four) and affective skills (see Chapter Five) among learners. As I was undertaking this inquiry (in Chapter Four) I realised that practical sessions that are designed to help develop hands-on skills are also designed around the didactic approach and rote memorisation of procedures to be applied. Further, from my discussion in Chapter Five, I felt that there have been significant gaps in the translation of knowledge acquired from a science classroom into the change of attitude, behaviour and action.

Making a shift towards outcome-based education

In December 2019, a national-level STEAM challenge was organised in Kathmandu. The event was participated by school students, who had to identify a real-world problem in the community and develop a project on-site as a solution to the issue. As the students were working on their projects, I visited each of the exhibits and interacted with the students to better understand their projects. While the students were putting forth their best efforts for the projects, I felt that for most of the projects, the students were limiting themselves within their curricular subject matters. There were also a few exceptions, in which the students, in their projects, were able to move beyond their curricular content and integrate transdisciplinary approaches to design a prototype as a solution to the problem they have been experiencing in their communities. Towards the end of the exhibition, I was sharing my observation with some of my friends who had also observed the projects and they had similar reflections as I had of the projects. In the evening, I started to recollect the discussion we had, a few weeks back, on Outcome based education (OBE) during one of the courses of the MPhil and realised the need for an OBE approach that makes learning to be an enriching and empowering experience for learners, but not limited to achieving specific curricular outcomes.

OBE focuses on what is important for students to be able to do in real life after they have completed their learning experience. OBE is all about “preparing students for life, not simply getting them ready for college or employment” (Brandt, 1992, p. 66). The 'when' and 'how' of student learning are prioritised in our modern education system, whereas outcome-based education focuses on 'what' students actually learn and 'whether' they learned well. Rather than simply knowing or understanding, outcomes require actual practice or doing (Spady, 1994b). OBE is built around these outcomes and employs flexible scheduling to achieve them for all students. Instructors can structure lessons to meet the needs of individual students.

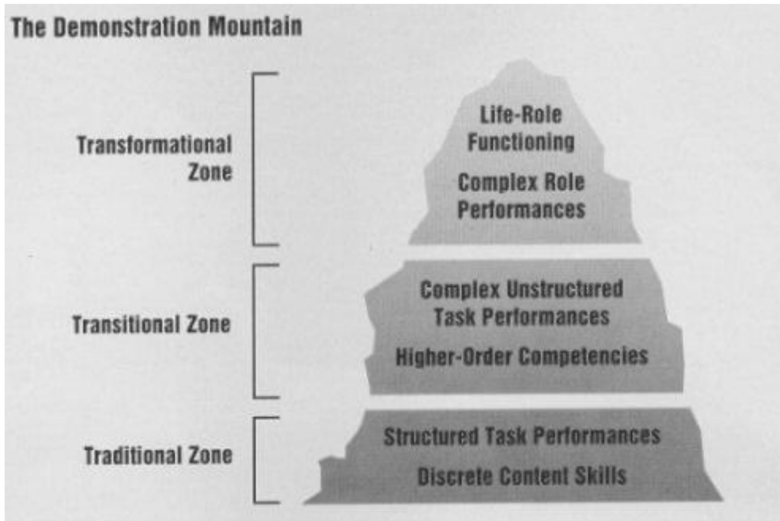

Figure 7: Demonstration Mountain as a metaphor to demonstrate the differences in learning outcomes as we climb up through the zones of Traditional, Transitional and Transformational OBE (Spady, 1994a)

The demonstration mountain (Spady, 1994a) consists of three zones and six different forms of learning demonstrations. The " complexity, generalisability, and significance of each form of demonstration increase" (Spady, 1994a, p. 19) as we climb from the lowest level (traditional) to the highest level (transformational). Traditional OBE skills are discrete, content-dependent, and primarily grounded in the subject matter. Teachers also strictly monitor task performance, which only represents day-to-day classroom activities and homework assignments. As a result, traditional OBE is proposed as Curriculum based objectives (CBO) (Spady & Marshall, 1991). As we progress upward, the transitional OBE zone appears, with blurred boundaries, between the traditional and transformational OBE zones. This includes a wide range of higher-order competencies such as effective communication, investigative research, complex analysis, problem-solving, and decision-making, as well as the ability to go beyond knowledge and skills related to subject content. (Spady, 1994b). The learners are allowed to refine their ability to perform complex tasks utilising knowledge from a variety of subjects and content areas.

The “highest evolution of OBE concept” (Spady & Marshall, 1991, p. 70) is Transformational OBE. Conventionally, the success of any student in school is determined by the grades they score and the rank they secure. *But how are these “successful” students performing in the real world after their graduation? Have they been able to utilise their skills to address challenges they encounter in real life? Are schools and universities helping students develop these skills?* Schools and universities must focus on preparing students to apply their knowledge in the real world. Transformational OBE aims to change the definition of learning in school education by moving away from the traditional narrow concept of content-bound behavioural objectives and formal curriculum (Spady, 1994b, 1994a). The transformational OBE also has the characteristic of being outcome-defined. This image, however, does not depict students' learning activities. As part of their learning, students will take on real-life roles in which they will apply their knowledge and skills. These performance roles are based on major life roles that students will face once they graduate from high schools, such as citizen, employer, worker, parent, and civic leader, and they prepare students for these roles in the future (see Figure 8).

The students work on individual and group projects while "exploring important issues or phenomena, use multiple media and technologies, create products that embody the results of students' explorations, and call for students to explain their work and products to adult and student audiences" (Spady, 1994a, p. 23). As the students engage in complex role performances, they demonstrate a high level of creativity, ownership, self-direction, and self-assessment as practitioners. Students can explore hegemonic practices and disempowering forces through engagement in society while performing roles. The transformational OBE is guided by the emancipatory curriculum interest. As a result, they learn to deal with challenges they encounter in real-life and social contexts. The goal of transformational OBE is to prepare students to be competent future citizens by equipping "all students with the knowledge, competence, and orientations needed for success after they leave school" (Spady & Marshall, 1991, p. 70). As the students are engaged in learning, they also develop creativity and critical consciousness that allows them to reflect and be critically aware of social inequalities.

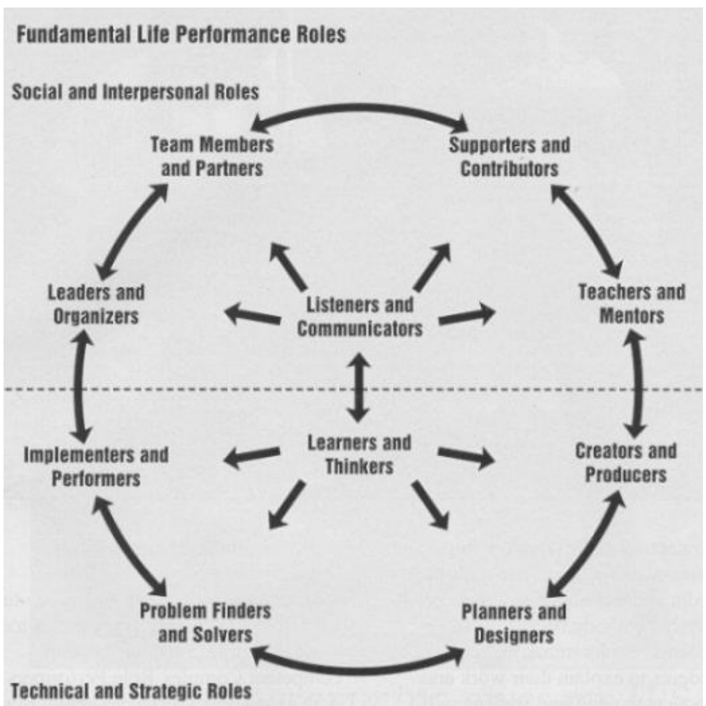

Figure 8: The framework shows 10 clusters of performance roles: Implementers and Performers, Problem Finders and Solvers, Creators and Producers, Learners and Thinkers, Listeners and Communicators, Teachers and Mentors, Supporters and Contributors, Team Members and Partners, Leaders and Organisers (Spady, 1994a).

Integrating social and emotional learning (SEL) in the classroom

During this research inquiry, as I reflected on my learning journey at school and university, I became more aware of the academic stress and pressure I endured to perform well in school and university and to complete homework and assignments within deadlines. This took me to a meeting I participated in sometime in November 2016. I was attending the Asia-Pacific Meeting on Education 2030 in Thailand and on the third day of the meeting, I had an opportunity to learn a lot about SDG 4.7 on Education for Sustainable Development and Global Citizenship during a session facilitated by the United Nations Educational Scientific and Cultural Organisation – Mahatma Gandhi Institute of Education for Peace and Sustainable Development (UNESCO MGIEP). While the session and the presentations were to set a scene for upcoming meetings the following year, they provided me with insights towards social and emotional learning (SEL) and equipping learners with knowledge and skills to promote sustainable development. Later, during a coffee break, I got to meet with the presenter, who during our short conversation, further highlighted the importance of SEL in not only building a sustainable future but also towards students' academic success. Since then, I have been regularly following up on different reports and working papers from the UNESCO MGIEP on SEL. Chatterjee Singh and Duraiappah (2020) highlight the urgent need for SEL adoption in classrooms through an integrated approach, but not as standalone subjects. As I envision the future(s) of STEAM education, I considered SEL to be one of the necessities that allow learners to understand and manage their stress, emotions and behaviour, as well as show empathy towards others and in making responsible decisions.

The teaching and learning process is all about promoting the active engagement of students (Lashari et al., 2013) and is a multifaceted construct comprising the cognitive, affective, and behavioural dimensions (Fredricks et al., 2004). Students' engagement is part of the learning process that refers to the extent to which students are cognitively, actively, and emotionally involved in their learning. A teacher needs to be able to recognise students' emotions and respond to students' behaviour accordingly.

The Social and Emotional Learning (SEL) (*Social and Emotional Learning (SEL) Competencies*, 2017) approach makes it possible to direct the teaching and learning process because it encourages activities that help kids learn how to identify and control their emotions, form relationships, resolve interpersonal conflicts, and make wise decisions (Payton et al., 2000). SEL fosters the development of five interrelated sets of cognitive, affective, and behavioural competencies: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making, and the skills associated with it (Yoder, 2014). This allows students to manage their behaviours, understand and relate to the perspectives of others, and make sound personal and social choices. Self-awareness is the ability to recognise one's own emotions, thoughts, and values, and how they influence behaviour. Students need to be reflective and open to feedback to develop an awareness of self. When they can understand themselves, they can better manage their behaviour. Further, when students are aware of their strengths, it builds their self-confidence and promotes their healthy social-emotional state of mind. Building from the foundation of self-awareness, the competency of self-management is the ability to regulate emotions and behaviours so that goals are achieved. With these skills, students can apply strategies to reduce personal and interpersonal stress and persevere with difficult tasks and complex social interactions. Self-awareness and self-management go hand in hand; for instance, self-management skills like being able to stop and calm down when one is upset require self-awareness skills like the ability to recognise and label the emotions as well as to think about how those emotions might be influencing one's behaviour choices (*SEL for Students: Self-Awareness and Self-Management*, n.d.).

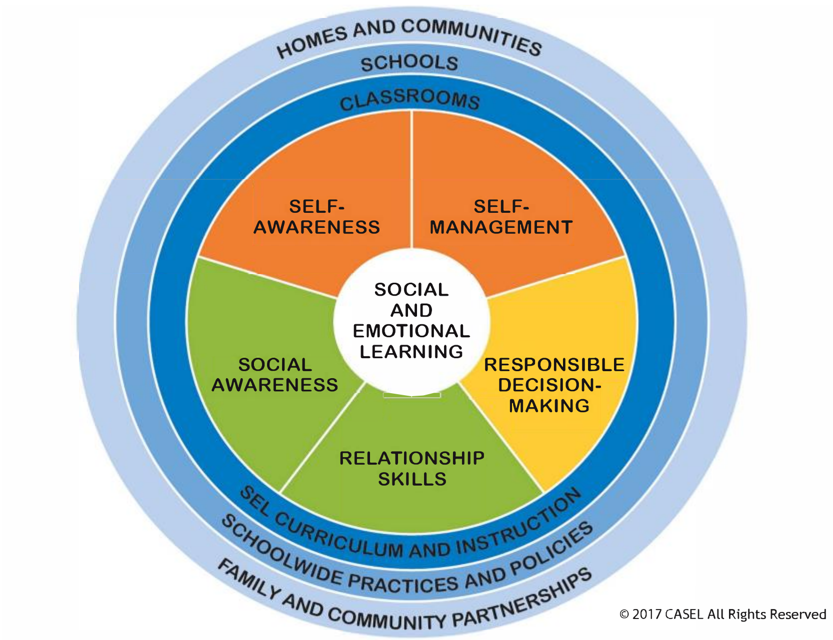

Figure 9: Effective social and emotional learning programming involves coordinated classroom, schoolwide, family, and community practices that help students develop the five key skills. (Social and Emotional Learning (SEL) Competencies, 2017)

Social awareness is the ability to understand and recognize the emotions, thoughts, and perspectives of others. This skill helps individuals to identify and interpret the intentions, desires, feelings, and beliefs of others, and to respond to them in a sensitive and appropriate way. As students develop their social awareness, they become more adept at forming positive social relationships, working with others, and managing conflict effectively. This skill is important for students to be able to navigate social situations and build successful relationships with their peers and adults. Rubin, Bukowski and Parker (2006) suggest that students who are able to form positive relationships with their peers and feel socially connected tend to perform better academically. When children learn to make positive choices about their personal and social behaviour, they can make responsible decisions. The skills related to problem-solving, reflection, perceptive thinking, self-direction, and motivation skills will contribute towards making responsible decisions and for their lifelong success (Adams & Hamm, 1994). As children master these competencies, they become aware of themselves and develop concern for others, make good choices, and take responsibility for their behaviours.

Further, the incorporation of different classroom activities will help develop specific skills using strategies that are sequenced within and across lessons (Durlak et al., 2011), which will rely on active learning techniques, such as discussions, small-group work, and role plays within the context of the curriculum. Ethical dilemma story pedagogy (Taylor, 2022) can be employed, in which students are presented with real-life ethical dilemmas to help them understand and analyse ethical decision-making. This pedagogical tool can promote critical thinking and problem-solving skills among students, as well as help them understand others' perspectives. This approach can be integrated into teaching and learning by incorporating ethical dilemmas related to STEM fields into students' learning experiences, thus encouraging students to think about the social and ethical implications of their actions.

In addition, I admire the 'Blue eyes/Brown eyes' exercise introduced by Ms Jane Elliott (Gupta, 2020), an American diversity educator and the activities I envision as part of classroom activities will be similar, for awareness on issues like that of menstruation (which I discussed in Chapter Five). Ms Elliott conducted the exercise for her class on the very next day Martin Luther King Jr. was assassinated. This was triggered by a question from a third-grade student on why Luther King was shot dead. It was difficult for Ms Elliot to make the three graders understand the discrimination without making them experience it by themselves. To simulate racial segregation for the kids through role plays, she chose to base the activity on eye colour rather than skin tone. She designated the children with brown eyes as the superior group on the first day, and they were granted special privileges. The kids with blue eyes were told to stay out of the game and only the kids with brown eyes were encouraged to play. The following day, Ms Elliott changed the exercise so that the children with blue eyes were superior. While the teasing of the brown-eyed children by the blue-eyed kids was similar to what happened the day before, because of the activity, the kids learned what it's like to be hurt in that way and have vowed never to hurt one another again.

As the students are engaged in complex role performances, they exhibit a high degree of creativity, ownership, self-direction, and self-assessment on their part as a practitioner. With other activities involving their engagement in the community during performing roles, the students can explore the hegemonic practices and disempowering forces in society. In doing so, they learn to deal with challenges they encounter in real-life contexts and within the social context. Schools need to prepare children for their future by developing their social and emotional competence. Children encounter different people who perceive the world differently and who think differently than them. With social and emotional competence, children can manage possible conflicts between these individuals with varying perspectives and backgrounds in the classroom and outside. This results in a more engaging learning environment.

It is also important for the teachers to improve their SEL competencies because a teacher's competency would directly affect how they would interact with students on both social and instructional levels. The lesson plan, with the incorporation of affective and cognitive dimensions, aims at creating students as competent future citizens and equipping "all students with the knowledge, competence, and orientations needed for success after they leave school" (Spady & Marshall, 1991, p. 70). As the students are engaged in learning, they also develop creativity and critical consciousness that allows them to reflect and be critically aware of social inequalities.

Presenting a STEAM Project Plan

I believe that I can contribute to developing a STEAM model as a part of the emancipatory and transdisciplinary approach to science education. It will be carried out in close collaboration with the local government, parents, community and local stakeholders. Based on the different features that I have discussed in this chapter, about my vision of STEAM education, I prepare a model for a STEAM project plan that can be implemented at the school level.

In the presented project plan, I incorporate an outcome-based education model (Spady, 1994b) and provide space to allow students to be engaged in a transdisciplinary space where they are engaged in learning through discovery learning and critical inquiry-based learning, and in applying their understandings at their community. This creates an environment that reflects real-world practices (in this case addressing a disease pandemic) and is not limited to theoretical concepts (Danish & Gresalfi, 2018). Instead of going through fragmented learning, I identify several related topics across various subjects and grades and explore interlinkages between different topics. By finding these interlinkages and with the idea of 'thematic indivisibility', students can have a better understanding of the overall context (which traditionally was spread across various subjects). Depending on the individual activity, students are required to closely collaborate with other students across different grades, family members, local community members, senior citizens, health workers and government officials, while performing as an individual or as a team, which promotes development collaboration, communication, and problem-solving as well as social awareness skills among learners. I believe incorporating similar STEAM approaches across teaching and learning at different levels of school and university allows learners to attain scientific knowledge and skills, develop critical consciousness and become competent future citizens.

I have also employed design thinking in the project plan. Integrating design thinking into transdisciplinary projects can help students develop various skills and abilities such as problem-solving, critical thinking, creativity, communication, and collaboration (Henriksen et al., 2019). This approach allows teachers to engage students in hands-on projects that address real-world issues and communities to benefit from the projects as well, as students work to address pressing issues and identify solutions.

STEAM Project Plan: Community resilience in addressing the disease epidemic

Learning Objectives: The learners will be able to:

- learn about different diseases
- analyse maps to identify potential epidemics in the community
- adopt preventive measures to keep oneself and the community safe
- show empathy among family members, friends and community during the time of illness

Activities:

	Grades 4 – 5	**Grades 6-8**	**Grades 9-10**
Brainstorming/ Discussion/ Think-Pair-Share	Brainstorming about various diseases in the community/country (**Health and Physical Education, Grade 4-5, Diseases**) - Interaction with family members, community - Review newspapers in the library and access online news portals to learn about any diseases in the community, country and globally (TECHNOLOGY)	Identify diseases and their association with different organs and systems **(Science, Grade 8, Human System)** Preventive Measures **(Science and Environment, Grade 6-8, Diseases)** - Learning and experience sharing session(s) with school(s)/community-based organisation(s) at an international level to learn about preventive/disease control measures and lessons learnt from each other's country/community	

Community Visit	Visit Local Health Posts/Hospitals and Interaction with Female Community Health Volunteers (FCHVs) and health workers to learn about diseases and preventive measures (**Health and Physical Education, Grade 4-5, Health Services**) What diseases are treatable at the local health service? Where to go for treatment of other diseases? - Identify services available in the local health services and nearby and create a contact list for emergency services	Visit senior citizens, and local/indigenous knowledge holders to identify Indigenous Knowledge of Disease Prevention (**Social Studies and Population Education, Grade 7, Our Religious and Social Traditions**) - Is the community still utilising some of these preventive measures? - What are truths/myths?	Visit Local Government Offices, Health Offices to obtain disease prevalence data Statistical Analysis, Histogram (Data by Ward), Probability of getting the disease **(Mathematics, Grade 10, Statistics and Probability)**

Visual Instruction/ Community Visit/Mapping	Preparing a community map with settlement area, and potential sources of diseases (ENGINEERING)
	- Use of Google Maps to identify nearby rivers, lakes, and industries (TECHNOLOGY)
	- Visit Community and map local water sources (tap, sprout)
	- Collect water samples and observe the microorganisms under a microscope **(Science, Grade 9, Organism).**
	    o What are the characteristics of the cell you observe?
	    o Is there any pathogenic organism in the sample? (If possible, perform an experiment in a school laboratory, else collaborate with any health laboratories in the community)
	- Mark the map with a dot where the source has pathogens identified. Which sources do you think might have pathogen-infected water?		

Self-Awareness for Prevention	How do you keep yourself clean? **(Health and Physical Education, Grade 4-5, Personal Hygiene)** - Fun Activities: Rub hands with oil-based glitter and try washing hands (1) with water, (2) with mud water, (3) with soap water for (i) 1 sec, (ii) 5 sec, (iii) 10, sec, (iv) 20 sec. Which method of handwashing is the most effective? Why?	Advocacy in the community (in collaboration with the Red Cross Clubs, and FCHVs) on preventive measures)	
	Get information by reading a thermometer (**Mathematics, Grade 4, Statistics**) - Keep a track record of the temperature every day of family members/friends. Is anyone not feeling well? (**Social Studies, Grade 5, Self, One's Family and Neighbour – Empathy)**	- Conversion of the temperature records into different units: Celsius to F to K **(Science, Grade 8, Heat)** - Understanding working of Clinical Thermometer **(Science, Grade 8, Heat)**	

Summing Up

This chapter outlined my idea for emancipatory and transdisciplinary STEAM education in response to my third research question. The discussions highlight the need for transformation from technical interest in teaching and learning practices to emancipatory interest; curriculum redesign from a subject-centric to a transdisciplinary approach; and harmonisation of learners' engagement across cognitive, affective, and psychomotor learning domains, allowing students to develop reflective and critical awareness. The emancipatory approach of STEAM vision enables student engagement through the use of transformative pedagogy and fosters critical consciousness in students so that they can be reflective and critically aware of the social inequalities around them. Students can learn in a setting that supports ‘thematic indivisibility’ thanks to the transdisciplinary approach, and they are not required to categorise their learning according to subjects. The learning tasks also take into account students' progress in the cognitive, affective, and psychomotor learning domains. Guided by these constructs, I created a sample STEAM plan that offers learners access to a transdisciplinary environment where they can learn through discovery learning and critical inquiry-based learning while also applying what they have learned in real-world settings within their communities.

The following and final chapter will contain my concluding reflections on my research process, the research questions, methodological choices, theoretical referents as well as my plans and implications of the study.

CHAPTER SEVEN

RECOLLECTIONS AND REFLECTIONS

Chapter Overview

With this chapter, my research journey is coming to an end. My engagement in qualitative research for the first time was challenging as well as an empowering learning experience. This journey was an eye-opening exercise for me that it allowed me to get deeper into my lived experiences and explore connections of science education to personal, professional and societal relevance. In this last chapter, I reflect on my research journey, followed by my concluding reflections on the research questions, the methodology I employed and theoretical referents. I also put forward my future directions and possible implications of the study.

Reflecting on my research journey

With a master's degree in biotechnology and having professional engagement in the field of education, I was looking for a possible academic enrolment that would best complement my academic and professional experiences. Just then, I came to know about the MPhil in Education programme (with specialisation in STEAM Education) that was being introduced at Kathmandu University. For me, this was a perfect opportunity and I tried to get more information on the programme. My interaction with the then-head of the department was very rich and it further inspired me to join the programme.

With my engagement in the MPhil programme, I received theoretical knowledge and practical insights into deepening my understanding of different lenses of STEAM education. Different courses opened new avenues for me to look into science education.

In particular, two courses I took: ‘Reflective Practice in STEAM Education’ and ‘Advanced Qualitative Research’ helped me plan a course of action to undertake this research journey.

The courses generated interest within me towards qualitative research and prompted me to look into various social issues and problems from the perspective of those experiencing them (in the case of my research, I was the representation of the voices of those who were having similar experiences to mine). In this regard, I got introduced to autoethnographic design as one of the qualitative research methods (Creswell, 2012; Ellis et al., 2010), which I found to be the most suitable method of inquiry for my particular study, as it allowed me to reflect my own experiences.

I started to feel that I should not be over-dependent on theory (Collins & Stockton, 2018) as qualitative researchers do not design research to test any formally constructed theories. I wanted to move beyond the post-positivist paradigm and also give equal importance, as theories, to my personal-professional context (Luitel, 2009; Pant, 2015). I realised that it is important for me to investigate the phenomenon using critical reflectivity based on my own experience and draw on the pre-existing theories (Collins & Stockton, 2018) and world views selectively, rather than contributing to a particular theory (Given, 2008; Willis, 2007). Hence, rather than treating theories as a framework, I employed theories like Vygotsky’s sociocultural theory, Bloom’s taxonomy, Habermas Constitutive Interest and transformative learning as referents in my research (Tobin & Tippins, 1993) (which I have discussed in Chapter One).

I also received opportunities to learn about different research paradigms (as discussed in Chapter Two), which was very new to me as it was the first time, I was attempting to undertake social science research. It took some time for me to understand and internalise different aspects of qualitative research. The discussions I was engaged in during the course were really helpful for me in defining my philosophical orientation to guide my research. I applied multi-paradigmatic research design space (Luitel, 2019) by drawing in these three paradigms. I employed interpretivism for multiple interpretations of a single phenomenon to gain a deeper understanding of the subject matter. Further, criticalism provided me with a theoretical base for understanding a socially constructed reality (Pham, 2018) in view of science education in Nepal. The paradigm of postmodernism was the most interesting to me as this paradigm allowed me to present my qualitative data texts in the form of narratives, metaphors, stories etc. (Taylor, 2014). I applied the paradigm of postmodernism to give a literary turn to the knowledge generated during my study and used multiple research genres and logics to allow the space for multiple pluralism in my research (Rai, 2017).

As a practitioner-researcher, I got motivated to get engaged in transformative research about my personal-professional practices as it involved critically examining my values and beliefs and "creatively reconceptualising own professionalism, and committing to transform education policy, curricula and/or pedagogical practices" (Taylor et al., 2012, p. 374). Based on this, as part of my research study, I planned to reflect on my experience of learning science and understand the inter-relations between the knowledge of science and the lived experience. From my experience, the current decontextualised nature of curriculum materials and textbooks (UNESCO & Kathmandu University, 2008) has disconnected students from their local environment and knowledge system – leading to their low participation and underachievement in science education.

With valuable inputs from my supervisors, I focused my study on relinking science with our day-to-day functioning to make science a manifestation of our understanding of the environment and everyday happenings in our lives. I attempted to explore the space allowed in science education for the learners to be self-reflective on their local knowledge and social construct to allow social change and improvement in society.

Consequently, drawing upon my research purposes, I developed an overarching research question: *How (de)contextualised was my journey of science education and how can science education be (re)constructed?* Under this, I designed three subsidiary research questions to look into different dimensions of my inquiry:

1. How have I experienced learning of science at home, school and university?
2. How applicable has the learning of science been to my personal, professional and societal lifeworlds?
3. How can science education be reconstructed to respond to personal-professional and societal needs?

Reflecting on my research questions

The first research question surfaced from my lived experiences of learning science at home and during my formal education in Nepal, from school education to a bachelor's degree in biotechnology. In response to the research question, I discussed the issues of school science being not linked to the learner's home and social context which leads to decontextualised learning and developed narratives in Chapter Three under various sub-themes: '*Setting the scene: Scientific knowledge at the home/school interplay'*, '*Blurring out the experience: 'Padera janincha'*', '*The More Knowledgeable Others: My parents* *and grandparents*', '*Embarrassment with my urban-centric understanding*', '*Real World Learning*', '*Visualising in the textbooks*', '*Natural science without naturality*', '*Science projects as (in)active construction of knowledge*' and '*Washback effect in science education*'. At home, the knowledge of indigenous science possessed by my grandparents and parents had a biospheric focus and I felt it had well-established connections to everyday lives. But, from what I experienced at school and university, the teaching was textbook-based and disconnected from students' lives (Bajracharya & Brouwer, 1997). The culture of teaching was didactic and appeared to be depositing teachers' ideas into students like me (Luitel & Taylor, 2005). The 'chalk and talk' was the dominant pedagogy (Connor et al., 2015). In most of my classes, as a student, I waited passively for the teacher's lecture and lacked student interaction (Bajracharya & Brouwer, 1997). I was among the students who "create a compartment for scientific knowledge from which it can be retrieved on special occasions, such as a school exam, but in everyday life it has no effect" (Cobern, 1994, p.588).

In response to the second research question, I developed narratives under three themes, based on which I had also developed the chapters: *Science education as/for personal (ir)relevance* (Chapter Three), *Science education as/for professional (ir)relevance* (Chapter Four) *and Science education as/for social (ir)relevance* (Chapter Five). Starting from Chapter Three, under the sub-theme *'My sciences in my everyday life'*, I discussed the relevance of science education, to my personal lifeworld. I developed this theme based on my personal experiences in which I rarely saw a relationship between the science I studied and science problems I encountered in my everyday life (Burbules & Linn, 1991) and hardly had any opportunity to relate science to my life. I did not know how to problematise science subjects to make them relevant to my life (Burbules & Linn, 1991). In Chapter Four, I discussed the relevance of science education to me in my professional settings. Here, I developed several sub-themes '*Becoming a Thulo Manche', 'Saving myself from a brain drain', 'Being Competent: Knowledge vs Skills' and 'With science at my heart: Transitioning from a scientific researcher to a social science (education) researcher'.* From what I experienced, society had a high regard for those who opt for science majors for higher secondary education and those choosing traditional science professions. For my parents and relatives, getting a first division in SLC was securing my way towards taking science for 10+2 that would help me get a STEM degree and I was destined to become a '*thulo manche*'. Here, *'thulo manche'* resonates with Bista's (2020) fatalism. However, as I was nearing my graduation, I started getting worried about my next steps. From what I observed, university education was catalysing student migration than encouraging graduates to contribute and respond to local and national needs. Like school education, science and technology education offered at the university level was also based on a textbook- and presentation-slide-printout-driven curriculum that prioritised rote learning. Science education provided limited importance towards developing desirable competencies and necessary skill sets among graduates. In Chapter Five, I developed two sub-themes '*Valuing local knowledge, advocating justice'*, and *'Disregarding science, fearing divinity' and* discussed the relevance of science education for benefit of the society. From my lived experiences, the science I studied at school and university provided very limited space to local issues and knowledge systems, as a result, the learners are not well equipped with skills and attitudes that require them to be critical and responsive to the existing issues in the society. Overall, from what I experienced and observed in my personal, professional and societal lifeworlds, the science education at school and university has been structured with a focus on the cognitive learning domain and has not been able to much contribute to the development of the psychomotor and affective learning domains among the learners.

In response to the third research question, I developed a vision for STEAM education in Chapter Six. I discussed three key features of my vision: *'Towards emancipatory practice in teaching and learning of science', 'From interdisciplinary to a transdisciplinary approach to STEAM Education'*, and *'Valuing science of learning for learning of science'*. The emancipatory approach of my STEAM vision allows the engagement of learners by use of transformative pedagogy and develops critical consciousness among learners to allow them to be reflective and critically aware of the social inequalities around them. The transdisciplinary approach allows students to learn in an environment that features 'thematic indivisibility', and learners are not required to categorise their learning by subjects. Additionally, the learning tasks will take into account the learning achievement of learners across cognitive, affective and psychomotor domains of learning. Based on these approaches, I designed a STEAM plan that includes an outcome-based education model (Spady, 1994b) and also gives learners access to a transdisciplinary setting, where they can learn through discovery learning and critical inquiry-based learning while also applying what they have learned in a real-world setting within their communities.

Reflecting on my methodological choices

This research is based on my personal experiences and values and is aimed at promoting the meaningful engagement of learners in science education. I adopted value-laden axiology, relativist ontology and transcendental idealist epistemology. The knowledge generated in this research is based on my personal and professional experiences and is analysed through a subjective lens. The multi-paradigmatic research design space allowed me to take on the paradigms of interpretivism, criticalism and postmodernism. The research employs an interpretivist approach, aiming to gain a deeper understanding of the subject matter through multiple interpretations, and a criticalist approach, which seeks to understand a socially constructed reality in the context of science education in Nepal. The research incorporates a postmodernist perspective, recognising the importance of multiple perspectives and allowing for the exploration of multiple logics and genres.

I used autoethnography as the research method in this inquiry as it combines elements of autobiography and ethnography and allows for the exploration of personal experiences within a cultural context. I, as a researcher, was able to take on dual roles of subject and observer, using my lived experiences as a starting point for further inquiry into broader cultural and societal issues related to science education. I employed critical autoethnography, a specific type of autoethnography, which involves challenging dominant narratives and power structures while critically analysing my experiences and biases. This method provided me with a space for self-reflection and self-exploration and the potential for personal and societal transformation. I was also able to contribute to the creation of a more inclusive and equitable vision for science education (see Chapter Six).

Reflecting on theoretical referents

To minimise the dominance of a single theory in the interpretation and meaning-making process, I chose to use several theories as referents in my inquiry. Rather than limiting the scope of my inquiry to a defined viewpoint of any theory, I have used theories as points of reference. By using different theories as referents, I was able to consider a range of perspectives and ideas and minimise the influence of any one theory on the interpretation and meaning-making process. I used four theories – Vygotsky's sociocultural theory, Bloom's Taxonomy, Knowledge Constitutive Interests and Transformative learning theory - as referents in my autoethnographic inquiry.

I grew up observing sociocultural practices and learning through interactions with my community, which aligns with Vygotsky's sociocultural theory that learning occurs through interactions with others. I learned many life skills and problem-solving strategies through observing and interacting with my parents and others in my community. However, my learning at school was primarily through rote learning and a textbook- and lecture-based approach, which did not allow for as much collaboration and interaction with their community. In this study, I explored the curricular space provided for knowledge construction through interaction within the learners' sociocultural environment and how sociocultural contexts are brought into the classroom for better understanding and social awareness. The research suggests that to promote meaningful learning, there is a need to recognise the vast local and indigenous knowledge of Nepal in the teaching and learning practice as well as for better social interaction and collaborative dialogue with knowledge holders.

The other theoretical reference I used is Bloom's Taxonomy which classifies the educational learning objectives based on the cognitive, affective, and psychomotor learning domains. The study, based on my experiences, informs that learning in science at school and university has primarily focused on the cognitive domain, with an emphasis on rote memorisation and the ability to recall information. There has been limited opportunity for psychomotor development, with practical sessions often focusing on following instructions rather than developing proficiency in scientific skills. The affective domain, which includes attitudes and motivation, has also been undervalued in science education. I argued that the affective dimension is a necessary condition for learning to occur and that promoting active participation and fostering achievement in science education can be aided by considering the affective domain. The research further suggests that through STEAM education, learners can be provided with a space to think about their social, cultural and environmental context, and contribute to solving local and global issues.

The other theory, the Knowledge Constitutive Interests suggests three types of knowledge constitutive interests: technical, practical, and emancipatory. My learning of science was guided by technical interests, with a focus on didactic, teacher-centric pedagogy, rote learning and memorisation. I experienced a lack of emphasis on practical and emancipatory interests where there was limited space for meaning-making and critical examination of social contexts. This study envisions an education system guided by emancipatory interests, in which teachers and students share authority and work towards mitigating social inequalities.

The incorporation of transformative learning theory into my research allowed me to envision a shift in science education from a focus on pure scientific knowledge to one that also encourages critical self-reflection and encourages learners to be ‘critical self-reflective thinkers’. This was achieved through the use of Taylor's (2015) five ways of knowing, which include cultural-self knowing, relational knowing, critical knowing, visionary and ethical knowing, and knowing in action. These allow individuals to understand their cultural context and beliefs, question assumptions, and critically reflect on local knowledge systems.

Conclusion and Future Directions: Crossing the ‘transformative’ bridge as a learner, as a practitioner researcher

Along this journey so far, I am learning to “use critical reflexivity (or critical self-reflective inquiry) as a self-study tool to help decolonise my own personal and professional practices of hegemonic ideologies that serve asymmetric social interests” (Taylor et al., 2012, p. 379). I need to work as an agent for transforming the current education practice I also play a role in (Luitel, 2019). Conventionally, there is more finger-pointing to the outward world, which is not sufficient for a transformative reform (Luitel, 2009). Hence, I will be aware of my possible roles in transformation and break the hegemony in education practices by bringing a shift in my thoughts, feelings and actions towards my practice. This journey has allowed me to have a critical realisation of myself and understand the structural forces governing the education system to empower myself and reconceptualise my onward journey. I aim to be a change agent and bring my vision of STEAM education (see Chapter Six) to fruition, making science education more empowering and relevant to learners. I am committed to personal and professional growth, and to contributing to the community of practice through research.

Implications of the study

The autoethnographic inquiry I have carried out has proved revealing to unfold and understand the (re)positioning of science education. My research will have implications for change at personal, pedagogical and policy levels. It will also contribute to opening ways for the next level of academic engagement in the field of science education. The research will have the following implications:

Implications for myself

As a transformative learner, researcher and practitioner, I have witnessed changes within me and have been able to deepen my understanding of the (re)positioning of science and science education. The changes that occurred to me have been manifested in my attitudes and behaviours while conducting this research.

My role as a learner will be to observe openness in my learning, unlearning and relearning of science and science education; my role as a researcher will be to uphold criticality and challenge stereotyping in science education; and my role as a practitioner will be to advocate and employ critical pedagogy for enhancing the learning of science.

I will keep on making critical reflections on the way I should strive for science education and will engage myself at personal and professional levels to transform my pedagogical practices. I will work for constructing my identity and will add value to transform the science education to which I am dedicated.

I will work as a change agent and will advocate for bringing my vision of STEAM education (see Chapter Six) into action, so the learning of science becomes emancipatory, empowering and relevant to learners' personal, professional and societal lifeworlds. I will continue engaging in the pursuit of knowledge creation, research, publication and dissemination, thus contributing to the community of practice.

As a father of a two-year-old, my new insights through this research would be most helpful to allow me to support the learning of my daughter and empower her to become an informed and responsible citizen.

Implications for change in curricula and pedagogy

My study reveals that the problem in STEM education lies in curricular design and pedagogical delivery. The curriculum is designed centrally without giving due space to the local contexts and contents (Luitel & Taylor, 2005). The curriculum and textbooks are decontextualised and appear to be imported from non-local/indigenous contexts, emphasising technical interests. The students, hence, do not find a connection between the subject matter and their surroundings and their everyday life. This has contributed to disempowering culturally diverse students and communities at the local level.

As part of transformative STEAM pedagogy, there is a need for reconceptualising curricula and making science education responsive to learners' needs and their biosphere. Science needs to be taught as a living subject relating it to the learner's everyday life. The place pedagogy (Wagle, 2021) is equally critical to give learners opportunities to explore science, connecting with local cosmologies and contexts.

Science curricula and pedagogy need to deliver knowledge employing transdisciplinarity with a focus on the skills necessary for tackling twenty-first-century challenges and problems. Further, there should be a space for the integration of socio-scientific issues (Gu & Belland, 2015), which will allow students to find possible connections between the subject they learn at school and the problem they face in their day-to-day life.

Implications for teachers and teacher educators

When it comes to the question of the classroom, it is the sole responsibility of the teachers to blend science, technology, engineering, art and mathematics to create a seamlessly integrated STEAM curriculum (Smith, 2015). The teachers are “central to fostering critical thinking and independent judgement, instead of unreflective conformity” (UNESCO, 2015b, p. 83). This study suggests that there is a need for teachers to obtain knowledge on various teaching and learning approaches such as narrative reflective writing, dialectical reasoning for generating student narratives and ethical dilemma story pedagogy for developing students’ transdisciplinary abilities (Taylor & Taylor, 2019).

To promote active learning of science and to develop problem-solving skills among students, there is a need to introduce problem-based learning by using real-world problems. The teachers and educators need to promote design thinking pedagogy (Henriksen et al., 2019), ethical dilemma story pedagogy (Taylor, 2022), the use of maker spaces, interdisciplinary/transdisciplinary projects, and hands-on learning and integrate it into classrooms, and encourage teamwork and creative problem-solving. Realising that not all students contribute equally and function well in groups, teachers will have an additional challenge to ensure each group have a range of abilities and strengths that they can collectively utilise.

As teachers themselves have experienced and gone through a ‘teacher-centric’ education system, most teachers are not able to internalise new approaches to teaching and learning in practice (Bentley et al., n.d.). As suggested by Bentley et al. (n.d.), during pre-service and in-service training, teachers should not be ‘only’ convinced to adopt the student-centric approach, but rather they need to be ensured that using these approaches will help them experience something different in the classroom and promote meaningful learning. Further, there is also a need to strengthen teachers’ capacities in critical reflective teaching practices.

Teacher preparation is extremely crucial for the transformation of science education at schools and universities. To make science education emancipatory, teachers’ revitalisation of knowledge and reorientation to pedagogies appear to be fundamental. Emphasis needs to be placed on a departure in teacher education, promoting the science of teaching, not limiting it to the teaching of science.

Implications for change in policy

The Constitution of Nepal (2015) has allocated school functions to the local government. Local governments have been given the authority to develop and implement local curricula (Local Government Operation Act, 2017). In this context, my study suggests that the local governments are required to design and implement locally appropriate and contextualised STEAM curricula and explore the possibilities for introducing a transdisciplinary approach to these locally developed curricula. The introduction of the locally constructed curricula would also allow teachers and students to get engaged in the process of integrating local and indigenous knowledge. This will also help reduce the existing gaps in educational policies and pedagogical practices.

The agenda of science education largely depends on the local level readiness to deliver the subject in schools. Local-level capacity is equally important for the relevant authorities to make informed policy decisions to enhance students' learning of science. Reconstruction of science education is possible provided that the local governments recognise the role of the family, linking children's home knowledge with their learning of science in schools. Policies on teacher recruitment and pedagogical choices are deeply associated with the effective delivery of science in classrooms. School management's positive attitudes towards children's home knowledge and creativity play a vital role in cultivating children's interest and enthusiasm in learning science.

Local government's policy on introducing local content in curricula, recognising place pedagogies and practising translanguaging for students' interactive engagement in class will provide a basis for transforming science education across the country. University science education needs to fulfil capacity building and demonstrative functions for generating knowledge and promoting emancipatory pedagogical practices.

Implications for further study

My study has opened ways for further engagement in generating knowledge at the academic level. The following dimensions of science education appear to be critical for further studies:

1. Home - school continuum of science education
2. Locally constructed curricula for science education in schools
3. Teachers' emancipatory pedagogical practices in science education
4. Transdisciplinary practices in schools

REFERENCES

Abrahams, I., & Millar, R. (2008). Does Practical Work Really Work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education*, *30*(14), 1945–1969. https://doi.org/10.1080/09500690701749305

Adams, D., & Hamm, M. (1994). *New designs for teaching and learning: promoting active learning in tomorrow's School*. Jossey-Bass.

Adams, T. E., Boylorn, R. M., & Tillmann, L. M. (2021). Advances in Autoethnography and Narrative Inquiry. In T. E. Adams, R. M. Boylorn, & L. M. Tillmann (Eds.), *Advances in Autoethnography and Narrative Inquiry: Reflections on the Legacy of Carolyn Ellis and Arthur Bochner*. Routledge. https://doi.org/10.4324/9781003035763

Adams, T. E., Holman Jones, S., & Ellis, C. (Eds.). (2016). *Handbook of Autoethnography*. Routledge. https://doi.org/10.4324/9781315427812

Agarkar, S., & Brock, R. (2017). Learning Theories in Science Education. In K. S. Taber & B. Akpan (Eds.), *Science Education* (Issue 1927, pp. 93–103). Sense Publishers. https://doi.org/10.1007/978-94-6300-749-8_7

Aikenhead, G. S., & Ogawa, M. (2007). Indigenous knowledge and science revisited. *Cultural Studies of Science Education*, *2*(3), 539–620. https://doi.org/10.1007/s11422-007-9067-8

Airasian, P., Cruikshank, K. A., Mayer, R. E., Pintrich, P., Raths, J., & Wittrock, M. C. (2001). *Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's*

Taxonomy of Educational Objectives (L. Anderson & D. Krathwohl (Eds.)). Longman.

Akaygun, S., & Jones, L. L. (2014). Words or Pictures: A comparison of written and pictorial explanations of physical and chemical equilibria. *International Journal of Science Education*, *36*(5), 783–807. https://doi.org/10.1080/09500693.2013.828361

Alsop, S., & Watts, M. (2003). Science education and affect. *International Journal of Science Education*, *25*(9), 1043–1047. https://doi.org/10.1080/0950069032000052180

Amador, F., Martinho, A. P., Bacelar-Nicolau, P., Caeiro, S., & Oliveira, C. P. (2015). Education for sustainable development in higher education: evaluating coherence between theory and praxis. *Assessment & Evaluation in Higher Education*, *40*(6), 867–882. https://doi.org/10.1080/02602938.2015.1054783

Archer, M., Morley, D. A., & Souppez, J.-B. R. G. (2021). Real World Learning and Authentic Assessment. In *Applied Pedagogies for Higher Education* (pp. 323–341). Springer International Publishing. https://doi.org/10.1007/978-3-030-46951-1_14

Assamoi, C. A. O. (2015). Core Competencies Development among Science and Technology (S&T) College Students and New Graduates. *American Journal of Educational Research*, *3*(9), 1077–1084. https://doi.org/10.12691/education-3-9-3

Awasthi, L. D. (2004). *Exploring Monolingual School Practices in Multilingual Nepal*. Danish University of Education.

Babaci-Wilhite, Z. (2019). Educational Tools to Teach STEAM Subjects Integrating Linguistic Rights, Collaboration, and Critical Thinking. In Z. Babaci-Wilhite (Ed.), *Promoting Language and STEAM as Human Rights in Education*. Springer

Singapore. https://doi.org/10.1007/978-981-13-2880-0

Bajracharya, H., & Brouwer, W. (1997). A narrative approach to science teaching in Nepal. *International Journal of Science Education*, *19*(4), 429–446. https://doi.org/10.1080/0950069970190406

Baldwin, C. K. (2019). Transformative Learning and Identity: A review and synthesis of Dirkx and Illeris. *Adult Education Research Conference*.

Barone, T., & Eisner, E. W. (2012). *Arts Based Research*. SAGE Publications, Inc. https://doi.org/10.4135/9781452230627

Beane, J. A. (1995). Curriculum Integration and The Disciplines of Knowledge. *The Phi Delta Kappan*, *76*(8), 616–622.

Bencze, J. L., Carter, L., Chiu, M.-H., Duit, R., Martin, S., Siry, C., Krajcik, J., Shin, N., Choi, K., Lee, H., & Kim, S.-W. (2012). Globalization and Science Education. *COSMOS*, *08*(02), 139–152. https://doi.org/10.1142/S021960771250005X

Bentley, M., Fleury, S. C., Garrison, J., & Tech, V. (n.d.). *Critical Constructivism for Teaching and Learning in a Democratic Society*.

Bhatta, B., & Bhandari, B. (2015, November 15). More Nepali households switch to electric cookers. *The Kathmandu Post*.

Bird, S. J. (2014). Socially Responsible Science Is More than “Good Science”. *Journal of Microbiology & Biology Education*, *15*(2), 172. https://doi.org/10.1128/JMBE.V15I2.870

Bista, D. B. (2020). *Bhagyabad Ra Vikas [Fatalism and Development]*.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals* (Vol.

1). David McKay Company.

Bodner, G., Klobuchar, M., & Geelan, D. (2001). The Many Forms of Constructivism. *Journal of Chemical Education*, *78*(8), 1107. https://doi.org/10.1021/ed078p1107.4

Brandt, R. (1992). On Outcome - Based Education: A Conversation with Bill Spady. *Educational Leadership*, *50*(4), 66–70.

Brookfield, S. (1994). Tales from the dark side: a phenomenography of adult critical reflection. *International Journal of Lifelong Education*, *13*(3), 203–216. https://doi.org/10.1080/0260137940130303

Brookfield, S. (1998). Critically Reflective Practice. *The Journal of Continuing Education in the Health Professions*, *18*, 197–205.

Bruner, J. S. (1960). *The Process of Education*. Harvard University Press.

Burbules, N. C., & Linn, M. C. (1991). Science education and philosophy of science: Congruence or contradiction? *International Journal of Science Education*, *13*(3), 227–241. https://doi.org/10.1080/0950069910130302

Bush, S. B., & Cook, K. L. (2019). Structuring STEAM Inquiries: Lessons Learned from Practice. In *STEAM Education* (pp. 19–35). Springer International Publishing. https://doi.org/10.1007/978-3-030-04003-1_2

Canagarajah, S. (2012). *Translingual Practice*. Routledge. https://doi.org/10.4324/9780203073889

Carspecken, P. F. (1996). *Critical Ethnography in Educational Research: A Theoretical and Practical Guide*. Routledge.

CBS. (2012). *National Population and Housing Census 2011*.

CDC. (2019). *National Curriculum Framework for School Education*.

Chang, H. (2016). *Autoethnography as Method*. Routledge. https://doi.org/10.4324/9781315433370

Chatterjee Singh, N., & Duraiappah, A. K. (Eds.). (2020). *Rethinking learning: a review of social and emotional learning frameworks for education systems*. UNESCO MGIEP.

Cobern, W. W. (1994). *Worldview theory and conceptual change in science education. Scientific Literacy and Cultural Studies project*. *80*(5), 1–31.

Collins, C. S., & Stockton, C. M. (2018). The Central Role of Theory in Qualitative Research. *International Journal of Qualitative Methods*, *17*(1), 1–10. https://doi.org/10.1177/1609406918797475

Connor, A. M., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: Strategies for Enhancing Engineering & Technology Education. *International Journal of Engineering Pedagogy (IJEP)*, *5*(2), 37. https://doi.org/10.3991/ijep.v5i2.4458

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. *Handbook of Research on Science Education*, *2*(11237), 515–542. https://doi.org/10.4324/9780203097267

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (4th ed.). Pearson. https://doi.org/10.1017/CBO9781107415324.004

Creswell, J. W., & Poth, C. N. (2017). Qualitative Inquiry and Research Design: Choosing Among Five Approaches. In *SAGE* (4th ed.). SAGE Publications, Inc.

Cummins, J. (2000). Language, Power and Pedagogy. In *Language, Power and*

Pedagogy (Issue 23). Multilingual Matters. https://doi.org/10.21832/9781853596773

Danish, J. A., & Gresalfi, M. (2018). *Cognitive and Sociocultural Perspective on Learning: Tensions and Synergy in the Learning Sciences* (F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.); pp. 1–11). Routledge.

Dastgoshadeh, A., & Jalilzadeh, K. (2011). Language loss, identity, and English as an international language. *European Journal of Social Sciences*, *21*(4), 659–665.

DeBoer, G. E. (1991). *A history of ideas in science education: Implications for practice.* Teachers College Press.

Denzin, N. K. (1997). *Interpretive ethnography: ethnographic practices for the 21st century*. SAGE Publications.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The Discipline and Practice of Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (pp. 1–32). Sage Publications Ltd.

Denzin, N. K., & Lincoln, Y. S. (Eds.). (2018). *The SAGE Handbook of Qualitative Research* (5th ed.). SAGE Publications.

Dewey, J. (1986). Experience and Education. *The Educational Forum*, *50*(3), 241–252. https://doi.org/10.1080/00131728609335764

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The Impact of Enhancing Students' Social and Emotional Learning: A Meta-Analysis of School-Based Universal Interventions. *Child Development*, *82*(1), 405–432. https://doi.org/10.1111/j.1467-8624.2010.01564.x

Edgar, A. (2006). *Habermas. The Key Concepts.* Routledge.

Educators say integrating school subjects into interdisciplinary approach has benefits.

(2017). https://www.k-state.edu/media/newsreleases/2017-03/subjects31017.html

Ellis, C., Adams, T. E., & Bochner, A. P. (2010). Autoethnography: An overview. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *12*(1). https://doi.org/https://doi.org/10.17169/fqs-12.1.1589

Ellis, C., & Bochner, A. (2000). Autoethnography, Personal Narrative, Reflexivity: Researcher as Subject. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (2nd ed., pp. 733–768). SAGE Publications.

Ermine, W., Sinclair, R., & Jeffery, B. (2004). *The Ethics of Research Involving Indigenous Peoples*. https://doi.org/10.13140/RG.2.2.23069.31200

Fabiansson, C. (2015). Young people's societal belonging and perception of social status within networks. *Rural Society*, *24*(1), 85–105. https://doi.org/10.1080/10371656.2014.1001476

Fanon, F. (1963). *The wretched of the earth* (C. Farrington (Trans.)). Grove Press.

FAO in Nepal. (n.d.). *Nepal at a glance*. Retrieved 3 October 2022, from https://www.fao.org/nepal/fao-in-nepal/nepal-at-a-glance/en/

Fazzino, E. (2017, August 10). *The Skills of the 21st Century*. Scientific Scribbles. https://blogs.unimelb.edu.au/sciencecommunication/2017/08/10/the-skills-of-the-21st-century-emma-fazzino/

Fensham, P. J. (2008). *Science education policy-making: eleven emerging issues*. UNESCO.

Fitts, P. M., & Postner, M. T. (1967). *Human performance*. Brooks/Cole Pub. Co.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School Engagement: Potential of the Concept, State of the Evidence. *Review of Educational Research*, *74*(1), 59–

109. https://doi.org/10.3102/00346543074001059

García, O., & Wei, L. (2014). *Translanguaging: Language, Bilingualism and Education*. Palgrave Macmillan UK. https://doi.org/10.1057/9781137385765

Gautam, G. R. (2018). *Becoming and being an English education professional: an autoethnographic inquiry from Gurukum Sankskrit education to English language teacher education*. Kathmandu University.

Gautam, S. (2016). Need of Soft Skills for Undergraduate Urban Youth for Career Development. *Journal of Training and Development*, *2*, 79–87. https://doi.org/10.3126/JTD.V2I0.15441

Gevelt, T. van. (2019). *Romanticizing the adaptive capacity of indigenous communities*. https://sustainabilitycommunity.nature.com/users/320749-terry-van-gevelt/posts/54794-romanticizing-the-adaptive-capability-of-indigenous-communities

Given, L. M. (Ed.). (2008). *The SAGE Encyclopedia of Qualitative Research Methods* (Vols 1 & 2). SAGE Publications.

Gross, K., & Gross, S. (2016). Transformation: Constructivism, Design Thinking, and Elementary STEAM. *Art Education*, *69*(6), 36–43.

Grundy, S. (1987). Three Fundamental Human Interests. In *Curriculum: Product or Praxis* (pp. 5–20). The Falmer Press.

Gu, J., & Belland, B. R. (2015). Preparing Students with 21st Century Skills: Integrating Scientific Knowledge, Skills, and Epistemic Beliefs in Middle School Science Curricula. In X. Ge, D. Ifenthaler, & J. M. Spector (Eds.), *Emerging Technologies for STEAM Education* (pp. 39–60). Springer International Publishing.

https://doi.org/10.1007/978-3-319-02573-5

Gupta, A. H. (2020, July 15). A Teacher Held a Famous Racism Exercise in 1968. She’s Still at It. *The New York Times*.

Habermas, J. (1971). *Knowledge and Human Interests* (J. Shapiro (Trans.)). Beacon Press.

Harari, Y. N. (2018). *21 Lessons for the 21st Century*. Spiegel & Grau.

Henderson, J. G., & Gornik, R. (2007). *Transformative curriculum leadership*. Pearson Merrill/Prentice Hall.

Henriksen, D., Mehta, R., & Mehta, S. (2019). Design Thinking Gives STEAM to Teaching: A Framework That Breaks Disciplinary Boundaries. In *STEAM Education* (pp. 57–78). Springer International Publishing. https://doi.org/10.1007/978-3-030-04003-1_4

Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education*, *25*(6), 645–670. https://doi.org/10.1080/09500690305021

Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education-a pedagogical justification and the state-of-the-art in Israel, Germany, and the USA. *International Journal of Science and Mathematics Education*, *9*(6), 1459–1483. https://doi.org/10.1007/s10763-010-9273-9

Howes, E. V. (2002). *Connecting Girls and Science: Constructivism, Feminism, and Science Education Reform. Ways of Knowing in Science and Mathematics Series*.

Hunter-Doniger, T., & Sydow, L. (2016). A Journey from STEM to STEAM: A Middle School Case Study. *The Clearing House: A Journal of Educational Strategies,* *Issues and Ideas*, *89*(4–5), 159–166. https://doi.org/10.1080/00098655.2016.1170461

Image: Student of University of Madras. Preparations for exams (working hard, they tie hair to nail in wall to prevent falling into sleep). (1905). In *Vlas Mikhailovich Doroshevich - East and War* (p. 113). Sytin publisher.

Jones, C. A., & Davison, A. (2021). Disempowering emotions: The role of educational experiences in social responses to climate change. *Geoforum*, *118*, 190–200. https://doi.org/10.1016/J.GEOFORUM.2020.11.006

Kant, I. (1998). *Critique of Pure Reason* (P. Guyer & A. W. Wood (Trans.)). Cambridge University Press.

Kennedy, V., & Cram, F. (2010). Ethics of Researching with Whānau Collectives. *MAI Review*, *3*.

Kioupi, V., & Voulvoulis, N. (2019). Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes. *Sustainability*, *11*(21), 6104. https://doi.org/10.3390/su11216104

Kolawole, O. D. (2015). Twenty reasons why local knowledge will remain relevant to development. *Development in Practice*, *25*(8), 1189–1195. https://doi.org/10.1080/09614524.2015.1078777

Kompf, M. (1996). *Changing research and practice : teachers' professionalism, identities, and knowledge*. Falmer Press.

Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). *Taxonomy of educational objectives: The classification of educational goals* (Vol. 2). David McKay Company.

Larrivee, B. (2000). Transforming Teaching Practice: Becoming the critically reflective teacher. *Reflective Practice*, *1*(3), 293–307. https://doi.org/10.1080/713693162

Lashari, T. A., Alias, M., Kesot, M. J., & Akasah, Z. A. (2013). An affective-cognitive teaching and learning approach for enhanced behavioural engagements among engineering students. *Engineering Education*, *8*(2), 65–76. https://doi.org/10.11120/ened.2013.00011

Liao, C. (2018). From Interdisciplinary to Transdisciplinary: An Arts-Integrated Approach to STEAM Education. *Art Education*, *69*(6), 44–49. https://doi.org/10.1080/00043125.2016.1224873

Local Government Operation Act, (2017).

Luitel, B. C. (2009). *Culture, Worldview and Transformative Philosophy of Mathematics Education in Nepal: A Cultural-Philosophical Inquiry*. Curtin University of Technology.

Luitel, B. C. (2019). Journeying towards a Multi-Paradigmatic Transformative Research Program. In P. C. Taylor & B. C. Luitel (Eds.), *Research as Transformative Learning for Sustainable Futures*. Brill | Sense. https://doi.org/10.1163/9789004393349_002

Luitel, B. C., & Taylor, P. C. (2005). Overcoming culturally dislocated curricula in a transitional society: An autoethnographic journey towards pragmatic wisdom. *Annual Meeting of the American Educational Research Association*. https://doi.org/10.1145/3132847.3132886

Luitel, B. C., & Taylor, P. C. (2008). *Globalization, ecological consciousness and curriculum as montage: A vision for culturally contextualized mathematics* *education*.

Maiese, M. (2017). Transformative Learning, Enactivism, and Affectivity. *Studies in Philosophy and Education*, *36*(2), 197–216. https://doi.org/10.1007/s11217-015-9506-z

Maila, M., & Loubser, C. (2003). Emancipatory Indigenous Knowledge Systems: implications for environmental education in South Africa. *South African Journal of Education*, *23*(4), 276–280.

Majoni, C. (2017). Curriculum Overload and its Impact on Teacher Effectiveness in Primary Schools. *European Journal of Education Studies*, *3*(3), 331–346. https://doi.org/10.5281/zenodo.290597

Martin, M. (1994). Pseudoscience, the paranormal, and science education. *Science and Education*, *3*(4), 357–371. https://doi.org/10.1007/BF00488452

Matthews, M. R. (1992). Constructivism and empiricism: An incomplete divorce. *Research in Science Education*. https://doi.org/10.1007/BF02356909

Miedema, F. (2022). Transition to Open Science. In *Open Science: the Very Idea* (pp. 179–210). Springer Netherlands. https://doi.org/10.1007/978-94-024-2115-6_7

MoEST. (2019). *National Education Policy, 2019*. Ministry of Education, Science and Technology. https://moe.gov.np/assets/uploads/files/Education_Policy.pdf

Mohapatra, J. K. (1991). The interaction of cultural rituals and the concepts of science in student learning: A case study on solar eclipse. *International Journal of Science Education*. https://doi.org/10.1080/0950069910130406

Mukherjee, A., Lama, M., Khakurel, U., Jha, A. N., Ajose, F., Acharya, S., Tymes-Wilbekin, K., Sommer, M., Jolly, P. E., Lhaki, P., & Shrestha, S. (2020). Perception and practices of menstruation restrictions among urban adolescent girls and women in Nepal: a cross-sectional survey. *Reproductive Health*, *17*(1), 81. https://doi.org/10.1186/s12978-020-00935-6

Murphy, A. N., Luna, M. J., & Bernstein, M. B. (2017). *Science as experience, exploration, and experiments: elementary teachers' notions of 'doing science'*. *39*(17), 2283–2303. https://doi.org/10.1080/09500693.2017.1374578

Nakashima, D., Rubis, J., Bates, P., & Ávila, B. (2017). *Local knowledge, global goals*. UNESCO.

Nepal, H. P. (2014). *The Role of Curriculum for Rural Transformation in Nepal: A Neglected Area of Discussion*.

Nepal National Education Planning Commission. (1956). *Education in Nepal: Report of the Nepal National Education Planning Commission*.

Nicolescu, B. (1997). The Transdisciplinary Evolution of the University Condition for Sustainable Development. *International Congress 'Universities'' Responsibilities to Society"'*.

O'Sullivan, E., Morrell, A., & O'Connor, M. A. (Eds.). (2002). *Expanding the Boundaries of Transformative Learning*. Palgrave Macmillan US. https://doi.org/10.1007/978-1-349-63550-4

Ogawa, M. (1995). Science education in a multiscience perspective. *Science Education*, *79*(5), 583–593. https://doi.org/doi:10.1002/sce.3730790507

Oh, H., & Lee, Y. (2010). A Study on the Perceptual Differences about Core Competencies between Higher Education and Business Sectors. *Asian Journal of Education*, *11*(4), 95–118.

Ojha, A. (2019, October 23). Valley locals are turning to gods to combat littering and urination. *The Kathmandu Post*.

Ormiston, N. T. (2010). Re-Conceptualizing Research: An Indigenous Perspective. *First Peoples Child & Family Review*, *5*(1), 50–56.

Ortiz-Vilarelle, L. (2021). Autoethnography and Beyond: Genealogy, Memory, Media, Witness. *Life Writing*, *18*(4), 475–482. https://doi.org/10.1080/14484528.2021.1982161

Padma, T. V. (2017). Indian scientists urged to speak out about pseudoscience. *Nature*. https://doi.org/10.1038/nature.2017.22957

Pajares, M. F. (1992). Teachers' Beliefs and Educational Research: Cleaning up a Messy Construct. *Review of Educational Research*, *62*(3), 307. https://doi.org/10.2307/1170741

Pals, F. F. B., Tolboom, J. L. J., Suhre, C. J. M., & van Geert, P. L. C. (2018). Memorisation methods in science education: tactics to improve the teaching and learning practice. *International Journal of Science Education*, *40*(2), 227–241. https://doi.org/10.1080/09500693.2017.1407885

Pant, B. P. (2015). *Pondering on my Beliefs and Practices on Mathematics, Pedagogy, Curriculum and Assessment*. Kathmandu University.

Pavlenko, A., & Lantolf, J. P. (2000). Second language learning as participation: Reconstructing a self. In J. Lantolf (Ed.), *Sociocultural theory and second language learning* (pp. 155–178). Oxford University Press.

Payton, J. W., Wardlaw, D. M., Graczyk, P. A., Bloodworth, M. R., Tompsett, C. J., & Weissberg, R. P. (2000). Social and Emotional Learning: A Framework for

Promoting Mental Health and Reducing Risk Behavior in Children and Youth. *Journal of School Health*, *70*(5), 179–185. https://doi.org/10.1111/j.1746-1561.2000.tb06468.x

Perrier, F., & Nsengiyumva, J. B. (2003). Active science as a contribution to the trauma recovery process: Preliminary indications with orphans from the 1994 genocide in Rwanda. *International Journal of Science Education*, *25*(9), 1111–1128. https://doi.org/10.1080/0950069032000052225

Pham, L. (2018). *A Review of key paradigms: positivism, interpretivism and critical inquiry*. *April*. https://doi.org/10.13140/RG.2.2.13995.54569

Piaget, J. (1952). The origins of intelligence in children. *International Universities Press*.

Pinar, W. F. (1975, April). The Method of 'Currere.' *Annual Meeting of the American Research Association*.

Prasain, S. (2021, June 29). Nepal wants to be an agriculture-driven economy but future of the sector is in crisis. *Kathmandu Post*.

Pun, U. (2019, May 15). Agricultural education. *Kathmandu Post*.

Qutoshi, S. B. (2015). Auto/ethnography: A Transformative Research Paradigm. *Dhaulagiri Journal of Sociology and Anthropology*, *9*, 161–190. https://doi.org/10.3126/dsaj.v9i0.14027

Qutoshi, S. B. (2019). Cultural-Self Knowing: Transforming Self and Others. In P. C. Taylor & B. C. Luitel (Eds.), *Research as Transformative Learning for Sustainable Futures* (pp. 147–159). Brill | Sense. https://doi.org/10.1163/9789004393349_009

Radziwill, N., Benton, M., & Moellers, C. (2015). From STEM to STEAM: Reframing What it Means to Learn. *The STEAM Journal*, *2*(1), 1–7.

https://doi.org/10.5642/steam.20150201.3

Rahmawati, Y., & Taylor, P. C. (2015). Moments of critical realisation and appreciation: a transformative chemistry teacher reflects. *Reflective Practice*, *16*(1), 31–42. https://doi.org/10.1080/14623943.2014.944142

Rai, I. M. (2017). Identity Paradoxes of Urbanized Kirats: An Auto/ethnographic Inquiry. In *Unpublished PhD thesis*. Kathmandu University.

Raikhan, S., Moldakhmet, M., Ryskeldy, M., & Alua, M. (2014). The Interaction of Globalization and Culture in the Modern World. *Procedia - Social and Behavioral Sciences*, *122*, 8–12. https://doi.org/10.1016/j.sbspro.2014.01.1294

Rhulani Ubisi, N., Kolanisi, U., & Jiri, O. (2019). Comparative review of indigenous knowledge systems and modern climate science. *Ubuntu : Journal of Conflict and Social Transformation*, *8*(2), 53–73. https://doi.org/10.31920/2050-4950/2019/8n2a3

Rubin, K. H., Bukowski, W. M., & Parker, J. G. (2006). Peer Interactions, Relationships, and Groups. In N. Eisenberg, W. Damon, & R. M. Lerner (Eds.), *Handbook of child psychology: Social, emotional, and personality development* (pp. 571–645). John Wiley & Sons, Inc.

Rushton, I., & Suter, M. (2012). *Reflective Practice for Teaching in Lifelong Learning*. McGraw-Hill.

Sadler, T. D. (2011). *Situating Socio-scientific Issues in Classrooms as a Means of Achieving Goals of Science Education* (pp. 1–9). https://doi.org/10.1007/978-94-007-1159-4_1

Said, E. W. (1995). *Orientalism*. Penguin Books India.

SEL for Students: Self-Awareness and Self-Management. (n.d.). Greater Good In

Education. Retrieved 31 July 2020, from https://ggie.berkeley.edu/student-well-being/sel-for-students-self-awareness-and-self-management/

Sellar, S., & Lingard, B. (2014). The OECD and the expansion of PISA: new global modes of governance in education. *British Educational Research Journal, 40*(6), 917–936. https://doi.org/10.1002/berj.3120

Shaker, D. (2018). Cognitivism and psychomotor skills in surgical training: from theory to practice. *International Journal of Medical Education*, *9*, 253–254. https://doi.org/10.5116/IJME.5B9A.129B

Sharma, C. B., Pathak, A., & Sinha, A. (n.d.). Constructivism. In *Theories of Learning: A Critical Summary* (pp. 51–65).

Sharma, N. K. (2014). Globalization and its Impact on the Third World Economy. *Crossing the Border: International Journal of Interdisciplinary Studies*, *1*(1), 21–28. https://doi.org/10.3126/ctbijis.v1i1.10465

Shrestha, I. M. (2015). *Disempowering Forces Influencing Meaningful Learning of Mathematics: A Case of a Private School*.

Sidik, S. M. (2022). Weaving Indigenous knowledge into the scientific method. *Nature*, *601*(7892), 285–287. https://doi.org/10.1038/d41586-022-00029-2

Silk, M., Stewart, C., & Mauer, A. (2019). Hungry Birds – a STEAM Experience. In S. Goldstine, D. McKenna, & K. Fenyvesi (Eds.), *Proceedings of Bridges 2019: Mathematics, Art, Music, Architecture, Education, Culture* (pp. 561–568). Tessellations Publishing.

Simpson, E. (1972). *The classification of educational objectives in the psychomotor domain: The psychomotor domain* (Vol. 3). Gryphon House.

Smith, O. (2015). There is an Art to Teaching Science in the 21st Century. In X. Ge, D. Ifenthaler, & J. M. Spector (Eds.), *Emerging Technologies for STEAM Education* (pp. 81–92). Springer International Publishing. https://doi.org/10.1007/978-3-319-02573-5

Social and emotional learning (SEL) competencies. (2017). Collaborative for Academic, Social, and Emotional Learning and Emotional Learning.

Spady, W. G. (1994a). Choosing outcomes of significance. *Educational Leadership*, *51*(6), 18–22.

Spady, W. G. (1994b). *Outcome-Based Education: Critical Issues and Answers*. American Association of School Administrators. https://doi.org/10.1016/S0197-0070(86)80137-1

Spady, W. G., & Marshall, K. J. (1991). Beyond Traditional Outcome-Based Education. *Educational Leadership*, *49*(2), 67–72.

Stacey, O., De Lazzari, G., Grayson, H., Griffin, H., Jones, E., Taylor, A., & Thomas, D. (2018). The Globalization of Science Curricula. In *IEA Research for Education* (Vol. 3). Springer International Publishing. https://doi.org/10.1007/978-3-319-71532-2

Stewart, M. (2012). Understanding Learning: Theories and Critique. In L. Hunt & D. Chalmer (Eds.), *University teaching in focus: a learning-centred approach* (pp. 3–20). Routledge.

Strauss, V. (2016, December 23). Teacher: A one-size-fits-all approach to instruction is stifling our classrooms. *The Washington Post*.

Taber, K. S. (2020). Why do natural scientists tend to make poor social scientists?

Tennessee Association of Science Department Chairs Research Symposium and Competition.

Taimur, S., & Sattar, H. (2019). *Education for Sustainable Development and Critical Thinking Competency* (pp. 1–11). https://doi.org/10.1007/978-3-319-69902-8_64-1

Taylor, E. (Lily). (2022). Ethical Dilemma Story Pedagogy. In *Transformative STEAM Education for Sustainable Development* (pp. 20–33). BRILL. https://doi.org/10.1163/9789004524705_002

Taylor, P. C. (2014). Contemporary Qualitative Research. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of Research on Science Education, Volume II*. Routledge. https://doi.org/10.4324/9780203097267.ch3

Taylor, P. C. (2015). Transformative Science Education. In R. Gunstone (Ed.), *Encyclopedia of Science Education*. Springer Netherlands. https://doi.org/10.1007/978-94-007-6165-0_212-2

Taylor, P. C., & Campbell-Williams, M. (1992). Discourse towards balanced rationality in the high school mathematics classroom: Ideas from Habermas' critical theory. *Seventh International Congress of Mathematics Educators (ICME-7)*.

Taylor, P. C., & Taylor, E. (2019). *Transformative STEAM Education for Sustainable Development*. *December 2018*. https://doi.org/10.13140/RG.2.2.16860.44160

Taylor, P. C., Taylor, E., & Luitel, B. C. (2012). Multi-paradigmatic Transformative Research as/for Teacher Education: An Integral Perspective. In K. Tobin, B. Fraser, & C. McRobbie (Eds.), *Second International Handbook of Science Education* (pp. 373–387). Springer Netherlands. https://doi.org/10.1007/978-1-4020-9041-7_26

Thagard, P. R. (1978). Why Astrology is a Pseudoscience. *PSA: Proceedings of the*

Biennial Meeting of the Philosophy of Science Association, *1978*(1), 223–234. https://doi.org/10.1086/psaprocbienmeetp.1978.1.192639

The Constitution of Nepal, (2015).

The Himalayan Times. (2021, November 3). Students' exodus. *The Himalayan Times*.

The Perth Declaration on Science and Technology Education. (2007). *World Conference on Science and Technology Education*.

Tobin, K. G., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. G. Tobin (Ed.), *The practice of constructivism in science education* (pp. 3–21). Lawrence Erlbaum.

UNESCO. (n.d.). *Science for Society*. Retrieved 4 February 2021, from https://en.unesco.org/themes/science-society

UNESCO. (2015a). *Incheon Declaration Framework for Action*.

UNESCO. (2015b). *Rethinking Education: Toward Global Common Good?*

UNESCO. (2017). *Education for Sustainable Development Goals: Learning Objectives*. UNESCO.

UNESCO, & Kathmandu University. (2008). *Developing culturally contextualised mathematics resource materials: capturing local practices of Tamang and Gopali communities*.

Van Aalsvoort, J. (2004). Logical positivism as a tool to analyse the problem of chemistry's lack of relevance in secondary school chemical education. *International Journal of Science Education*, *26*(9), 1151–1168. https://doi.org/10.1080/0950069042000205369

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020).

Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. *SAGE Open*, *10*(1). https://doi.org/10.1177/2158244019900176

Vygotsky, L. S. (1978). *Mind in Society: Development of Higher Psychological Processes*. Harvard University Press.

Wagle, S. K. (2021). *Place Pedagogies, Eco-Spiritual Cosmologies, and Cultural Stories: Wisdom from Dharmashala*. Kathmandu University.

Wai, J., Lubinski, D., & Benbow, C. P. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative psychological knowledge solidifies its importance. *Journal of Educational Psychology*, *101*(4), 817–835. https://doi.org/10.1037/a0016127

Wang, Q., Song, Q., & Kim Koh, J. B. (2017). Culture, Memory, and Narrative Self-Making. *Imagination, Cognition and Personality*, *37*(2), 199–223. https://doi.org/10.1177/0276236617733827

Werder, C. (2016). Chapter 10 - Writing As Inquiry, Writing As Thinking. In *The Research Process: Strategies for Undergraduate Students*.

Willis, J. (2007). *Foundations of Qualitative Research: Interpretive and Critical Approaches*. SAGE Publications, Inc. https://doi.org/10.4135/9781452230108

Wujastyk, D. (1998). Science and Vedic Studies. *Journal of Indian Philosophy*, *26*(4), 335–345. https://doi.org/10.1023/A:1004393620724

Yoder, N. (2014). Teaching the Whole Child: Instructional Practices That Support Social-Emotional Learning in Three Teacher Evaluation Frameworks. In *The English Journal*. American Institutes for Research.

Zaidi, Z., & Larsen, D. (2018). Commentary. *Academic Medicine*, *93*(11S), S1–S7. https://doi.org/10.1097/ACM.0000000000002384