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Teaching with Cloud Computing in Schools: an affordance analysis of Hong Kong teacher perceptions

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ABSTRACT

Cloud computing distinguishes itself from traditional computing models by providing infrastructure, platform, and software services from the provider's data centre to fulfil consumer needs across the Internet. Given the established government policy in Hong Kong to extend the use of information and communication technology (ICT) in education, this research explored how and evaluated whether cloud computing supported teaching according to the teachers' perceptions in primary and secondary schools of Hong Kong.

This research was guided by a theoretical framework that drew on Norman's notion of perceived affordances, socio-cultural theory by Vygotsky and mediation theory by Wertsch, recognising that learning should be understood in the socio-cultural context in which students interact with each other, with the teacher and with the technology. The socio-cultural context was conceptualised by viewing the classroom as a pedagogic assemblage including pentadic elements suggested by Burke. The socio-cultural theory helped to reflect on the classroom phenomena, e.g. 'Why teachers do or do not perceive affordance in different socio-cultural contexts?'.

This research adopted the pragmatic paradigm. Both qualitative and quantitative data were collected through face-to-face semi-structured interviews with fifteen participants who used Google applications in their daily teaching duty in primary and secondary schools of Hong Kong. The research collected data only on the teachers' use of Google applications. The quantitative data allowed for a comparison of how teachers rated different affordances, while the qualitative data described the values and approaches of each teacher and how the teacher used the Google applications.

The findings suggested that affordance could best be studied within a specific socio-cultural context, particularly that of the human agents (the teachers and students) who used technological tools that mediated learning. A comparison of teachers of different subjects and levels revealed how technological features that promoted learning in one context might hinder learning in the other contexts. It further showed that the use of cloud computing was in the beginning stages when the data were collected for this research in May–June 2017. This was attributed to different constraints, conceptualised as negative affordances, e.g. WiFi dependency, training required before use, and some teachers' belief that they were not useful, based on their experiences.

The data analysis led to the development of a coding scheme of affordances from the qualitative data on how cloud computing supported teaching. An attempt was made to create an evaluation checklist from the teachers' experience of affordances, as a tool that can be used in schools, e.g. by teachers and IT professionals trying to evaluate or design an ICT tool for teaching in a specific classroom.

Author's declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

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Chapter 1 Introduction

1.1 Background to the research study

Millions of teachers and students across primary and secondary schools have become dependent on cloud computing for teaching and learning because of the coronavirus pandemic (COVID-19). When I started conducting this research in 2017, the use of cloud computing within schools was just beginning to become popular. In Hong Kong, government policy was encouraging the use of information and communication technology (ICT) in teaching and learning, viewing it as a crucial tool to facilitate access to learning resources and online services to develop collaboration and problem-solving skills in order to make students self-directed learners. In the current context, where children around the world are studying remotely, the flexibility offered by cloud computing has greater value.

With cloud computing, school teachers can, for example, use a wide range of software tools at any time inside and outside the school, facilitating collaboration and supporting teaching and learning through a web browser. Cloud computing can also be used as a personal workspace for problem solving (Masud *et al.*, 2012). In contrast, there are some concerns related to the adoption of cloud computing by teachers. For example, 'Will the software not be available when there is no Internet access?', 'Are my files secured?', 'Are my files private?', and 'Are there some things that are inefficient to do online?' (Johnson 2012). Questions regarding the three-way interaction between teachers, students, and technology have become particularly urgent.

This research focused on the possibilities for teaching and learning in secondary and primary education that are opened up by cloud computing.

1.2 Rationale of the study

Previous research suggests that ICT enables schools to develop collaborative modes of learning. For example, Ingram (2016) has argued that successful use of ICT tends to favour collaborative modes of learning that contain 'discovery' elements and to empower students to learn by taking more control over their direction, pace, and sequence of learning, by using an 'invisible' pedagogy, with evidence from InterActive project, a classroom practice research project on secondary education in UK between 2000 and 2004 (John & Sutherland, 2004).

In Hong Kong, government policy supported a greater use of ICT in schools when this research started. The 'Fourth Strategy on Information Technology in Education' (ITE4) was launched in the 2015/2016 school year by Education Bureau of Hong Kong. ITE4 states that:

> 'To achieve the goal of ITE4, we aim to strengthen students' self-directed learning, problem solving, collaboration, and computational thinking competency and enhance their creativity, innovation, and even entrepreneurship skills.'
>
> ITE4 (2015/2016)

This government policy encourages students to use ICT to access learning resources and online services to develop collaboration and problem-solving skills in order to become self-directed learners, as mentioned in the goal of ITE4. In the meantime, teachers would have access to digital textbooks, educational tools, and online resources. Cloud computing is one of the technologies that can best support teachers in different ways by, for example, providing a collaboration platform for teaching and learning, and facilitating students to collaborate and access learning resources and educational tools on the cloud. At the time of data collection, however, there was little research on the use of cloud computing within school education in Hong Kong.

I have been observing the technological evolution during my career in information

technology from personal computers, inter-networking and intranet, multimedia, client/server computing, and web 2.0 to cloud computing nowadays. I was previously an information technology consultant to schools and have found that these technologies have contributed to the education sector in different ways while bringing along changes in the teaching practice. The use of cloud computing is advantageous because users do not need to purchase expensive hardware infrastructure before they can use software tools provided over the Internet. However, some teachers who have attempted to use this technology encounter problems, finding out neither what the technology could do for them nor whether it was useful for them. Some technologies, such as Google applications, are general-purpose software, and experienced users find different ways to use them but their other colleagues might not discover these uses for themselves. Education is a complex environment in which teachers and students have their own teaching beliefs and learning needs. How do I advise teachers on how to use technology in this complex situation? What do they want from the technology? Therefore, I am interested in the exploration of different ways in which a technology can help teachers and the approach to study its usefulness for teaching.

Chu & Kennedy (2011), Fu *et al.* (2011), Deng & Yuen (2010), and Yuen & Ma (2008), have all studied the affordances of Wiki and blogs, which are similar to cloud computing in that information is shared via an online platform, for undergraduate and school education. In contrast, this research studied the affordances of cloud computing in primary and secondary schools of Hong Kong.

1.3 Aims, objectives, and research questions

Given the established government policy to extend the use of ICT in education, cloud computing is one of the technologies that can best support teachers in different ways by, for example, providing a collaboration platform for teaching and learning and facilitating students to access learning resources and educational tools on the cloud. The aims of this research were, first, to explore how cloud computing supports teaching, and second, to evaluate whether teachers in primary and secondary schools in Hong Kong perceive that cloud computing can support teaching and the reasons for their perception.

These questions aimed to provide an insight into the different ways in which cloud computing could support pedagogical approaches that could in turn help teachers design learning activities involving cloud computing. They were also intended to develop an insight into teacher experiences that could help IT professionals in technology improvement. An attempt was also made to use these experiences to construct an evaluation checklist, that was more user friendly, such that other observers who might be teachers or IT professionals could use it to study how and whether an educational tool supports teaching.

Affordance analysis was used to explore how cloud computing supports teaching in different socio-cultural contexts. According to the concept of perceived affordances from Norman (1988) applied to this topic, the affordance under study referred to the perceived properties of the technology that determined how it could possibly be used for teaching. This research set out a theoretical framework that integrated the socio-cultural study on pedagogic assemblage into the affordance analysis, recognising that affordance was influenced by the socio-cultural context of the classroom.

Therefore, the objectives of this research were as follows:

i) to review the international literature on socio-cultural theory, pedagogical approaches regarding the use of technology, and affordance theories;
ii) to present an overview of the context for the use of ICT in teaching and learning in the schools of Hong Kong;
iii) to set out a theoretical framework of the affordance analysis for an educational technology;
iv) to interview teachers and information technology officers in schools about the use of Google applications in teaching and learning;
v) to study the perceived affordances of teachers and use these affordances to construct an evaluation checklist; and
vi) to contribute to the academic debate on the affordance analysis if ICT is used for teaching and learning.

This research pursued the following three research questions:

RQ1: What do teachers perceive to be the affordances of Google applications with respect to supporting their teaching?
RQ2: How do teachers perceive the affordances of Google applications in different school subjects and at different educational levels?
RQ3: What are the teachers' opinions of the usability of Google applications in supporting their teaching?

RQ1 explores how cloud computing supports teaching through the affordance analysis. RQ2 is concerned with whether the teachers' perceptions of the affordances of cloud computing differ across school subjects and school year groups, and the causes of their beliefs. RQ3 evaluates whether cloud computing supports teaching in terms of the teachers' rating on the overall fit for use and ease to use and explores the reasons why

teachers give these opinions.

Google applications are used as an example for the study of the affordances of cloud computing. Google applications cannot represent cloud computing, but Google applications are chosen as an example of 'Software as a Service' (SaaS) under the cloud computing service model, to be discussed in Section 3.1.1, because they are software tools for general purposes that can have a different significance in different teaching and learning scenes, for example different school subjects at different educational levels, and have been used in schools worldwide including Hong Kong. The research did not inquire into applications from multiple companies because this would introduce different variables. For example, they have different designs and different compatibility with other platforms. Investigating a single application allows for a comparison of the affordances identified by different teachers for the same technology. If a teacher perceived an affordance but another teacher who used the same application did not perceive the same affordance, what is the reason of this disparity?

The next two sections explain how the aims, research objectives, and research questions cohere theoretically and methodologically.

1.4 Theoretical overview

Gibson (1979) coined the term 'affordance' by saying that affordances are what the technology offers the users, or what it provides, either for good or bad. The concept of perceived affordances by Norman (1988) developed this idea and described the term 'affordance' as the perceived properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used.

This research attempted to answer the three research questions by a study of the perceived properties of the technology that determine how it could possibly be used according to the definition by Norman (1988), recognising that teachers are teaching experts in the field and their perception will provide insights into affordances.

Google applications are general-purpose cloud computing tools. This research set out a theoretical framework that integrates the socio-cultural study on pedagogic assemblage into the affordance analysis, recognising that teachers may indeed use the same application for different educational purposes and that affordance can only be perceived in a specific socio-cultural context. In other words, affordances are situated.

This research categorised affordances into educational, social, and technological, recognising the different roles of ICT in teaching and learning and into different themes of affordances under these categories. The framework conceptualises the socio-cultural context by viewing the classroom as a pedagogic assemblage (Robertson & Dale, 2009) that includes pentadic elements (Burke, 1969): an educational '**scene**' such as teaching a certain school subject at a certain educational level; '**agents**' who are the teacher and the students; pedagogical '**purposes**'; '**agencies**' which are the technologies such as WiFi, broadband, computer, and iPad; and pedagogic '**acts**'. This is consistent with the socio-cultural theory by Vygotsky (1978), who argued that learning should be understood by studying the socio-cultural context in which children interact with each other and with

the teacher.

The concept of mediation was introduced by Wertsch (1997), who argued that the human agents (the teachers and students) and the agencies (the cultural tools for teaching and learning including the technologies) are the fundamental unit of analysis (Wertsch, 1994) and we cannot study either the human agents or the technology in isolation from each other. Any attempt to do so obscures the whole picture of the interactions among them and thus fails to evaluate whether these interactions are successful in promoting learning.

Taking these principles as a starting point, a theoretical framework is set out in Chapter 2, which guides the affordance analysis in the empirical research.

1.5 Overview of the methodology

This research adopted a research design under the pragmatic paradigm. Semi-structured interviews were used to collect both qualitative and quantitative data through face-to-face semi-structured interviews. Teachers who used Google applications to teach different school subjects at different educational levels in primary and secondary schools of Hong Kong and information technology officers who supported teachers in using these tools were invited for the interviews. The interview approach was adopted, instead of using any other approach such as direct observation, recognising that these participants were teaching experts in the field and their perception could provide insight into affordances. Quantitative data were collected by asking the participants to rate the usefulness of Google applications in their teaching and were used for a comparison across the sample through descriptive statistics. Qualitative data were collected in the same interview by inviting the participants to reflect more deeply on their experiences, allowing them to give opinions and the reasons behind their rating in the quantitative questions, and to express their feeling in different affordances and constraints. The coding of qualitative data was guided by the theoretical framework that categorised the different themes of affordances perceived from the technology in teaching and learning. The socio-cultural theory was used to reflect on the classroom phenomena for the reasons, for example, why teachers did or did not perceive affordance in the different socio-cultural contexts conceptualised in the pedagogic assemblage.

1.6 Dissertation structure

Chapter 2 reviews the international literature on socio-cultural theory, the concept of mediation, and affordance theories, and introduces the theoretical framework derived from the literature. Chapter 3 reviews the definition of cloud computing, describes Google applications, and the benefits and disadvantages of cloud computing identified in previous research, including research in the Hong Kong context. Chapter 3 also presents an overview of the context for ICT use in teaching and learning in Hong Kong schools. Chapter 4 presents the research methodology which adopts a pragmatic paradigm to collect both qualitative and quantitative data. Chapter 5 presents the findings from the data analysis that identifies and elaborates on the affordances and the constraints. How the findings answer the three research questions (RQ1, RQ2, and RQ3) and how an evaluation checklist for the affordances and the constraints can be constructed from the coding schemes studied are discussed. Chapter 6 discusses the findings, such as the significance of further research in the Hong Kong school context, and presents the conclusion of this research, including its contribution to the existing knowledge, the implication of findings, limitations of this research, further research directions, and personal reflections.

Chapter 2 Literature review

This chapter reviews the international literature that develops the concepts of socio-cultural theory, mediation, pedagogic assemblage, Burke's pentad, and affordance theories regarding technology relevant to this study. It also reviews different learning theories and pedagogical approaches that locate the affordance theory within a wider socio-cultural context and sets out the theoretical framework for the study, based on this research.

2.1 Socio-cultural theory

The tradition of socio-cultural theory was introduced by Vygotsky (1978). There are two major themes of the socio-cultural theory significant to this research: first, learning should be understood by examining the socio-cultural contexts in which children interact with each other and with the teacher. Second, human action is brought about (mediated) by psychological tools, and the concept of mediation advocates that it is the cultural tools that promote the transfer of knowledge from the external social world to the internal world of a child's thinking and remembering.

The first theme originated from Vygotsky (1978), who proposed that children learn in two stages: first, through social interactions with, for example, peers, parents, and the community, and then by integrating new knowledge into their mental structure individually:

> 'Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (inter-psychological) and then inside the child (intra-psychological).'
>
> (Vygotsky 1978, p.57)

Therefore, to understand how children gain their knowledge, we must examine the socio-cultural context in which they interact with each other, as Wertsch & Tulviste (1996)

said:

> 'In Vygotsky's view, mental functioning in the individual can be understood only by examining the social and cultural processes from which it derives.'
>
> (Wertsch & Tulviste 1996, p.54)

The interactions of cloud technology with the teacher and students form an integral part of the socio-cultural context in which learning takes place.

This research has argued that affordances could best be studied within particular socio-cultural contexts, particularly that of the human agents (the teachers and students) who use the technological tools that mediate learning. As these contexts vary within the Hong Kong classrooms, so will the affordances. Technological features that promote learning in one context might hinder learning in the other contexts.

Therefore, it is necessary to understand the socio-cultural context in which the teacher and the students interact, or we cannot properly understand the affordances that can be offered. In addition, this study also inquired into whether the technological tools offer affordances to students who are engaged in learning at both social and individual levels.

There are many potentially important factors that can influence the socio-cultural context in which learning takes place. These include elements of pedagogy such as a teacher's approach to the framing of lessons involving the sequencing and organisation of content, pacing, and classroom organisation (Bernstein, 1990). The use of ICT tools on cloud computing adds an additional layer of complexity, including the teacher's and the students' proficiency with the tools, the accessibility and stability of the ICT systems, the actors' motivation, the classroom settings, teacher-to-students relationships, and students-to-students relationships. There are different factors that influence the teachers' decision to use technology in the classroom; these include the following:

> ‘access to resources, quality of software and hardware, ease of use, incentives to change, support and collegiality in their school, school and national polices, commitment to professional learning, and background in formal computer training.’
>
> (Mumtaz 2000)

The affordances of the technological tools that mediate the interactions in the classroom will interpolate into each of these interactions, promoting or interfering with learning.

The following section discusses a key concept in socio-cultural theory, that of mediation.

2.2 Mediation

A key way in which children develop and learn involves what Vygotsky called ‘psychological tools’. Vygotsky wrote that:

> ‘humans master themselves from the outside through psychological tools’
>
> (Vygotsky 1981, p.141)

Psychological tools include language, teaching and learning strategies, and other pedagogical techniques. Sutherland *et al*. (2004) discussed that:

> ‘An important aspect of socio-cultural theory is the claim that all human action is mediated by tools.’
>
> (Sutherland *et al*. 2004)

Wertsch (1997) extended the term of psychological tools to include cultural tools. The ‘cultural tools’ concept of Wertsch encompasses both tangible and intangible objects, visual representations, sign systems, or technical tools that are involved in human action (Davis & Miyake, 2004).

Wertsch’s cultural tools include computers and computer software. For example, when students learn from their teacher through remote teaching, they cannot communicate without the mediation of cultural tools, the Google Hangouts software, the hardware, and WiFi, each of these tools connects the students and the teacher. In this direct sense, these tools mediate the communication. It is the mediation of software that facilitates the

student to learn. Most of the time, they interact with the software successfully, and at the end of remote teaching, the students learn something. In the absence of mediation or when something in the technology goes wrong, they cannot communicate at all.

According to Wertsch (1997),

> ‘mediated action involves focusing on agents and their cultural tools – the mediators of action.’
>
> (Wertsch 1997, p.25)

Wertsch (2002) offered an example of mediated action for learning:

> ‘a colleague recently asked me to recommend a book on a particular topic. I knew the book he wanted to suggest...I therefore used a cultural tool, the Internet, to go to the bookseller Amazon.com, where he looked up the author of the book in question. Her list of books appeared on the screen.’
>
> (Wertsch 2002, p.11)

The question that arises here is ‘who did the remembering?’ Wertsch (2002) discussed that:

> ‘On the one hand, a human had to be involved as an active agent who had mastered the relevant cultural tool sufficiently well to conduct the appropriate search. On the other hand, this active agent, at least at that moment, was quite incapable of remembering the title of the book in question when operating in isolation -that is, without additional help from an external cultural tool. From the perspective of mediated action, there are good reasons to say that neither the human nor Amazon.com did the remembering in isolation. Instead, both of them were involved in a system that distributed memory and both were needed to get the job done.’
>
> (Wertsch 2002, p.11)

The cultural tool facilitates remembering, but the human agent who may be a teacher, is still involved in the remembering process. For example, a teacher creates his notes on a particular topic in a document and stores them on Google Drive until the day he would want to share that topic with his students. Therefore, the teacher’s remembering of that topic cannot be separated from the notes he created earlier, as though it were an extension of his/her brain. The teacher need not remember the details of that topic but

just needs to know where to find the notes. Google Drive becomes a way of helping teachers, and students, to remember.

Google Drive mediates learning by providing storage space from the provider's data centre such that users can store documents. However, we cannot separate the role of a teacher from that of technology because they are both equally important for successful teaching.

One of the arguments in the concept of mediation from Wertsch is that there is an irreducible tension between the human agents and the cultural tool:

> 'mediated action must be understood as involving an irreducible tension between the mediational means provided by the socio-cultural setting, on the one hand, and the unique, contextualised use of these means in carrying out particular concrete actions, on the other.'
>
> (Wertsch 1994, p.202)

> 'the concrete use of cultural tools involves "irreducible tension" between active agents on the one hand, and items such as maps, narratives, and computers on the other hand.'
>
> (Wertsch 1997, p.11)

It is not only the ICT but also other media such as TV programmes, multimedia, and books that allow us to learn. If we are going to learn something, it is not just us in the learning. For Wertsch, irreducible tension implies the fundamental unit of analysis. Wertsch (1994) argued that:

> 'any attempt to reduce this basic unit of analysis to the mediational means or to the individual in isolation is misguided.'
>
> (Wertsch 1994, p.205)

What Wertsch means by 'irreducible tension' is that when human agents use a technology, they are interacting with it and there is a fundamental tension between the technology and its agents. These are held together in *tension* for the learning to take place. If any one component is taken away, the whole structure collapses. Further, by

irreducible, Wertsch meant that we cannot study either the human agents or the technology in isolation from each other, because by doing so, we cannot see the whole picture of the interactions among them for the evaluation and whether these interactions are successful and thus promote learning.

Wertsch (1997) discussed how important it is to identify the agent and the agency in a socio-cultural study. He said:

> 'analyses of mediated action, or "agent-acting-with-mediational-means", provide important insights into the other dimensions of the pentad-scene, purpose, and act. This is because these other pentadic elements are often shaped, or even 'created', by mediated action.'
>
> (Wertsch 1997, p.25)

In this research on Google applications, teachers could use technology as enabling tools to plan or teach their lessons, if they had familiarity with the tools or the tools were designed to use intuitively. This is not an inevitable outcome of giving the technology to a teacher. Sometimes, if the agents (the teacher and the students), cannot use the technological tools to enable the teacher's intended strategy, there is no affordance to teaching and learning at all. The agents cannot use the tools if they have not been trained on these tools or the tools are not designed to use intuitively. Therefore, affordance is only meaningful when analysed with respect to the socio-cultural context in which the human agents and the technology operate.

In this research, cultural tools could incorporate a range of artefacts, for example Google applications, which are a cloud computing tool with several software components (Section 3.2.1); computer hardware; and tools such as personal computers, mobile devices, networking, and WiFi that are required to gain access to the Internet. The cultural tools identified also include the information and materials stored on the cloud. It is not only the technology itself that promotes learning but also the content on the tool.

The people who interact with one another are the agents, including the teacher, the students, and all the members of the class. The agents not only interact with the technology itself but also indirectly interact with other social agents, such as the authors who wrote the learning materials (otherwise, the materials would not exist). These are what Wertsch called the fundamental unit of analysis (Wertsch, 1994), and we cannot study them in isolation from each other for learning to take place.

Through the mediation of technology, teaching and learning can be enhanced by remembering information or knowledge, bringing together people and materials for learning, and facilitating the interactions of class members, as discussed above. However, the potential tension between whether or not students can learn also depends on whether the technology is used in the socio-cultural context for which it is designed, for example the age group or the educational level. The reason why learning does not happen might also be a poorly designed or an inefficient form of technology. The best technology should be transparent, easy to use, and intuitive. If a human cannot use the technology or the technology does not work properly, the learning fails.

As Sutherland *et al.* (2004) argued:

> 'the idea of person-acting-with-mediational (Wertsch 1991) both expands the view of what a person can do and also suggests that a person might be constrained by their situated and mediated action.'
>
> Sutherland, *et al.* (2004)

2.3 Pedagogic assemblage and Burke's pentad

This research attempted to view a classroom that contained the above elements as being a 'pedagogic assemblage'. Youdell (2015) attributed the term 'assemblage' to Deleuze & Guattari (1983) who used the notion of 'assemblage' to think about the multiplicity of diverse and moving elements that combine to form complex social formations. Robertson & Dale (2009) suggested that the classroom might be viewed as an assemblage to explore how new technologies can shift the balance of authority in terms of pedagogy and learning:

> 'We might imagine each classroom as an "assemblage" made up of combinations of elements (such as students, teachers, curriculum, texts, pedagogical practices, and community) that are "fixed" together by cultural norms, roles, official policies, and so on.'
>
> 'Viewing classrooms as an assemblage, on the one hand, keeps the system more open and, on the other hand, opens to the possibility of seeing it as far more dynamic and open to changes, both small and big.'
>
> (Robertson & Dale 2009, p.142)

Figure 1 illustrates an outline of the teacher and the students mediated by technological tools in a teaching scene for certain educational purposes in a pedagogic assemblage.

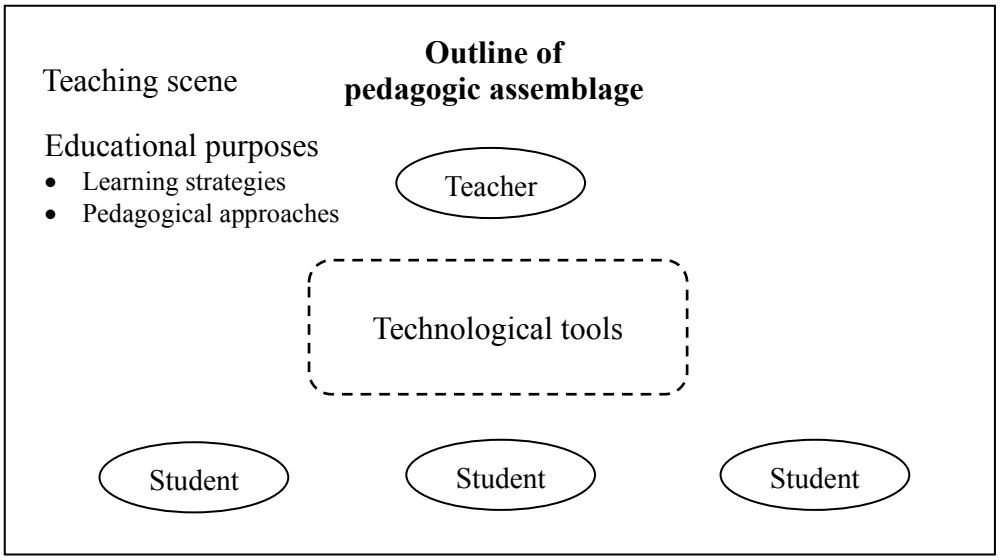

Figure 1 – Outline of pedagogic assemblage

Burke (1969) conceptualised the following five pentadic elements (Burke's pentad) that help to understand the socio-cultural context within a pedagogic assemblage:

Scene:	When and where was it done?
Agent:	Who did it?
Purpose:	Why was it done?
Agency:	How was it done?
Act:	What was done?

Ruth (2008) discussed that the pentad is a methodological tool for the investigation of how the learning theory offers a better understanding of the mediated learning environment and argued that:

> 'this framework provides a coherent and comprehensive consideration of learning and communication mediated by electronic means. Research on computer-mediated communication needs to acknowledge the intertwining notion of the agents, acts, and agency (mediation) within a specific scene, particularly in an online learning environment.'
>
> (Ruth 2008, p.1)

This research attempted to understand the socio-cultural context in a pedagogic assemblage mediated by the cultural tools by answering the following five questions according to Burke's pentad:

Scene:	What is the teaching and learning context (i.e. educational levels, school subjects, and/or classroom setting)?
Agent:	Who are involved in the pedagogic actions (e.g. the teacher, the students, and/or authors of learning materials)? The interactions can be interpreted using socio-cultural models, such as visible and invisible pedagogies, that describe the dynamics of power relations in the classroom. (Bernstein, 2000).
Purpose:	What are the learning objectives and motivations of the pedagogic actions (e.g. the learning outcomes)?
Agency:	Which tools allow these pedagogic actions to take place?
Act:	What pedagogic actions should take place between the teacher and the students? Learning can be interpreted as outcomes recognised by established learning theories such as behaviourism, cognitivism, constructivism, and social constructivism.

This research studied what affordances from cloud computing made the 'Act' successful, what constraints made the 'Act' unsuccessful, and what the 'irreducible tensions' among the agents and the agencies were.

The following scenario gives an example of the suggested approach for analysing the teaching and learning environment by Burke's pentad:

Scene:	Teaching English Language in the secondary school classroom
Agent:	The teacher, students
Purpose:	To teach English by cooperative writing on a piece of composition in the entire class
Agency:	Google Docs, Google Drive
Act:	The teacher and students interacted with Google Docs in the cooperative writing. This involved social constructivist learning.

2.4 Different pedagogical approaches

The 'purpose' dimension of the Burke's pentad describes the learning objectives and motivations of pedagogic actions. Teachers' designs of classroom activities are likely to depend on some underpinning learning theories to be discussed in Section 2.4.1.

Another example of the motivation is a collaborative mode of learning that uses ICT to maintain power relations in the classroom by using visible and invisible pedagogies (Bernstein, 2000), for knowledge to emerge from students themselves; this will be discussed in Section 2.4.2.

Besides classroom activities, different roles of assessment that can be facilitated through the mediation of technology will be discussed in Section 2.4.3.

Figure 2 interprets the elements of a pedagogic assemblage using Burke's pentad. These include pedagogic actions, i.e. the '**Acts**' mediated by the '**Agencies**', which are the technologies under a certain educational '**Scene**' from the '**Agents**' who are the teacher

and the students interacting together for specific educational '**Purposes**'. These elements allow us to understand the socio-cultural context in each example of teaching mediated by the technology that enables pedagogic actions.

The data analysis attempted to find different examples of affordances to different classroom activities, collaborative modes of learning, and different types of assessment in different educational scenes from the data collected.

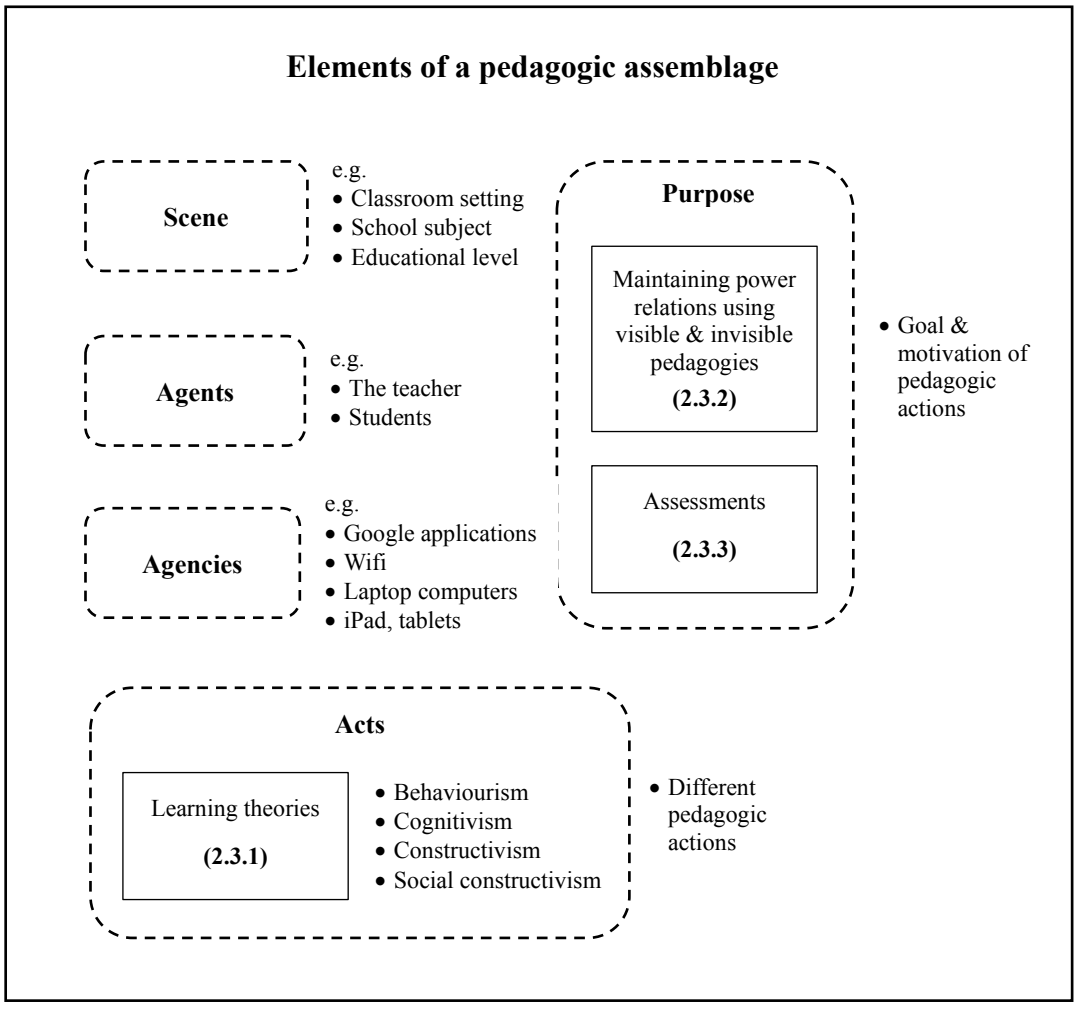

Figure 2 – Elements of pedagogic assemblage in socio-cultural study

2.4.1 Learning theories

How teachers design pedagogic actions within a pedagogic assemblage is likely to depend on the underpinning learning theories that inform their understanding of teaching and learning. In this section, four different learning theories are explored. Each of these may lead to different classroom activities within the same context, and therefore, how the technology could help teachers to embody these different learning theories was explored. The four learning theories considered here are behaviourism, cognitivism, constructivism, and social constructivism, each of which have been central to the teaching and learning practices over the years (Doherty, 2012).

Behaviourism focuses on changing the behaviour of students for learning. Doherty (2012) discussed that:

> 'Broadly speaking, behaviourists view the learning process in terms of an end point defined as an exhibited change in behaviour. That is, the learner has learned when he/she can do something that he/she could not do before. This something might exhibit knowledge by being tested or demonstrating a particular skill. A behaviourist advocates the educational process to be centred on eliciting the desired responses through, for example, drill and practice exercises.'
>
> (Doherty 2012, p.28)

Behaviourism suggests that behaviour is likely to be repeated if it produces a positive outcome, for example, by reward. Similarly, a negative experience is unlikely to be repeated, for example, by punishment. In the pedagogic assemblage, positive experiences are likely to lead to an increase in motivation, whereas negative experiences are demotivating. It is part of the affordances of the software that mediates learning to allow the user to feel a sense of satisfaction from using it. This research inquired whether students interact satisfactorily with Google applications from behaviourist perspective—for example in drill and practice exercises, or in some learning activities such as navigating a computer game to produce a positive outcome and a positive experience.

Cognitivism focuses on the generalisation, categorisation, and organisation of information for effective learning. Doherty (2012) discussed that:

> 'Cognitivists focus on the workings of the memory, and cognitivist theories are characterised by beliefs about how information is stored and retrieved in human memory. As cognitivists are interested in the workings of memory and the way in which human beings process information, the educational process is considered in terms of learning designs that enable students to efficiently store and retrieve information. It should also be understood that cognitivists are concerned not just with information storage and retrieval but also with, for example, whether knowledge is meaningful or usable by students.'
>
> (Doherty 2012, p.28)

This research inquired whether Google applications enable information to be stored and retrieved efficiently from cognitivist perspective—do they allow teachers to structure information in such a way that new knowledge can be integrated within an existing knowledge structure by their students and help students to structure their information sources in such a way that promotes the formation of new thinking?

Constructivism focuses on the construction of knowledge from the students' experience. Doherty (2012) discussed that:

> 'Constructivists believe that the learner constructs or at least interprets new knowledge in terms of prior ideas, concepts, and experiences. This prior knowledge plays a pivotal role in terms of what is being learned, and the learning process must therefore take account of prior beliefs and knowledge.'
>
> (Doherty 2012, p.28)

This research inquired whether teachers could use Google applications from constructivist perspective—do they enable their students to recall their prior knowledge, understanding, and beliefs and extend them in relation to new information?

These different types of learning are actually taking place at the same time in the

classroom, and they are being mediated by the technology. For example, a learning activity may be designed to use the technology in such a way that students produce a learning outcome by reward; this is behaviourist learning; when students try to construct their meaning by using the software to collaborate with each other, it is social constructivist learning. These learning theories are embodied at the same time with the support from technology.

2.4.2 Maintaining power relations in the pedagogic assemblage by using visible and invisible pedagogies

Teachers develop and maintain power relations that establish legitimate relations of order in the classroom (Bernstein, 2000). For example, a teacher can design seating plans to organise a classroom by controlling who sits next to whom. A teacher can organise the sequence in which the lesson develops: which idea comes first, which idea follows, and when idea moves from one to another. The teacher has the authority, granted by the school, to control and regulate the work of the students.

Teachers use their power to build working relationships with each of the students. In the language of relational databases, this is a one-to-many relationship. Reciprocally, each student forms a one-to-one relationship with the teacher. In turn, students form one-to-one relationships with each other (Figure 3). Robertson & Dale used the term ‘pedagogic assemblage’ to describe the totality of power relations in the ‘fluid, interconnected nature of classroom life’ (Roberston & Dale, 2009).

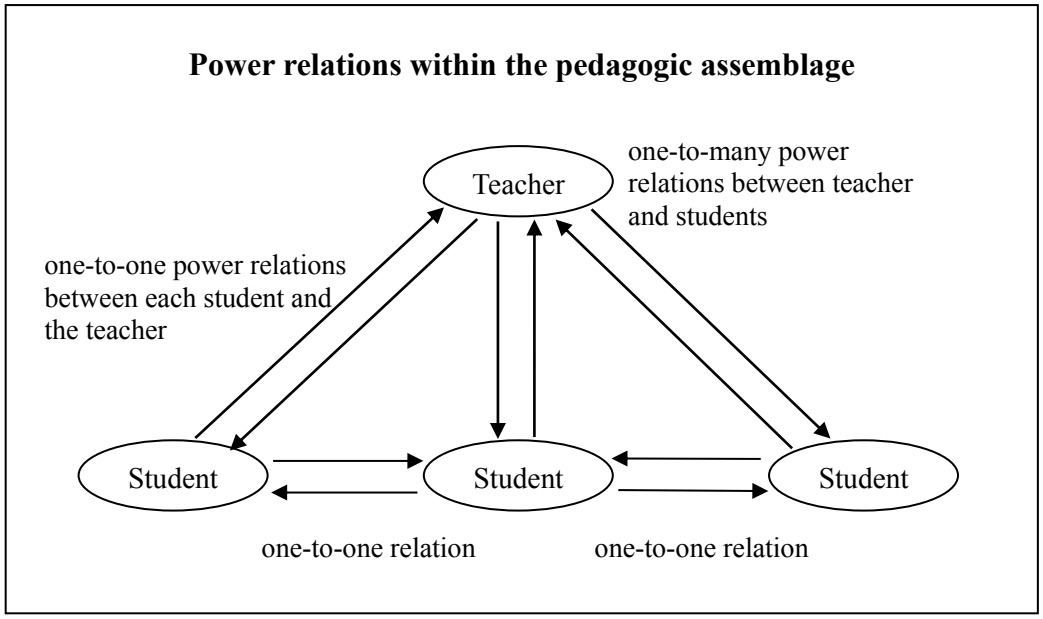

Figure 3 – Power relations within a pedagogic assemblage

The terms 'visible' and 'invisible' pedagogies were proposed by Bernstein (1975, 1990, 2000). Visible pedagogies have explicit rules about behavioural expectations, learning objectives, and learning outcomes, which are explained to the students before the classroom activity starts. Invisible pedagogies also have behavioural rules and task expectations, but these are not apparent at the start of the activity. Sometimes, these can develop through negotiation between the teacher and the students during the activity.

In a 'visible' pedagogy, a teacher, for example, can transmit knowledge to a group of students in the classroom, by writing on the blackboard. The students know to copy the information onto their books. The teacher controls the activities and the sequence and the pace at which the students learn. Students complete the exercise and respond to the questions that the teacher asks. There is no collaboration between the students in the learning process.

In an 'invisible' pedagogy, the control from the teacher over students is implicit rather than explicit (Bernstein, 1975). For example, the teacher wants the students to develop a

project in a group. The teacher arranges the context in which the students can rearrange and explore. The students are given the power to select the structure and sequence of their work, regulating their activities and social relationships. There is still an emphasis on the transmission of knowledge, but it is achieved through a different approach.

The teacher can exert power in classroom control in a variety of ways. Where the control is explicit and visible, the teacher is the centre of the learning (Bernstein, 2000). Sometimes, a teacher can give control to students to organise their workflows. The teacher still maintains control, but these controls are more invisible to the students and observers (Bernstein, 2000). This characterises student-centred learning. Most lessons are dynamic and oscillate between teacher-controlled and student-centred learning (Ingram, 2016).

In a traditional classroom in Hong Kong, the teacher is the figure of authority in the classroom. The teacher directs the students to learn, the teacher transmits information to the students, and the students copy down what the teacher says and obey instructions, which constitute the traditional form of pedagogy. These are visible controls (Bernstein, 2000).

Ingram (2016) discussed that one consequence of using technology to facilitate learning is that it allows an 'invisible' control in the classroom:

> 'successful uses of ICT tend to favour "invisible" pedagogies: collaborative modes of active working with shared competences, in lessons containing elements of "discovery".'
>
> (Ingram 2016, p.1)

Ingram (2016) discussed that students were empowered by the use of ICT by citing Anderson (2002) who said that the most significant outcome of innovative learning activities involving ICT was empowerment, particularly of students.

With this empowerment,

> ‘The pupils were taking more control over the direction, pace, and sequencing of their learning. The children were moving freely around the room, working collaboratively. The teacher’s role changed from that of a sole voice of authority controlling the transmission of knowledge to that of a facilitator.’
>
> (Ingram 2016, p.12)

The technology is designed to promote collaborative learning and tends to drive pedagogy toward invisible controls. The teacher is enabled to control students’ learning that can be either ‘visible’ or ‘invisible’.

This is an example of how technologies bring along changes in the teaching practice. Is there any example of the technology that enables ‘visible’ and ‘invisible’ control in a classroom in Hong Kong? Do teachers in Hong Kong prefer these modes of learning for a school subject and at the educational level they teach? Do teachers believe that students can learn with this empowerment? This research attempted to answer these questions on the basis of the interviews with teachers.

One consequence of introducing technology to facilitate learning in the assemblage is that it has the potential to alter the power relations between the teacher and the students. Ingram (2016) showed that ICT weakens the classification and framing of the pedagogic assemblage, leading (intentionally or unintentionally) to more invisible controls. In Figure 3, the technology is changing the hierarchical control of the teacher-to-student power relations and increasing the power of the non-hierarchical student-to-student relations.

For example, when a teacher sets up group discussions with the technology, the ideas that arise from the group discussion are those of the students, but not necessarily those of the teachers, and therefore, this can threaten the traditional ways of teaching where the teacher is the sole voice that can transmit knowledge. However, if this is an intentional

part of the learning outcomes, then this has the potential to enhance learning, because the students are expected to come up with information or knowledge in collaboration with each other, as a form of social constructivism.

With the use of technology, the teacher's role is changing from that of a sole voice of authority controlling the transmission of knowledge to that of a facilitator of the emerging knowledge. The students are learning from themselves and from each other. The students can take more control over their direction, pace, and sequence of learning. Ingram (2016) cited Anderson (2002) as follows:

> 'the most significant outcome of innovative learning activities involving ICT was empowerment, particularly of students.'
>
> (Anderson 2002 cited in Ingram 2016, p.13)

Some teachers enjoy working with this pedagogy in which they are the facilitators of knowledge, and thus, for them, being able to run these types of classes will be a huge advantage of using the technology. However, for other teachers, it would be a disadvantage for them, and they would seek to resist the levelling of authority that the technology brings. If the aim of the lesson works with the affordances of technology, there should be a successful outcome. However, if the aim of the lesson contradicts or goes against affordance, there would not be a very successful learning outcome.

The data analysis considered examples of how technology is changing the power relations in the classroom in Hong Kong.

2.4.3 Assessments

Besides classroom activities, assessment is an important process in education that can be facilitated through the mediation of technology. Broadly speaking, there are two roles of assessment: formative and summative. Formative assessment is used to monitor students' learning, providing feedback to students to improve learning or to adjust the teaching

strategy according to the students' needs. It is an ongoing activity during the students' learning process; for example, at the end of a chapter, there could be a quiz, exercise, or classroom poll. Summative assessment is used to evaluate the students' learning outcomes against certain benchmarks or standards. It takes place at the end of a teaching unit or school term and can be an examination or a final project. It also gives students' grades or scores as their achievement.

This research studied whether Google applications offer educational affordance, which supports different pedagogical approaches in the classroom activities and assessments mentioned above.

2.5 Affordance theory

There are different definitions of affordance by different authors.

2.5.1 Definition of affordance by Gibson

Gibson (1979) coined the term 'affordance' by saying that:

> 'The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment.'
>
> (Gibson 1979, p.127)

Gibson (1979) claimed that 'affordance is what the technology offers the users, or what it provides, either for good or bad, rather than at the level of physical properties'.

McGrenere & Ho (2000) discussed two properties of Gibson's affordance for its invariant. First, the existence of affordance is independent of the user's ability to perceive it. For example, the shape of the right height and material affords to sit irrespective of the way it is used (Barnes, 2000). Second, affordance does not change with the changes in the needs and the goals of the user. For example, Google Sheets is

spreadsheet software that offers calculation and data tabulation affordances, irrespective of whether it is used for financial, statistical, or educational purposes. Financial, statistical, and educational affordances are the perceived affordances defined by Norman.

2.5.2 Definition of affordance by Norman

Norman (1988) described the term 'affordance' as:

> 'the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used.'
>
> (Norman 1988, p.9)

Norman emphasised the idea of 'perceived' affordances, recognising that there is no utility to the potential user unless the affordance is perceived. Norman (2013) offered the following example:

> 'A chair affords ("is for") support and, therefore, affords sitting. A chair can also be carried. Most chairs can also be carried by a single person (they afford lifting), but some can only be lifted by a strong person or by a team of people. If young or relatively weak people cannot lift a chair, then for these people, the chair does not have that affordance, it does not afford lifting.'
>
> (Norman 2013, p.11)

According to Norman (2013), affordance refers to a relationship between the properties of an object and the capabilities of the agent that determine just how the object can possibly be used. Perceived affordances allow a user to use a new tool from the user's experience in a similar tool with some basic principles. A chair affords sitting because the user's experience supports this action.

The difference between Gibson's affordance and Norman's affordance is that in Gibson's theory, affordance either exists or does not exist and is independent of the user's experience or ability to perceive, but in Norman's theory, perceived affordances may or may not exist, which depend on a user's experience or ability to perceive (McGrenere & Ho, 2000).

For example, a teacher will perceive affordance from Google Sheets if the teacher has experience in using Microsoft Excel and if Google Sheets is designed with the same basic principles as those of Microsoft Excel. As Norman (2013) discussed,

> 'The presence of an affordance is jointly determined by the qualities of the object and the abilities of the agent that is interacting.'
>
> 'We are used to thinking that properties are associated with objects. However, affordance is not a property. An affordance is a relationship. Whether an affordance exists depends upon the properties of both the object and the agent.'
>
> (Norman 2013, p.11)

2.6 Affordances to be studied in this research

This research adopted the categorisation of affordances in the first level into educational, social, and technological by Kirschner (2002) and Fu *et al*. (2011). This categorisation has a limitation in which affordances can fit within two or more categories. To prevent this situation, these *first-level categories* have their own definition in this research, recognising the different roles of ICT in teaching and learning. These roles include the following: (1) support different types of learning, (2) enable different levels of social interactions and a social space, and (3) provide the technical capability of cloud computing, to be discussed below.

These affordances are further grouped into *second-level categories* under different themes, when they share similar characteristics. The following sections discussed the *second-level categories* that shape the coding scheme for affordance analysis. These lead to the development of a theoretical framework in Section 2.7 with the same key elements in these categories presented in a clearer and more organised way.

2.6.1 Educational affordance

Kirschner (2002) defined educational affordance as follows:

> 'Educational affordances can be defined as the relationships between the properties of an educational intervention and the characteristics of the learner that enable particular types of learning by the learner.'
>
> (Kirschner 2002, p.14)

This research identified the properties of Google applications that enable particular types of learning by the learner as educational affordances.

Educational affordances that enable different types of learning are grouped into *second-level categories* as follows:

Support different pedagogical approaches: These include affordances that support a variety of classroom activities promoting the different modalities of learning associated with learning theories, namely behaviourism, cognitivism, constructivism, and social constructivism (Section 2.4.1), and different roles of assessment (Section 2.4.3) such as formative and summative assessments.

Mediation: These include affordances that facilitate learning activities through different mediation methods (Section 2.2) by, for example,

i) promoting learning by facilitating processing in the working memory or transfer to and retrieval from the long-term memory during the private (internalisation) phase of learning (cognitivism);

ii) promoting motivation through rewarding interactions with the software (behaviourism); and

iii) empowering students to interact with each other and the external world to acquire knowledge and understanding (social constructivism).

These, and other learning experiences, will be mediated through the teaching maintaining appropriate power relations with the technology-enabled students.

Teacher control and power relation: These include affordances that maintain the power relations through both visible and invisible control of classroom activities and that empower students to take more control over their learning (Section 2.4.2).

2.6.2 Social affordance

According to Kreijns & Kirschner (2001), enabling social interaction involves both social affordance and educational affordance from an educational technology.

Social constructivists hold the same point of view as constructivists who argued that knowledge is constructed from prior experience but that knowledge construction is a social process (Doherty, 2012). Kreijns & Kirschner (2001) discussed that social affordance is the capability of an artefact to facilitate social interactions and therefore invite learners to a social communication:

> 'Social affordances are the properties of computer-supported collaborative learning (CSCL) environments which act as social-contextual facilitators relevant to the learner's social interactions. When perceptible, they invite i.e. to enter into a communication episode.'
>
> (Kreijns & Kirschner 2001)

Kreijns & Kirschner (2001) discussed that social interactions could be viewed in two dimensions. The first one is the educational dimension that considers the cognitive aspects of group learning. The second one is the social psychological or social dimension that considers the social process that may give rise to a social space through affiliation, impression formation, and interpersonal attraction that may end in social relationships and group cohesion. A sound social space enables the reinforcement of social interactions.

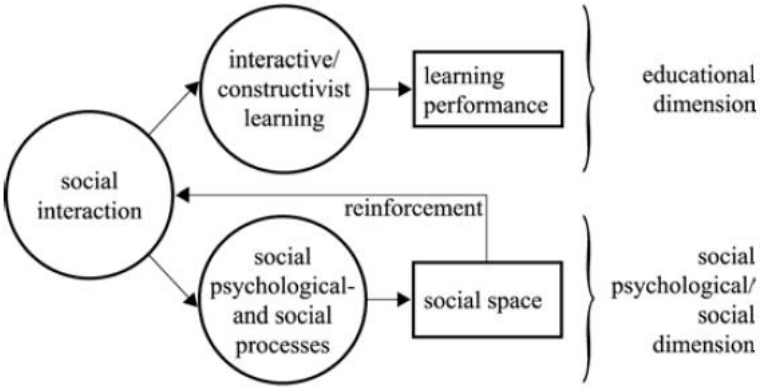

Figure 4 – Social interactions from two different dimensions

Source: Kreijns & Kirschner (2001)

From a social constructivist perspective, this research studied whether Google applications offer social affordance which enables students to learn in groups collaboratively with shared competence and social interactions by creating a social space for students.

One consequence of using technology is that it introduces greater flexibility into the potential interactions between the teachers, students, and the other agents in the world outside the classroom. This flexibility in interactions enables pedagogic actions in different pedagogical approaches, alters the ways the teacher and the students communicate inside and outside of the classroom, and creates a social space for students.

The concept of mediation from Wertsch (1997) provides an insight, which states that for learning to take place, there must be fundamental interactions between the cultural tool which is the technology, and its agents. The following figure illustrates these relationships:

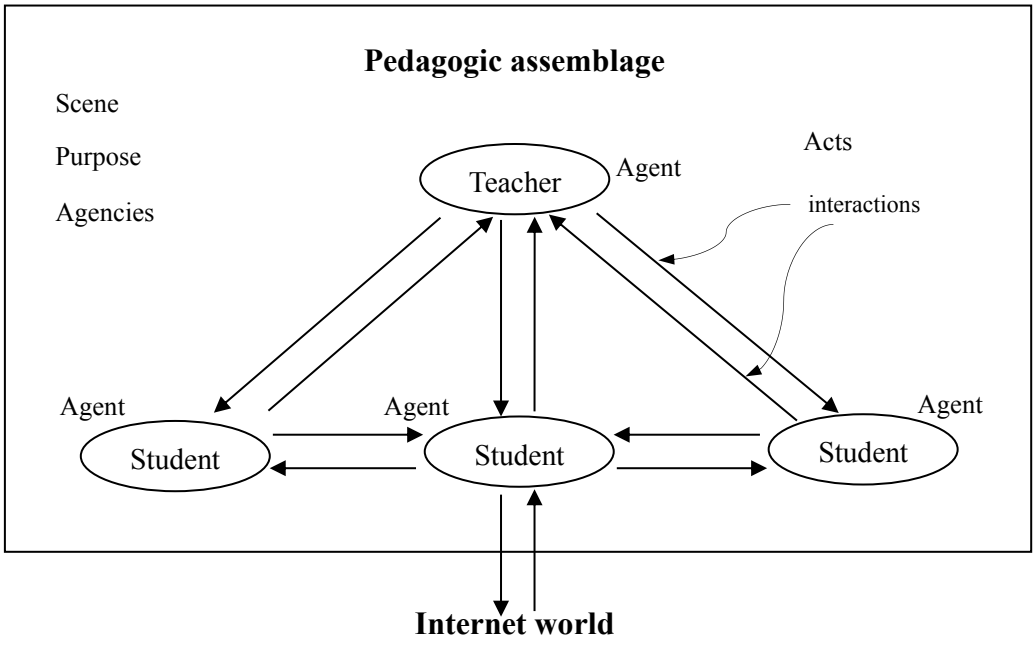

Figure 5 – Different levels of social interactions in the pedagogic assemblage

Figure 5 illustrates the interactions between pentad elements in the pedagogic assemblage. In this simple scenario, the teacher gives direct instructions to, for example, three students in the class. The teacher interacts with a one-to-many relation with the students, and each student interacts with a one-to-one reciprocal relation with the teacher. The students also interact in a social space with their classmates. The class as a whole interacts with two-way relations with the external world, via the World Wide Web (WWW) or some other digital system that provides access to the Internet. This group of the teacher and the class interacts in the pedagogic assemblage, which shows the different levels of social interactions going in the class during the instruction.

Social affordances are grouped into *second-level categories*, considering their support to these interactions at different levels. These include the following:

Enabling teacher-students interactions: These are affordances that support the one-to-many relation between the teacher and the students discussed above.

Enabling students-teacher interactions: These are affordances that support the one-to-one

and many-to-one relations between students and the teacher discussed above.

Enabling communication among students: These are affordances that provide a social space to the students, as discussed above.

The affordances that support the class in interacting with the external world are grouped into 'Mediation' affordance (Section 2.6.1). In this research, this affordance refers to the mediational mean to access learning resources on the Internet for educational purposes.

2.6.3 Technological affordance

There are several different interpretations of technological affordance, for example:

Kirschner (2002) interpreted technological affordance as follows:

> 'technological affordance is concerned with usability, i.e. whether a system allows for the accomplishment of a set of tasks in an efficient and effective way that satisfies the user.'
>
> (Kirschner 2002)

Fu (2014) interpreted technological affordance as follows:

> 'the ability to input and manipulate different media forms, to access records anytime anywhere, to allow or deny access, etc.'
>
> (Fu 2014)

In this research, technological affordance refers to the technical capability of cloud computing that enables different pedagogic actions.

Technological affordances are grouped into *second-level categories* considering the different capabilities of the essential characteristics of cloud computing. These essential characteristics will be discussed in Section 3.1.1. These second-level categories include the following:

Classroom administration: These are classroom administration affordances that can emerge from the data collected during coding. The data analysis attempted to find these

affordances as perceived by teachers.

Ubiquitous use: These include affordances offered by the essential characteristics of cloud computing, as discussed in Section 3.1.1, for example accessibility from anywhere at any time and resources-sharing capability on the Internet.

Innovative use: These are different uses that can emerge from the data collected during coding, recognising that teachers can use the software together with different hardware devices such as iPads and pen tablets, or different plugin software to enhance functionality.

‘Classroom administration’ and ‘Innovative use’ are two categories not based on the literature but created for the affordances that emerged from the data collected.

2.7 Theoretical framework of this research

To study how and whether cloud computing supports teaching, this research set out a theoretical framework that informs and shapes the coding scheme in the qualitative data analysis. The coding scheme conceptualises the different roles of ICT in teaching and learning into educational, social and technological roles, as the top level of the scheme.

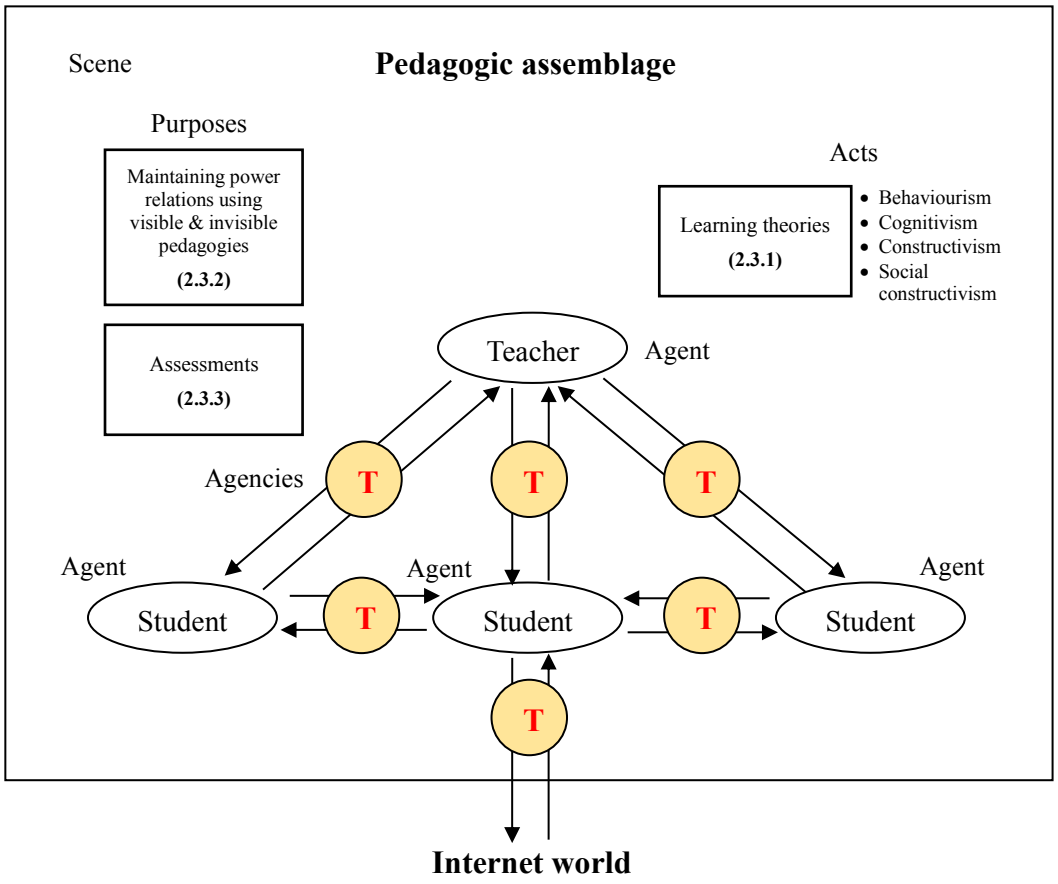

Figure 6 – Socio-cultural study on pedagogic assemblage for educational purposes

This theoretical framework views the classroom as a pedagogic assemblage for educational purposes and integrates the socio-cultural study on pedagogic assemblage (Figure 6) into the affordance analysis (Figure 7), recognising that affordance is influenced by the socio-cultural context of the classroom.

Figure 6 illustrates the socio-cultural study on pedagogic assemblage developed from Figure 5 that embodies the pedagogic actions discussed in Section 2.4.1 with the

educational purposes discussed in Sections 2.4.2 and 2.4.3. Burke's pentad in Section 2.3 was used to conceptualise the socio-cultural contexts of pedagogic assemblage into pentadic elements including: the pedagogic actions (Acts) that were mediated by the technologies (Agencies) in an educational scenario (Scene) from the teacher and the students (Agents) for specific educational (Purposes). The socio-cultural theory helped to reflect on the classroom phenomena, e.g. the reason teachers do or do not perceive affordance in different socio-cultural contexts.

Technologies, represented by the yellow circles with the letter 'T' in them, mediate the teacher and students' interactions within the pedagogic assemblage. Figure 7 illustrates a model of affordances from the technologies that facilitate these interactions.

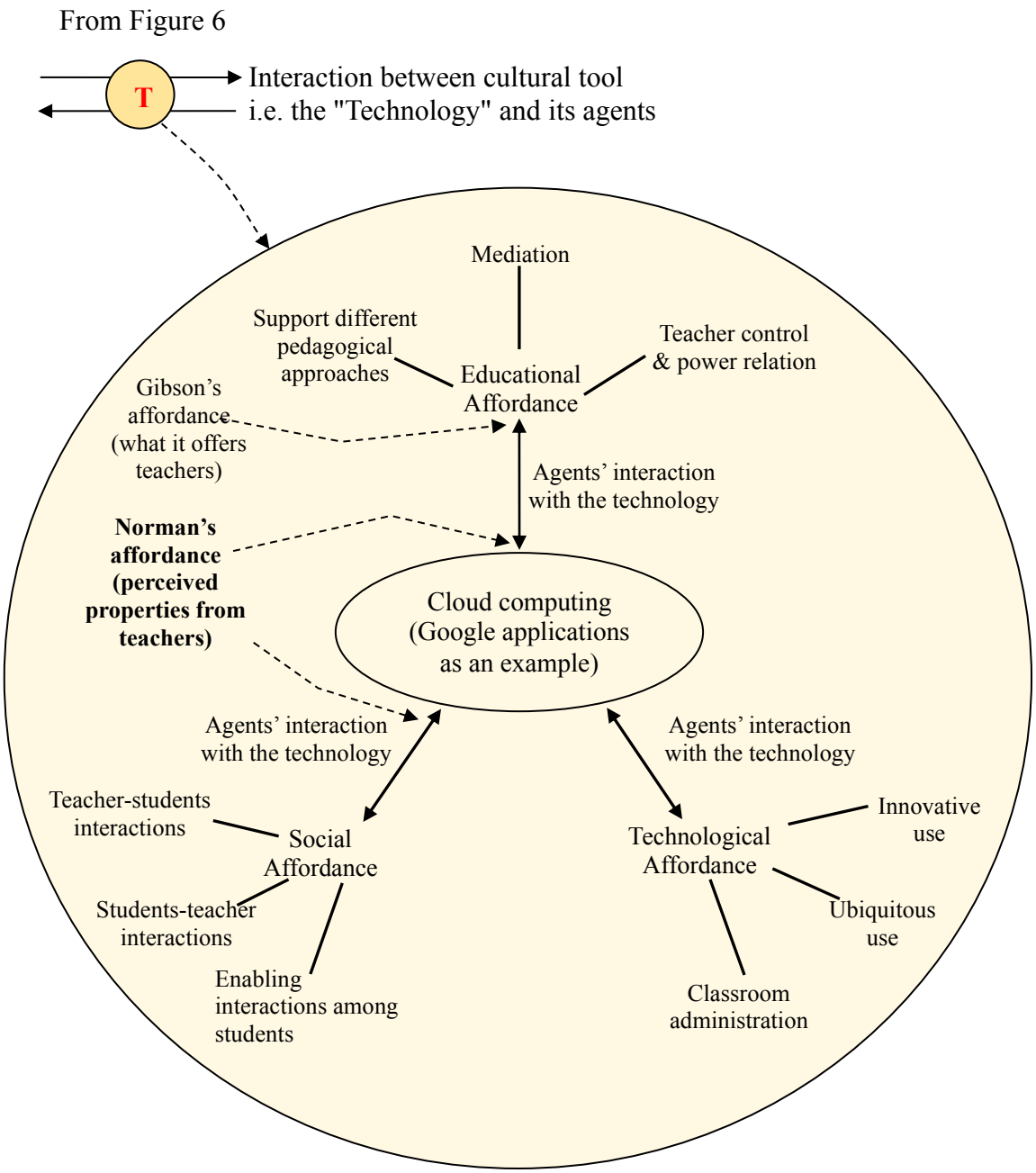

Figure 7 – Theoretical framework of affordance analysis for educational technology

In Figure 7, affordances are organised into first-level categories (educational, social, and technological) and their second-level categories discussed in Section 2.6 that combine the theory of mediation (Section 2.2), visible and invisible pedagogies, and different pedagogical approaches (Section 2.4). This research studied these affordances perceived by teachers according to Norman's definition (Section 2.5), in contrast to Gibson's definition, which is related to the affordances offered by the technologies to their users.

The perceived affordances identified in the qualitative data analysis were grouped within these categories.

2.8 Conclusion

This chapter reviewed the international literature that was used to form the theoretical framework in this research. The theoretical framework integrates the socio-cultural study on pedagogic assemblage into the affordance analysis, recognising that affordance is influenced by the socio-cultural context of the classroom. There are different definitions of affordance from different authors. The definition of affordance by Gibson (1979) and the definition of perceived affordances by Norman (1988) were reviewed. Perceived affordances were obtained from the teachers interviewed in this research. The theoretical framework views each classroom as a pedagogic assemblage that made up of pentadic elements including teachers, students, teaching scene, learning strategies, and pedagogical approaches fixed together to explore how human agents and technologies interact to support teaching and learning. Different pedagogical approaches that elaborated the educational purposes in the socio-cultural study were reviewed. These include the visible and invisible pedagogies that maintain the power relations in the classroom, learning theories that underpin the different classroom activities, and the different roles of assessment. Lastly, the definitions of the first-level and the second-level categories of affordances within the theoretical framework that were used to shape the coding scheme for the qualitative analysis were discussed.

Chapter 3 Cloud computing and Google applications

This chapter discusses the definition of cloud computing with respect to the title of this research and specifically introduces Google applications as an example of cloud computing. Google applications offer a set of affordances for teaching and learning that go beyond other information technologies in terms of their essential characteristics, service models, and deployment models, which are discussed in this chapter, and therefore, their affordances are worthwhile to study. In the meantime, some authors have discussed their advantages and disadvantages to education, and their user experiences with respect to teaching and learning. This research will use this information for reference in interviews and inquire whether these advantages, disadvantages, and user experiences perceived by teachers in Hong Kong. Lastly, the features of the Hong Kong context for using ICT in teaching and learning will be discussed; for instance, the extended study time outside school, and the availability of WiFi infrastructure, one of the agencies in the pedagogic assemblage, that leads to a unique experience of local teachers are discussed.

3.1 Cloud computing

3.1.1 What is cloud computing?

Cloud computing is not a new computing concept; it was introduced several decades ago:

> 'It was pioneered by Professor John McCarthy who expected some corporations to be able to sell computing resources through a utility business model. McCarthy is a well-known computer scientist who initiated time-sharing on modified IBM 704 and IBM 7090 computers in the late 1957.'
>
> (Hassan 2011, p.16)

This computing concept aims at selling computing resources and services at the consumers' demand:

> ‘Since that time, there are computing models that enable organisations to pay for their use of computing resources, such as data storage, processing, bulk printing, and software packages, which are available at *service bureaus*.’
>
> (Hassan 2011, p.16)

According to the definition of cloud computing from Information Technology Laboratory (ITL) of National Institute of Standards and Technology (NIST), U.S. Department of Commerce:

> ‘Cloud computing is a model for enabling ubiquitous, convenient, and on-demand network access to a shared pool of configurable computing resources, e.g. networks, servers, storage, applications, and services, that can be rapidly provisioned and released with minimal management effort or service provider interaction.’
>
> (NIST 2011)

Under the cloud definition framework from NIST (2011), the cloud computing model is composed of the following five essential characteristics, three service models, and four deployment models (Mell & Grance, 2011), offering different affordances to the consumers. Service models and deployment models are simple taxonomy that describe the method of cloud service delivery and deployment.

The following figure illustrates the cloud computing model from NIST with the essential characteristics, service models, and deployment models mentioned above:

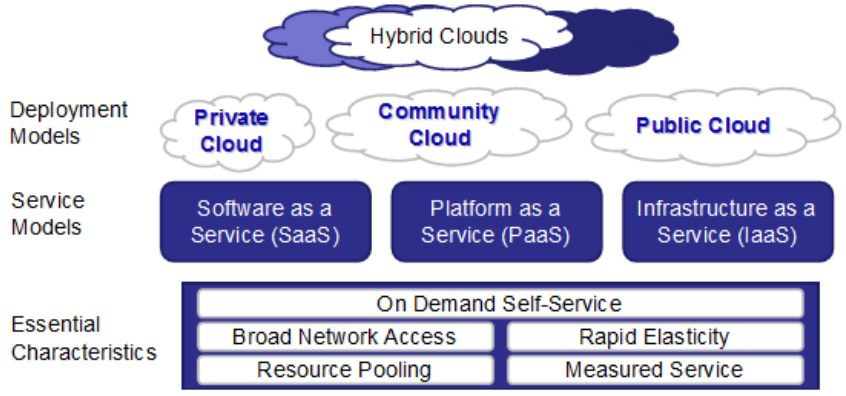

Figure 8 – The NIST Cloud Definition Framework

Source: Mell & Grance (2009)

Cloud computing has five essential characteristics. The first characteristic is *on-demand self-service*, in which consumers can acquire all computing resources, such as servers, network, and storage from only one provider. It is convenient for organisations or users who are not specialised in building their own computer and network infrastructure. Schools are one example of these organisations, which are specialised in teaching and learning only. The second characteristic is *broad network access*, in which consumers can utilise capabilities over the network by a heterogeneous thin client platform. There is no need for the consumer to purchase computers of higher processing power, which are expensive in terms of cost, to utilise capabilities. The third characteristic is *resource pooling*, owing to which service providers and their computing resources can be located anywhere in the world. In other words, consumers can acquire the computing resources that they need from anywhere at any time in the world. The fourth characteristic is *rapid elasticity*. The benefit of this characteristic is that not only can the service provider elasticity meet the computing demand, but their costs and therefore the consumer price can also be reduced because of the economies of scale in computing. For the consumer, there is no need to pay for the high initial investment to acquire the sophisticated server, network equipment and software for these capabilities. Instead, the computing demand is fulfilled immediately upon the subscription of services, eliminating the purchasing lead time of computer hardware and software. The fifth characteristic is *measured service*. Instead of organisations operating the consumers' own data centres, they can rent computing power and storage capacity from a service provider, paying only for what they use as they do with electricity or water, in which the computing capacity is treated like any other metered utility service. For Google applications, the consumers subscribe for their use when they need the capabilities. However, when the consumers do not need the capabilities, they just cease their subscription.

Cloud computing has three service models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). SaaS refers to the service provided to the consumer to use the provider's software running on a cloud infrastructure. These software services are accessible through different devices and a thin client interface such as a web browser (Mell & Grance, 2011). Google applications are types of Software as a Service (SaaS). Before the emergence of cloud computing, the consumers need to purchase different software and to install them on their computers for use.

Cloud computing has four deployment models: private cloud, community cloud, public cloud, and hybrid cloud. Public cloud refers to the cloud infrastructure provided for open use by the public. It may be owned, managed, and operated by a business, academic, or government organisation, or by a combination of them (Mell & Grance, 2011). Google applications are types of public cloud.

Technically, cloud computing is a computing paradigm in which tasks are assigned to a combination of servers and software connected over a network or the World Wide Web (WWW). This network of servers and connections is collectively known as the '*cloud*' (Thomas 2011).

Google applications are deployed by Google LLC as Software as a Service (SaaS) on the public cloud accessible by consumers worldwide on the Internet. For Google applications, computing resources may reside on a network of servers at different data centres or even span across continents. However, they are designed to operate like a single computer on the cloud serving the worldwide consumers. Therefore, this paradigm benefits the consumers because they need not acquire their own computers, can reach into the cloud for the computing resources that they need from anywhere at any time, and the computing capacity is treated like a metered utility service.

3.1.2 Use of cloud computing in education

Examples of Software as a Service (SaaS) for educational use include Google applications and Microsoft Office. These SaaS applications provide ready-made software tools such as word processing, presentation and communication software, data storage, and email for use after a subscription, minimising the development and deployment time for consumers.

Masud *et al*. (2012) and Johnson (2012) provided different insights into the use of cloud computing in education. Masud *et al*. (2012) discussed the typical uses of cloud computing from an educator's perspective in an academic environment, while Johnson (2012) discussed specifically how school teachers could make use of cloud computing in their teaching. This research attempted to use Masud *et al*. (2012) and Johnson (2012) as a reference to inquire whether teachers of Hong Kong also perceive the uses mentioned by these authors.

Masud *et al*. (2012) mentioned the different uses of cloud computing in an academic environment. First, it can be used as a personal workspace. Second, it makes teaching and learning interactive, providing a strong potential for social interactivity. Third, it serves as a personal learning environment (PLE) with personalised tools to meet the students' needs and preferences. Fourth, it provides an opportunity for ubiquitous computing. Fifth, there is no need for backing up everything to an USB drive for transferring data from one device to another. Sixth, there is no need to copy everything from one computer to another when buying a new one, and seventh, it provides large amounts of processing power as compared to a self-owned infrastructure.

Johnson (2012) mentioned the different uses and benefits of cloud computing from a school teacher's perspective. First, it works with a netbook, rather than a full-scale laptop computer, which is lower in cost but with acceptable speed and wireless connectivity.

Second, the teacher just uses a delicious account in a browser with a bookmark to access the services. Third, it allows the creation of presentations and spreadsheets. Google Docs worked fine for 95% of the author's work, and the author perceived that the work created by this software was compatible with Microsoft Office. Fourth, the teacher can store his/her best photographs on a storage site for years and edit them with Photoshop elements. Fifth, it allows the complete management and editing of personal blogs, Wiki entries, and websites with online tools.

In the interview with teachers, an attempt is made to inquire with reference to the above features in cloud computing. For example, whether students in Hong Kong schools will use Google applications as a personal workspace? Do the applications provide an opportunity for ubiquitous computing? Do the applications facilitate backup everything? Is there a huge demand of storage from teachers because, for example, they have many photographs? Do the applications facilitate creating presentations and spreadsheets, and are these works compatible with Microsoft Office? Do the applications embody collaborative modes of learning among students?

3.1.3 Benefits of cloud computing to education sector

Cloud computing is particularly useful for the education sector because it allows consumers to gain immediate access to the resources and software tools available in the market. As the consumers of cloud computing pay for the computing resources only when these are used, they have control over their amount of use by scaling it up or down. Because shared resources are used, costs are lowered because of the economies of scale. Owing to the cost reduction, teachers and students have more choice of educational resources, particularly those having a limited financial budget.

> 'By shifting the computing needs to the cloud, an organisation can forego the need for building an extensive and expensive computing infrastructure and replacing it with the services in the cloud where the costs are only incurred by usage. The cost of the

> computing capacity changes depending on the acquisition of infrastructure, platform, and software to a monthly subscription per user and to a monthly basis which is considerably lower than the cost in the former case.'
>
> (Anderson *et al*. 2008, p.203)

This research will hear the voice of teachers in interviews. Do teachers in Hong Kong benefit from the lowered cost of resource acquisition from cloud computing? Do teachers find a disadvantage, although there is cost reduction?

3.1.4 Disadvantages of cloud computing

Kranzberg (1986) is known for his laws of technology, the first of which states that:

> 'Technology is neither good nor bad; nor is it neutral.'
>
> (Kranzberg 1986, p.545)

Kranzberg (1992) further claimed that:

> 'technology's interaction with the social ecology is such that technical developments have environmental, social, and human consequences that go far beyond the immediate purposes of the technical devices and practices themselves, and technology can have different results when introduced into different contexts or under different circumstances.'
>
> (Kranzberg 1992, p.100)

Along with the advantages of cloud computing, there might be disadvantages in some circumstances. For example, Johnson (2012) discussed the following disadvantages of using cloud computing from a school teacher's perspective:

i) Service is lost if the Internet is unavailable

> 'What happens when there is no Internet access?'
>
> (Johnson 2012, p.39)

Johnson (2012) found that some software can work without an Internet connection, and their documents will be synchronised when the next Internet connection is made. However, some software cannot do this. Bandwidth limitation is also a

challenge for some districts.

ii) There might be a charge in the future for a free of charge service today

> 'There might someday be a charge for these now "free" services?'
>
> (Johnson 2012, p.39)

When a service provider dominates the market, it is 'yes'. In the meantime, the sustainability of the provider's revenue model is anybody's guess.

iii) Security concern

> 'Are my files secured?'
>
> (Johnson 2012, p.39)

Johnson (2012) found that so far there have been minor reported instances of security problems, data loss, or interruptions in his experience. However, teachers are normally advised to keep local backup copies of all the important documents.

iv) Privacy concern

> 'Are my files private? Can we trust service providers such as Google and the others to not peek at our stuff?'
>
> (Johnson 2012, p.39)

Johnson (2012) found that teachers have a major concern in this area. Although some teachers believed that their data were secure and private, the author advised teachers to carefully study the privacy settings of all the online programs.

v) Some tasks are not efficient to work online.

> 'Are there some things just too cumbersome to do online?'
>
> (Johnson 2012, p.40)

Johnson (2012) discussed that cloud computing does not fulfil every computing need. For example, a full-blown computer might be needed for editing videos, CDs or DVDs cannot be played or created with online software, and big tasks might need a considerable amount of processing power.

In this research, the teachers' opinions and their concerns in these areas and whether these disadvantages are critical to their teaching were studied in the interviews.

3.2 Google applications for education

3.2.1 What are the Google applications for education?

This section discusses the Google applications that are used as the example of cloud computing in this research.

Google applications contain several software components licensed to schools for use by teachers and students, as well as commercial users. Appendix 1 (Table 8) presents a list of these components in Google applications and their capabilities offered to consumers. Besides these licensed components, school teachers can use the Google applications on the Internet, which are available to all public users; refer to Appendix 1 (Table 9).

Besides the Google applications licensed to schools and those available on the Internet, Google Classroom is a component designed for schools, particularly for teachers and students. Appendix 1 (Table 10) presents a list of capabilities from Google Classroom.

There are two reasons I am interested in the research of the affordances of Google applications:

i) Google applications is one of the popular cloud computing services. Daly (2013) discussed in EdTech magazine that students and faculty agree on the benefits of cloud collaboration. According to the study of Daly (2013), the number of students using Google applications for Education has increased by 100% in two years (from October 2010 to October 2012) with over 20 million students in the US using Google applications for education at the time of his research.

ii) Google applications provide not only a teacher-centric environment for learning but also a student-centric environment, as compared to other cloud computing

services such as Moodle. Doherty (2013) discussed that:

> ‘To be fair to Moodle, students can and do have a presence: discussion forums, Wiki exercises, database activities, blogs, polls, and surveys (slide 4).’
>
> ‘However, what happens when we think of students authoring content and/or maintaining a portfolio of their learning? Moodle does not do so well here, and we need to look at alternatives to provide students with an environment in which they can be authors and architects of their own learning (slide 5).’
>
> ‘Google applications facilitate student-centred collaborative learning in a cloud-based environment rich with possibilities (slide 11).’
>
> (Doherty 2013)

With these capabilities, students can manage their own learning environment when the pedagogy allows them to learn cooperatively. Ingram (2016) discussed that students were empowered by the use of ICT by citing Anderson (2002) who said that the most significant outcome of innovative learning activities involving ICT was empowerment, particularly of students.

3.2.2 Experience shared by local teachers in Google applications

This section reviews two sources in Hong Kong: Go eLearning and the proceeding from the 20th Global Chinese Conference on Computers in Education (GCCCE).

Go eLearning is a portal dedicated to promoting the use of educational technologies by school teachers and to bring together practical experience from teachers who are already using different technologies. Go eLearning is owned and managed by HKEdCity, which was established in 2000 with the support from Quality Education Fund and was now a wholly owned company of the government. HKEdCity has the following mission:

> ‘to enable a better adaptation to the changes in the curriculum initiatives through technology.’
>
> (HKEdCity 2019)

Go eLearning produces videos in demonstration events for how to use different electronic tools to achieve the teaching aims and share the examples and teaching experience in the currently used technologies. The teachers cited in Table 1 presented in these videos, and their conversations were used as a reference in this research.

Global Chinese Conference on Computers in Education (GCCCE) is an international academic conference hosted by Global Chinese Society for Computer Education Application. The 20th GCCCE was held at the Hong Kong Institute of Education in 2016. This conference has been the academic and teaching exchange event for global Chinese researchers and teaching practitioners. The conference has a teacher forum to explore how ICT can be applied to K-12 teaching practices for the improvement of teaching effectiveness in primary and secondary schools of the Chinese region. The teachers cited in Table 1 presented in the proceeding of this conference, and their discussions were used as a reference in this research.

In these sources, the local experienced primary school and secondary school teachers share their experiences, opinions, and recommendations for using Google applications for teaching, providing a reference for developing interview questions about how these technologies facilitate teaching and learning. An attempt was also made to find whether the perceived affordances held by the interviewed teachers were different from those held by the teachers of these sources. The difference might be attributed to a more experienced teacher finding an affordance or a constraint, but another teacher, for example the interviewee, not finding it. For this purpose, the teachers' perceived affordances from these sources were also coded using the same approach as that used for the qualitative data collected through the interviews with the same affordance variables.

The following table contains information about teachers with teachers from Go eLearning prefixed with the letter A (i.e. Teacher A1, A2, …) and teachers from GCCCE prefixed with the letter B (i.e. Teacher B1, B2, B3...):

	Taught school subject	Taught educational level	URL	Updated on
Teacher A1	General Studies	Primary school	https://www.hkedcity.net/goelearning/resource/56a88b2e316e832442000000	29 Dec 2016
Teacher A2	Chinese Language	Secondary school	https://www.hkedcity.net/goelearning/resource/583fff85316e838639000000	29 Dec 2016
Teacher A3	Mathematics	Primary school	https://www.hkedcity.net/goelearning/resource/56a8893d316e834e3f000000	29 Dec 2016
Teacher A4	Chinese Language	Secondary school	https://www.hkedcity.net/goelearning/resource/589980ab316e83d70a000000	13 Feb 2017
Teacher B1	Mathematics	Secondary school - Form 3	http://gccce2016.ied.edu.hk/proceedings/3GCCCE2016TeacherForumProceedings.pdf	27 May 2016
Teacher B2	Multiple discipline	Secondary school	http://gccce2016.ied.edu.hk/proceedings/3GCCCE2016TeacherForumProceedings.pdf	27 May 2016

Table 1 – List of teachers who shared their experiences from local sources

The presenters in these sources were more experienced teachers who shared their experience of using ICT for teaching. As schools in Hong Kong are in different stages of using cloud computing for educational purposes and teachers have different computer knowledge, these more experienced teachers provide more information about the different uses of the technological tool or the workaround of some application issues.

However, there are certain limitations and difficulties of the information gathered from Go eLearning. One limitation is that the teachers' presentations are through YouTube videos. Information on YouTube might give rise to accreditation issues because there is no validation process like that with published journals, which are checked for accuracy by editors. Another limitation is that, unlike in interviews, we can neither ask questions for clarification nor guide the presenter in providing the required information. However, it has been found that the user experiences and information from these sources are useful and we can always play the videos again and again when necessary.

3.3 The Hong Kong context for using ICTs in education

This section reviews the context for using ICT in teaching and learning in Hong Kong schools in cases wherein teachers may perceive that some affordances or constraints from cloud computing are more important under the existing school circumstances.

It is a government policy to promote the use of educational technology and the flipped classroom approach. The 'Fourth Strategy on Information Technology in Education' (ITE4) was launched by Education Bureau in the 2015/2016 school year. ITE4 states that:

> 'to achieve the goal of ITE4, we aim to strengthen the students' self-directed learning, problem solving, collaboration, and computational thinking competency, and enhance their creativity, innovation, and even entrepreneurship skills.'
>
> ITE4 (2015/2016)

ITE4 also states that:

> ‘By adopting teaching approaches such as Flipped Classroom, teachers could make better use of classroom time to cater to the needs and interests of their students.’
>
> ITE4 (2015/2016)

Flipped Classroom is the practice of assigning lectures outside the classroom and devoting the class time to a variety of learning activities (DeLozier & Rhodes, 2017).

One support from the government under ITE4 is to fund all the public sector schools in phases under the WiFi 100 and WiFi 900 Project. Referring to School Survey on ITE 2016/2017, the year when the data were collected in this research, the total WiFi coverage in schools in Hong Kong was: 58.6% of schools have WiFi in classrooms only, 48.1% of schools have WiFi in special rooms, 51.6% of schools have WiFi in the school hall, and 46% of schools have WiFi in the entire school campus.

An advantage of cloud computing is that software can be used any time if the Internet is available, such as somewhere outside the classroom. However, cloud computing is a technology dependent on the Internet connection, through WiFi at present, and therefore, the availability of WiFi is critical for this technology. There could be constraints instead of affordances from cloud computing if classrooms are not covered by WiFi.

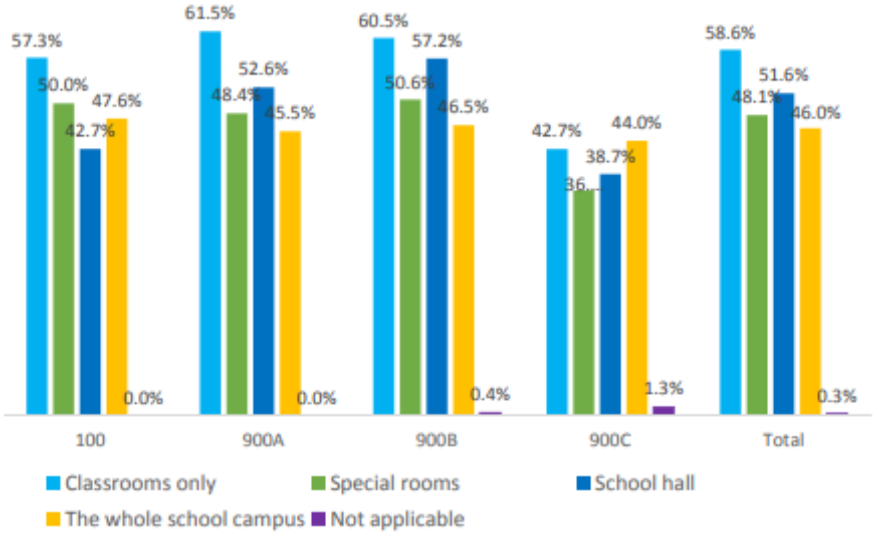

Figure 9 – WiFi coverage in schools from a school survey on ITE 2016/17

Source: Major Results of School Survey on ITE 2016/17, Education Bureau

Cloud computing can facilitate teachers and students when the study hours outside the school are high. According to The Programme for International Student Assessment (PISA) report on the study time of local students released by the Research Office of Legislative Council with respect to the weekly study time, Hong Kong students reported that they studied on average 46.4 hours each week in 2015, including 28.8 hours of formal classes in schools and 17.7 hours after school. PISA is conducted by the Organisation of Economic Cooperation and Development (OECD) in 2015 for a global comparison on the study time of 15-year-old students. About 5000 students aged 15 years from 138 secondary schools in Hong Kong were randomly selected to take part in the PISA tests in 2015.

	Total weekly study hours	*Within which*: Schooling hours	After-school study
OECD			
Finland	36.1	24.2	11.9
Germany	36.5	25.5	11.0
Netherlands	41.0	26.8	14.2
United Kingdom	43.4	26.5	17.0
France	42.6	27.2	15.4
OECD (average)	44.0	26.9	17.1
East Asia			
Singapore	50.8	28.6	22.2
Hong Kong	**46.4**	**28.8**	**17.7**
Japan	41.1	27.5	13.6
Taiwan	48.2	31.8	16.4
South Korea	50.5	30.3	20.2
Beijing-Shanghai-Jiangsu-Guangdong	57.1	30.1	27.0

Figure 10 – PISA 2015 results for selected places

Source: Overall study hours and student well-being in Hong Kong (2015), Research Office, Legislative Council Secretariat

According to this report, the total weekly study hours and the after-school study hours of students in Hong Kong are higher than the OECD average; thus, cloud computing can help the students by enabling them to learn from outside the classroom.

3.4 Conclusion

This chapter reviewed what cloud computing is and Google applications that generated affordances in teaching and learning. The benefits from these technologies to educators discussed by contemporary researchers are reviewed. These benefits from cloud computing in general include the following: organisations can be provided with computing resources on demand, without the need to purchase expensive computer hardware and software, computing resources can be provided at a lower cost, and resources can be accessed anywhere at any time. The benefits from Google applications, in particular, include the provision of not only a teacher-centric environment but also a student-centric environment in which students can take more control over their direction, pace, and sequencing of learning. Therefore, the students can learn from themselves, and they learn from each other. The educational context that may favour the use of cloud computing such as the high study time outside school for students in Hong Kong was reviewed. In the meantime, the availability of WiFi in Hong Kong schools, without which affordances for teaching cannot be perceived, was reviewed. This research attempted to inquire whether the above benefits and disadvantages were perceived and the reason why some affordances and constraints were perceived by school teachers in Hong Kong.

Chapter 4 Research methodology

4.1 Introduction

This research adopted a research design under the pragmatic paradigm (Section 4.2). The method of this research was to collect qualitative and quantitative data simultaneously through semi-structured interviews (Section 4.3). An interview schedule was designed to include a range of closed- and open-ended questions designed to answer the three research questions (Section 4.3.1). Fifteen participants who used Google applications in different school subjects at different educational levels in an opportunity sample from primary and secondary schools of Hong Kong were invited for the interviews (Section 4.3.2). I (the interviewer) went through all the questions in the interview schedule in the same order in a relaxed atmosphere. Different prompts were used to solicit more information and bring back the focus if there was any distraction from the discussion (Section 4.3.3).

Section 4.4.1 discusses the method of analysis that used a process of coding according to a coding scheme and used Burke's pentad to understand the socio-cultural context of the classroom. Section 4.4.2 discusses the coding scheme shaped by the theoretical framework and the interpretation of the coded affordances identified from the qualitative data. Section 4.5 discusses the limitations of the research method adopted and how these limitations were minimised. Section 4.6 discusses the ethical consideration in this research.

4.2 Research paradigm

Objectivism asserts that knowledge should be completely of the world, which is external to and measurable by the researcher. In contrast, subjectivism asserts that knowledge is completely of the mind; i.e., knowledge is subjective; knowledge generated by research is always limited by the partiality or bias of the researcher. However, pragmatism argues that the paradigm of positivism (objective) or constructivism (subjective) alone cannot fully explain the phenomena being studied in any research (Powell, 2001). A pragmatist believes that it is neither possible to obtain the 'truth' about the real world through a single scientific approach advocated by the positivist paradigm nor possible to determine the social reality constructed under the interpretivist paradigm (Kivunja & Kuyini, 2017).

The pragmatism of Dewey (1922/2008) has particular significance for educational research because it provides a different account of knowledge and a different understanding of how human beings acquire knowledge, in his philosophy of action. Dewey's transactional realism asserts that knowledge is a construction. Knowledge is not a construction of the mind but is a construction in the human-environment transaction that establishes the dynamic balance of humans and the environment. This balance manifests itself in both the changes in the environment and the changes in the patterns of human action. For Dewey, experience is a transaction between humans and the environment (Biesta & Burbules, 2003). This understanding of the way knowledge is acquired is symmetrical with how the learning process is understood in the theoretical framework of this research that adopted the mediation concept from Wertsch (1997), as an interaction between human agents and the agencies, which were the technological tools.

A person develops patterns of possible action through continuous transactions with the environment, which Dewey called habits (Morgan, 2014). As Biesta & Burbules (2003) discussed:

> 'We do something that affects our environment, we undergo the consequences of our doings, and try to adjust ourselves accordingly – and this cycle repeats itself. In the act of knowing – and hence in research – both the knower and what is to be known are changed by the transaction between them.'
>
> (Biesta & Burbules 2003, p.12)

Morgan (2014) citing Dewey (1922/2008) has stated that both inquiry and decision-making in everyday life are the same thing. Inquiry is a process that generates action by reflecting our belief in a problematic situation and then reflecting on the action taken to generate the belief. Experience is a process of interpretation. Belief is interpreted to generate action, and action is interpreted to generate belief (Figure 11) until a habit is formed, when we believe that our experience can adequately respond to the need for action in the current situation. In this situation, no further decision-making or inquiry is required. Pragmatists believe that inquiry is an on-going process based on experience. We need to check our knowledge with the force of experience (Choo, 2016).

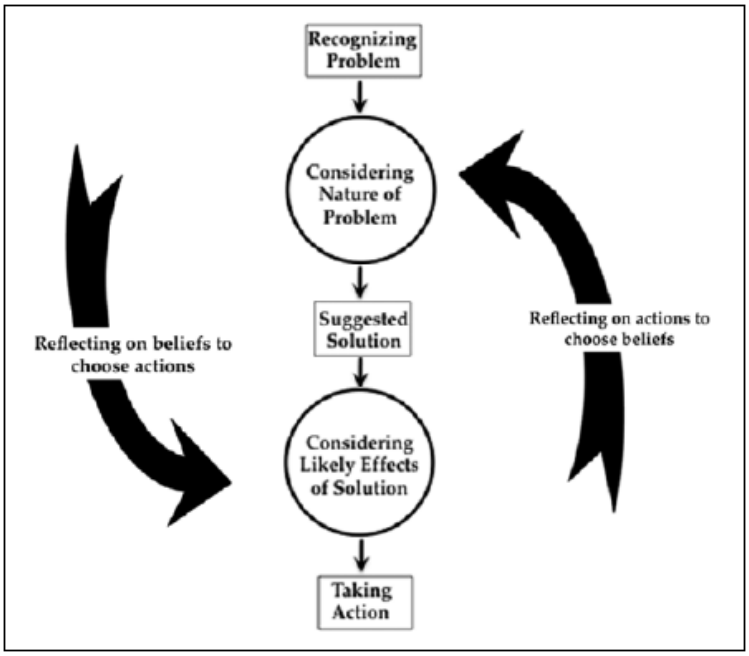

Figure 11 – Dewey's model of inquiry

Source: Morgan (2014)

According to Dewey (1922/2008), research is a form of inquiry performed more carefully than other responses to problematic situations (Hansen & Madsen, 2019). For example, the use of a new technology needs research by defining the new problem. This worldview of pragmatism concerns the question of 'why to' do the research in a certain way and emphasises the importance of experience in the interpretation of our beliefs and actions, as well as the question of 'how to' do the research that involves decisions about the research methods (Morgan, 2014).

Morgan (2014) citing Dewey (1922/2008) has stated that the process of inquiry is always social in nature and that even an inquiry is based solely on the individual thoughts, those thoughts have social origins. This research was designed on the basis of the belief that knowledge is socially constructed from the sharing of user experience and perception by teachers, external sources, and the teachers' peers and co-workers such as information technology officers. This research studied affordances from the user experience and perception of other practitioners, as a way to answer the questions of how and whether

cloud computing supports teaching in schools under the government policy.

Dewey's model of inquiry is a cycle of reflection on beliefs to choose actions and then reflection on actions to choose beliefs. Ambady (2018) discussed that reflection is a social process:

> 'Reflection needs to happen in community in interaction with others. This enables individuals to share and learn from experiences and ideas from others' perspectives, interpreting and reinterpreting, developing their own perspectives further.'
>
> (Ambady 2018, p.2)

Reflection is a social process, located in the relations with students, as well as the socio-cultural context of the pedagogic assemblage, for example, in the cases of different educational scenes and pedagogical purposes. This research proposes a model of affordance analysis with a socio-cultural study that helps teachers to reflect on the phenomena in the pedagogic assemblage for any reason why an interaction between the human agents and the technology is unsuccessful in a problematic situation. This type of research is an on-going process because the external environment is ever-changing. When the technology changes or the educational policy changes, further research is required to define the new problem. Therefore, this research was designed for adopting a pragmatic approach and for the cyclic process of inquiry that reflects on the teachers' beliefs and actions, as illustrated in Figure 11 – Dewey's model of inquiry.

4.3 Research method

4.3.1 Design of interview schedule

To study the teachers' perceived affordances of Google applications, data were collected through 30-min-long face-to-face semi-structured interviews of the participants. The interview schedule contained a mixed of closed Likert-style questions, which yielded

quantitative data, and open-ended questions, which yielded qualitative data, in order to give insight into affordance. These interviews were formal because of the need to go through all the questions in the interview schedule in the same order so that the data would be comparable across interviews. All the interviews were conducted in Cantonese, which was the first language of all the participants and the researcher.

The first research question (RQ1) studied what teachers perceived to be the affordances of Google applications with respect to supporting their teaching. Open-ended questions were used to collect qualitative data on how they used the applications, their perceived affordances, and the reasons they perceived these affordances. The second research question (RQ2) studied how the teachers perceived the affordances of Google applications for different school subjects and at different educational levels. Open-ended questions were used to collect qualitative data for the reasons why the applications were useful/not useful for the subjects and at the levels they taught. The third research question (RQ3) studied the teachers' opinions of the usability of Google applications in two dimensions: whether they are fit for use and whether they are easy to use. Two closed-ended questions were asked in the interviews: First, 'How do you rate the ease of use for Google applications?'; the teachers responded to this question by using a four-point Likert scale of Not easy to use, Quite easy to use, Easy to use, and Very easy to use. Second, 'How do you rate the usefulness of Google applications to support your teaching?'; the teachers responded to this question by using a four-point Likert scale of Not useful, Quite useful, Useful, and Very useful. Then, open-ended questions were used to prompt for the reasons behind their ratings in the quantitative questions and for more evidence. Qualitative data will be used in the socio-cultural study to reflect on the classroom phenomena for the reason, for example, why teachers did or did not perceive affordance in the different socio-cultural contexts in the findings.

The interview schedule was designed such that the quantitative and the qualitative data supported each other. For example, a closed-ended question asked the frequency of using different Google applications by using a three-point Likert scale (frequently used, sometimes used, and not used). The highest frequency of use might show that the applications were more important to teachers and had more affordance perceived, and therefore, I needed to pay attention and to ask more questions about them. A closed-ended question asked the amount of training received by the teachers on a three-point Likert scale (no training, some training, and a lot of training) for an attempt to evaluate whether some affordances or constraints depended on the amount of training received. Open-ended questions were used to collect the participants' comments on how they rated the questions to better understand the sentiment of their responses. The quantitative data helped to provide a comparable view across the interviewed teachers and to use consistent questions for whether they disagreed, strongly disagreed, agreed, or strongly agreed on an affordance, in order to prompt for reasons when there was any negative or extreme response to these questions. While the open-ended questions studied the values and approaches of these teachers with respect to how they perceived affordances, the closed-ended questions showed the degree to which the affordances were valued by the teachers with descriptive statistics.

The interview schedule was pilot-tested with my former colleague, who was an in-service teacher at a secondary school. The pilot test allowed me to try out the interview schedule and rehearse the interview protocol for improving the interview questions as well as the flow of the interview protocol. The interview protocol began with my introduction and a brief explanation of the goal of this inquiry, which was for my academic research and dissertation only. It was also explained that the interview would be audio-recorded, the data collected would be held in confidence, and the identity of the schools and the teachers would be anonymised in the dissertation and any subsequent

publication. Piloting showed that the term ‘affordance’ in the title of my research was not understood by a teacher and needed explanation. Therefore, the interview schedule was modified to avoid all terminologies and terms that might not be understood by the teachers. At the end of the interview protocol, the participants were informed that the findings would be shared with them, if they shared their contact details.

Table 11 in Appendix 2 presents the interview schedule used for the 30-min semi-structured interview with each participant. The right-hand column of this table was not part of the interview schedule but shows which research question the interview question was designed to answer.

4.3.2 Participants

The difficulty of recruiting schools for voluntary participation in Hong Kong necessitated me to use known contacts to be intermediaries for recruiting participants and to call the schools in the Education Bureau’s school list for voluntary teachers. In this sense, my sample is an opportunity sample. There are advantages and disadvantages of such a heterogeneous sample. For example, it allowed me to identify a full range of affordances across individual teachers, school subjects, age of students, and schools and make some qualitative comparisons. However, it limited the claims that I could make in the nuances of insights with respect to, for example, any specific subject or student age group, and the findings were attributed to the context of the schools and the capability of the teachers in the sample.

Thirteen teachers who taught different school subjects at different educational levels and two information technology officers from across four schools were invited during the period of May to July 2017 for a 30-min interview. Eleven male participants and four female participants were invited from one primary school and three secondary schools. The information technology officers from two of these schools were also invited for the

interviews, because they could provide information about how often the teachers used the cloud computing tools, how the teachers used these tools, their voices and preferences, and the problems the teachers faced while teaching with these tools; these information technology officers had more expertise of the technological tools.

The followings are information of participants invited for interviews and the date of interview:

	Taught school subject	Taught educational level	Years of use in Google applications	Years of teaching experience	Training in Google applications received	Interview date
Teacher C1	Physics, Integrated Science	Secondary school - Form 1, Form 3	5 years	4 years or below	Had no training	8 May 2017
Teacher C2	Integrated Science, Biology	Secondary school - Form 1, Form 2	2-3 years	15 years or above	Had no training	8 May 2017
Teacher C3	Mathematics	Secondary school - Form 3, Form 5	5 years or above	10 - 14 years	Had no training	8 May 2017
Teacher C4	Visual Arts	Secondary school	2 years	2 years	Had some training	8 May 2017
Teacher C5 (information technology officer)	N/A	N/A	10 years	N/A	Had some training	8 May 2017
Teacher C6	Computer Literacy, Chinese History	Primary 2, Primary 3, Primary 4	1 year	3 years	Had no training	8 May 2017

Table 2 – List of participants invited for interviews

	Taught school subject	Taught educational level	Years of use in Google applications	Years of teaching experience	Training in Google applications received	Interview date
Teacher C7 (information technology officer)	N/A	N/A	5 years or above	N/A	Has some training	8 May 2017
Teacher C8	Mathematics, Information & Communication Technology	Secondary school - Form 3	5 years or above	15 years or above	Had some training	8 May 2017
Teacher C9	Chinese Language	Secondary school - Form 1, Form 3, Form 5	3 years	5 - 9 years	Has some training	6 June 2017
Teacher C10	Information & Communication Technology (ICT), Mathematics	Secondary school - Form 1, Form 3, Form 4, Form 5	3 years	4 or below	Certified Google teacher	6 June 2017
Teacher C11	English Language	Form 1, Form 2	3 years	5 - 9 years	Has some training	6 June 2017

Table 2 - List of participants invited for interviews (cont'd)

	Taught school subject	Taught educational level	Years of use in Google applications	Years of teaching experience	Training in Google applications received	Interview date
Teacher C12	Mathematics	Secondary school - Form 4 to Form 6	2 years	5 years or above	Had some training	13 June 2017
Teacher C13	General Studies	Primary school - Primary 1 to Primary 6	1 years	4 years	Had no training	13 June 2017
Teacher C14	Physics, Geography	Secondary school - Form 4, Form 5	2 years	5 years or above	Had no training	13 June 2017
Teacher C15	Chinese Language	Secondary school - Form 5	2 years	15 years or above	Had no training	13 June 2017

Table 2 – List of participants invited for interviews (cont'd)

4.3.3 Conducting interviews

The teachers interviewed were contacted through the school's information technology officer or coordinator, who arranged the access of the school and a meeting place, which was quiet and uninterrupted for an interview. All the interviews in one school were arranged on the same day. Sometimes, it was necessary to take a recess between interviews and return at a time that suited the next participant.

In the interviews, all the participants showed that they were interested in the research because this was an opportunity for both of us to share our experiences and feelings. I would read all the questions of the schedule in all the interviews and thus asked the questions in the same order, but the participants were enabled to give their opinions in a free, easy, and relaxed atmosphere, encouraged by, for example, my demeanour such as a genuine smile. After each interview question, a brief summary of the participant's answer was given to confirm my understanding. There were situations in which some questions had been touched upon earlier in the schedule. When we reached these answered questions, a brief summary of what we had discussed was also given to the participant to confirm my understanding.

Prompts were always used: First, in quoting user experiences—for example, 'some teachers think that they are able to use cloud computing to ……, do you think so?'. These user experiences refer those shared by the local teachers in Google applications (Section 3.2.2) and the other teachers interviewed. Second, in the supplementary discussion—for example, 'could you give me an example?' and 'what makes you think like this?'—to solicit more information when needed. On many occasions, the participants got distracted, for example, by discussing their experiences of different technological tools, because they were using different tools together for teaching, in which case, I would use a prompt, for example, 'would you elaborate on your opinion of

Google applications?' such that the interview was focused on Google applications again.

4.4 Data analysis

4.4.1 Method of data analysis

The qualitative data collected were transcribed verbatim from the audio records of the conversation in the interviews to text in a Word file. I translated the data into English in another Word file and analysed the data by using a coding process according to the coding schemes shaped by the theoretical framework. The data analysis looked for affordances that the teachers mentioned as educational, social, and technological. Affordances were coded according to the semantic meaning in the data excerpt. I carried out the coding myself.

Table 5 in Section 4.4.2 tabulates the coding scheme, coded affordances, and the interpretation of the coded affordances. For example, the teacher said,

> 'We arrange four students into a group, and each group is provided with an iPad. With Google Slides, students respond by inputting the answer or choosing one of the several images relevant to a historical event, as in a matching game.' (Teacher C6)

This is an example of educational affordance about 'Classroom activities' defined in Table 5, a type of learning from behaviourism to produce a positive outcome by stimulus → response → reward. I copied and pasted this data excerpt to another Word file for the findings. Table 3 tabulates the coded affordances and the examples of data excerpts that support them. In the meantime, I found another set of affordances that appeared in conversations prompted by the open-ended questions, which did not map onto the coding scheme in Table 5. These affordances included the teachers' perceptions about whether a user interface design was attractive and therefore students tended to use it ('Aesthetic affordance'), the software helped students to learn at different speeds ('Addressing the learning difference issue'), it made the grading easier ('Automatic grading'), and it could

be used innovatively with different hardware and plugin software ('Use in integration with other tools'). These affordances were deduced from the data and were added to the coding scheme in Table 5.

The teachers also perceived constraints, i.e. negative affordance. Another cycle of coding was conducted in the same approach described above but treated with a minor difference. I paid attention to whether there were constraints perceived by the teachers that were discussed at the same time with affordances; these constraints were deduced from the data and added to the coding scheme. Table 4 tabulates the coded constraints and the examples of data excerpts that support them. Table 6 in Section 4.4.2 tabulates the coding scheme, coded constraints, and the interpretation of the coded constraints.

Further cycles of coding, the third and the fourth, were conducted to refine the categories and codes, as Saldana (2009) discussed:

> 'Rarely is the first cycle of coding data perfectly attempted. The second cycle (and possibly the third and fourth, and so on) of recoding further manages, filters, highlights, and focuses the salient features of the qualitative data record for generating categories, themes, and concepts, grasping meaning, and/or building theory.'
>
> (Saldana 2009, p.8)

For example, 'Aesthetic affordance' was finally grouped under social affordance instead of educational affordance, recognising that these examples were more about the motivation of group participation instead of individual learning. The 'Storage resource' affordance was finally grouped under educational affordance instead of technological affordance, recognising that storage on the cloud has pedagogical significance when it mediates different types of learning by providing a working memory according to the concept of mediation from Wertch (1997). The teachers' concerns about the loss of privacy and unexpected data changes were grouped under one coded constraint 'Lack of security' owing to that fact that both of these concerns were related to security.

A socio-cultural study was carried out on each of the data excerpts in Table 3 and Table 4 to understand its socio-cultural context with Burke's pentad. These findings are presented in Chapter 5, by using the following form, e.g.:

Scene:	Teaching Chinese History in the primary school classroom
Agent:	Teacher C6, students
Purpose:	To enable students to learn by responding to the teacher's questions on Google Slides cooperatively in groups through iPad
Agency:	Google Slides, Google Drive, iPad
Act:	Teacher C6 set up the slide show online. The students responded by inputting the answer or matching the correct image through iPad.

What Teacher C6 said in this example:

> 'We arrange four students into a group, and each group is provided with an iPad. With Google Slides, students respond by inputting the answer or choosing one of the several images relevant to a historical event, as in a matching game.'

Quantitative data were used to support the qualitative data. The quantitative data allowed me to compare across teachers in terms of their perception of affordances through descriptive statistics in a pie chart or a bar chart form. For example, the number of teachers who used different Google applications could inform the relative importance of the affordances they offered. The number of teachers who agreed/disagreed that Google applications could support cooperative learning revealed the extent to which the teachers agreed with social affordance. The teachers' rating on whether Google applications could support teaching revealed the extent to which the teachers found constraints related to supporting the pedagogy, while the qualitative data elaborated the different reasons for not supporting the pedagogy according to the teachers. The number of teachers who agreed/disagreed that Google applications could motivate learning revealed the extent to which the teachers believed that Google applications demotivated learning, while the qualitative data elaborated on the different reasons for demotivating learning according to the teachers. The teachers' ratings on the ease of use supported the teachers' argument

on whether training was required before use (a coded constraint). These findings will be discussed in Chapter 5.

The following table demonstrates the affordances coded according to semantic meaning in the excerpt of data:

First-level category	Second-level category	Coded affordance	Excerpt of data collected
Educational affordance	Support different pedagogical approaches	Classroom activities	'We arrange four students into a group, and each group is provided with an iPad. With Google Slides, students respond by inputting the answer or choosing one of the several images relevant to a historical event, as in a matching game.' (Teacher C6) 'In an English Language lesson, we use collaborative writing on a piece of composition. The teacher provides a topic for writing a story cooperatively, and the students create a mind map for the story and write it on Google Docs together.' (Teacher C8)
		Enabling assessment	'Google Forms is used for preparing a quiz…When statistics from the quiz shows that many students are weak in certain concepts, the teacher can adjust his/her teaching strategy accordingly.' (Teacher A4) 'The teacher can fine-tune teaching by referring to the pre-class preview. The result of the formative assessment is not only a grade but also the students' reflection such that the teacher and the students are more aware of their learning needs.' (Teacher B2)
	Mediation	Storage resource	'Google Drive on cloud is very convenient. I save files only on Google Drive because I am afraid that my USB storage will get lost.' (Teacher C1) 'Other software tools such as "Explain Everything", which is a cloud computing presentation app, can save work on Google Drive automatically, and thus, students do not lose their work when they forget to save it.' (Teacher C11)

Table 3 – Data analysis for the affordances of Google applications

First-level category	Second-level category	Coded affordance	Excerpt from data collected
Educational affordance	Mediation	Interesting to use	'I find that the students' motivation for learning is enhanced when they prepare a presentation on Google Classroom.' (Teacher C11) 'It (a Google application) facilitates classroom interaction by, for example, polling and project presentation. Students, particularly the younger children, like competition.' (Teacher C12)
		Enhancement of learning	'It is excellent to use Google Sheets to demonstrate the calculation of simple interest and compound interest, and to view the trend of data.' (Teacher C12) 'Google Earth helps in teaching geography, for example, the visualisation of the concept of contour lines, and the geographical views from different angles.' (Teacher C14)
	Teacher control and power relations	Cooperative learning	'I think we can use Google applications for cooperative learning after class instead of in the classroom only.' (Teacher C1) 'Students are arranged in groups of 2–3 or 3–5 members sitting next to each other. Group members were provided with iPads. The number of iPads provided depends on the activity.' (Teacher C10)
		Monitoring learning progress	'Google Classroom can share videos for the preview before a lesson. The use of Google Classroom has an advantage, as if the students respond, the teacher knows that they have watched the videos.' (Teacher C9) 'If a collaborative group works faster than the others, I will give them advice on improving their presentation, such as grammar and content, in which case I can take care of the students' learning difference.' (Teacher C11)

Table 3 – Data analysis for the affordances of Google applications (cont'd)

First-level category	Second-level category	Coded affordance	Excerpt from data collected
Social affordance	Enabling teacher-students interactions	Teacher to students communication	'The teacher can give a response to his/her students instantaneously through Google Classroom. The teacher can also receive the students' response in the class instantaneously, such that the teacher can teach according to the students' needs.' (Teacher C9)
	Enabling students-teacher interactions	Students to teacher communication	'Google Classroom can be used in the class for answering questions by all the students.' (Teacher C9) 'The (individual) student can respond by answering the teacher's questions or sending materials to the teacher or re-submitting an assigned work.' (Teacher C10)
	Enabling interactions among students	Enabling social space	'Students can share their feelings and reflections, and there is no need to send files back and forth in emails, as in the past.' (Teacher A2) 'We use Google Slides for students to co-edit a presentation in the class, and they can review other classmates' ideas after the class.' (Teacher C9)
		Aesthetic affordance	'We are now using Google Classroom more for after-class communication, because it looks like a forum.' (Teacher C9)
Technological affordance	Classroom administration	Resource sharing	'We produced videos on the use of mathematical techniques and on how to answer different types of questions in the public examination on Google Classroom for sharing with students…' (Teacher C10) 'We uploaded news, extended reading, English articles, sample writing, script, answers, multimedia, and lessons according to the learning goals, objectives, or topics on Google Classroom for sharing with students.' (Teacher C11)

Table 3 – Data analysis for the affordances of Google applications (cont'd)

First-level category	Second-level category	Coded affordance	Excerpt from data collected
Technological affordance	Classroom administration	Addressing learning difference issue	'Students have learning differences in my taught subject, and therefore, I keep the students' submissions and re-submissions with comments on them.' (Teacher C10) 'We use the iPad to help practise English conversation, so we can take care of weaker students. Students take turns using the iPad to respond and record the conversation. If necessary, the student can pause the recording and think about it before responding.' (Teacher C11)
		Automatic grading	'We often use Google Forms for a quiz that can be automatically graded. However, grading can only be carried out on multiple-choice questions and not on fill-in-the-blank ones.' (Teacher C9)
	Ubiquitous use	Compatibility across platform	'We use Microsoft Word commonly at school. However, because I may not be working long hours at school, I use Google Slides with files saved on Google Drive at home…There needs much exchange between the Google and Microsoft documents.' (Teacher C13) 'I mainly use Google Slides and save files on Google Drive after working at home. It is compatible with Microsoft PowerPoint. It is very convenient without using USB storage for the file exchange.' (Teacher C6)

Table 3 – Data analysis for the affordances of Google applications (cont'd)

First-level category	Second-level category	Coded affordance	Excerpt from data collected
Technological affordance	Ubiquitous use	Access anywhere, anytime	'I can use Google applications outside school when there is no installed software on the computer.' (Teacher C1) 'It is convenient to use, if there is a computer and Internet access, or by borrowing a colleague's computer when on a trip, a teacher can still access his own documents and share them with others.' (Teacher C4) 'It is convenient for students when they can use it for editing a document and can submit by uploading to the group after class.' (Teacher C5)
	Innovative use	Use in integration with other tools	'Both Google Slides and Google Forms can be used in integration with the iPad.' (Teacher C10) 'An interactive whiteboard app "Explain Everything" is used together with a pen tablet for producing videos and uploading them to YouTube, with their URLs shared with students through Google Classroom.' (Teacher A3)

Table 3 – Data analysis for the affordances of Google applications (cont'd)

The following table demonstrates the constraints coded according to semantic meaning in the excerpt of data:

First-level category	Second-level category	Coded constraint	Excerpt from data collected
Educational constraint	Not supporting pedagogy	Not applicable to taught subject	'In my lesson, Google applications might not be useful because drawing a picture with them is difficult, unless the teacher and students grasp the use of auxiliary equipment such as the mouse and the drawing board.' (Teacher C4) 'We mainly require teacher-to-student teaching. Google applications can be used for administrative work for reducing paper consumption but cannot inspire knowledge.' (Teacher C15)
	Demotivation in learning	Demotivating writing	'In a Chinese class, handwriting is also an important skill; i.e., writing Chinese characters requires one to follow the correct sequence of strokes. The data input device seems to not work satisfactorily for authentic Chinese characters... Students will not write good Chinese if the learning depends too much on a computer.' (Teacher C15)
Social constraint	Ineffective communication	Lack of body language while typing	'When we write with a pen, we can express our feelings, for example, through facial expressions, gestures, and body language. However, collaborative writing does not facilitate these interactions and prompts.' (Teacher C1)
Technological constraint	System constraint	WiFi dependency	'Our existing WiFi does not cover the entire school, and therefore, I cannot use an iPad in many situations.' (Teacher C12)
		Incompatibility across platforms	'Google applications cannot open a file in the Corel Draw format, and therefore, the teacher needs to download the file and then upload it back after commenting on it, which is time consuming.' (Teacher C10)

Table 4 – Data analysis for the constraints of Google applications

First-level category	Second-level category	Coded constraint	Excerpt from data collected
Technological constraint	System constraint	Require training before use	'When I use Google Forms, I do not know how to remove a form. There is no delete function on the right click (as in most Microsoft software), and nobody could tell me how to do so. It took me some time before I found the trash option.' (Teacher C4)
		Inspection problem	'If the students' assignments are stored digitally, the subject lead and parents cannot easily inspect the quality of work as they would a conventional hard copy of the student assignments. Parents can see the students' work easily when it is in the form of a conventional hard copy.' (Teacher C2)
		Lack of functionality	'Teachers get used to marking assignments with ticks and crosses. Teachers can easily write comments and strikeout or encircle things on a paper-based assessment. We hope that there is a fast grading process in the future similar to this.' (Teacher C8)
	Safety and security concerns	Lack of security	'Being free of charge might have an impact; for example, a possible loss of privacy and security are a big concern. Teachers think that there are certain risks related to the use of such technology.' (Teacher C8)
		Plagiarism problem	'Google Forms is useful, but if we use it for home assignments, I am afraid that students will copy from each other because it makes copying easy.' (Teacher C1)
		Loss of data	'Google's Terms of Use state that Google is not liable for any loss of stored content. Whether it is safe is a consideration for whether it (Google application) is used.' (Teacher C8)

Table 4 – Data analysis for the constraints of Google applications (cont'd)

4.4.2 Coding scheme for affordance

Coding enables a researcher to group and to organise similar data into categories or families because they share similar characteristics.

> 'A code in qualitative research is most often a word or a short phase that symbolically assigns a summative, salient, essence-capturing, and /or evocative attribute for a portion of language-based or visual data.'
>
> (Saldana 2009, p.3)

> 'It leads you from the data to the idea, and from the idea to all the data pertaining to this idea.'
>
> (Richards & Morse 2007, p.137 cited in Saldana 2009)

The theoretical framework illustrated in Figure 7 of Section 2.7 informs and shapes the coding scheme and the subsequent analysis of collected data. In the theoretical framework, the first-level categories group affordances into educational, social, and technological. The second-level categories group affordances under the different themes discussed in Section 2.6.

Data were coded to identify the affordances that the participants perceived from Google applications. Table 5 shows the coding scheme, coded affordances, and the literature review section from which the coded affordances were derived. The data analysis looked at examples from the data that supported these codes. Some coded affordances emerged from the data, instead of being derived from the literatures. The coded affordances that did not map onto these categories but were deduced from the data are marked with an asterisk in the table.

First-level categories	Second-level categories	Coded affordance	Code interpretation (Literature review)
Educational affordance	Support different pedagogical approaches	Classroom activities	These are properties that support a variety of classroom activities, promoting the different modalities of learning associated with learning theories, namely behaviourism, cognitivism, constructivism, and social constructivism. (Section 2.4.1)
		Enabling assessment	These are properties that support different roles of assessments. (Section 2.4.3)
	Mediation	Storage resource	These are properties that promote learning by facilitating processing in the working memory or transfer to and retrieval from the long-term memory during the private (internalisation) phase of learning (cognitivism). (Section 2.2)
		Interesting to use	These are properties that promote motivation through rewarding interactions with the software (behaviourism). (Section 2.2)

Table 5 – Coding scheme for affordance analysis

First-level categories	Second-level categories	Coded affordance	Code interpretation (Literature review)
Educational affordance	Mediation	Enhancement of learning	These are properties that empower students to interact with each other and the external world to acquire knowledge and understanding. (Section 2.2)
	Teacher control & power relation	Cooperative learning	These are properties that enable students to learn with shared competence and empower them to take more control over their learning. (Section 2.4.2)
		Monitoring learning progress	These are properties that promote the maintenance of appropriate power relations through visible and invisible control to classroom activities. (Section 2.4.2)
Social affordance	Enabling teacher-students interactions	Teacher to students communication	These are properties that support the one-to-many relation between the teacher and the students. (Section 2.6.2)
	Enabling students-teacher interactions	Students to teacher communication	These are properties that support the one-to-one and many-to-one relations between the students and the teacher. (Section 2.6.2)
	Enabling interactions among students	Enabling social space	These are properties that provide a social space to the students. (Section 2.6.2)

Table 5 – Coding scheme for affordance analysis (cont'd)

First-level categories	Second-level categories	Coded affordance	Code interpretation (Literature review)
Social affordance	Enabling interactions among students	Aesthetic affordance (*)	These are properties that enhance motivation among group members through aesthetic interface design.
Technological affordance	Classroom administration	Resource sharing	These are properties that allow the user to share resources with other users. (Section 3.1.1)
		Addressing learning difference issue (*)	These are properties that address the issue that some students learn faster or slower than the others.
		Automatic grading (*)	These are properties that automatically grade an online test.
	Ubiquitous use	Compatibility across platforms (*)	These are properties that allow the user to access material from any computing platform.
		Access anywhere, anytime	These are properties that allow the user to access material from anywhere at any time. (Section 3.1.1)
	Innovative use	Use in integration with other tools (*)	These are properties that allow the use of the software together with different hardware such as iPads and pen tablets, or different plugin software to enhance functionality.

Remark: (*) this code is induced from the data collected

Table 5 – Coding scheme for affordance analysis (cont'd)

Another set of codes was identified in Table 6 for the constraints, i.e. negative affordances, derived from the qualitative data presented in Table 4.

Johnson (2012) mentioned some disadvantages of using cloud computing from a school teacher's perspective. The data analysis looked at whether these constraints were perceived by the teachers in Hong Kong. Table 6 shows the coding scheme, coded constraints, and the literature review from which the coded constraints were derived. Some coded constraints emerged from the data during the affordance analysis. The coded constraints that did not map onto these categories but were deduced from the data are marked with an asterisk in the table.

First-level categories	Second-level categories	Coded constraint	Code interpretation (Literature review)
Educational constraint	Not supporting pedagogy	Not applicable to taught subject (*)	These are properties that cause teachers to believe that the software is not applicable to their curriculum.
		Uncontrolled student behaviour (*)	These are properties that cause students to do something that the teacher did not want in the class.
	Demotivation in learning	Not interesting to use (*)	These are properties that demotivate students from using the technology.
		Demotivating writing (*)	These are properties that affect the learning outcome because of the use of the keyboard instead of writing by hand.
Social constraint	Ineffective communication	Lack of body language while typing (*)	These are properties that hinder the teacher from using body language to communicate, to guide students to present an idea, etc., when using the keyboard.

Remark: (*) this code is induced from the data collected

Table 6 – Coding scheme for constraint analysis

First-level categories	Second-level categories	Coded constraint	Code interpretation (Literature review)
Technological constraint	System constraint	WiFi dependency	These are properties that disallow the user to use the software when there is no WiFi connection. (Section 3.1.4)
		Incompatibility across platforms (*)	These are properties that disallow the user to use the software across platforms, e.g. incompatibility of file formats, or when the other end is not using the same software for communication.
		Require training before use (*)	These are properties that disallow the user to use the software when there is insufficient training provided.
		Inspection problem (*)	These are properties that make it difficult for the students' assignments to be inspected by the subject lead or by parents (as in the case of the conventional written work) because they are stored digitally.
		Lack of functionality (*)	These are properties such as the lack of some functions that the teachers need for teaching.

Remark: (*) this code is induced from data collected

Table 6 – Coding scheme for constraint analysis (cont'd)

First-level categories	Second-level categories	Coded constraint	Code interpretation (Literature review)
Technological constraint	Safety and security concerns	Lack of security	These are properties that are related to data security such as loss of privacy and unauthorised data changes. (Section 3.1.4)
		Plagiarism problem (*)	These are properties that make it easier for the students to plagiarise.
		Loss of data	These are properties that lead to concerns related to the loss of data. (Section 3.1.4)

Remark: (*) this code is induced from data collected

Table 6 – Coding scheme for constraint analysis (cont'd)

4.5 Limitations

A limitation of using both qualitative and quantitative data is that they might give confusing results. To prevent a confusing result, open-ended questions that collected qualitative data were asked simultaneously with the related closed-ended question that collected quantitative data by using the Likert scales, such that these two types of data supported each other.

The research method of collecting both quantitative and qualitative data combines the strengths of a large-scale study for limited information that is statistically generalisable, and a small-scale study for in-depth insights drawn out from one or a small number of specific contexts. However, this research does not have any large-scale data that are statistically significant to be representative of the school teachers in Hong Kong. The

statistical data reveal the teachers' perceptions in my sample only and cannot be generalised to the school teachers of Hong Kong.

Quantitative questions seek to measure whether participants agree with an affordance. The difference between strongly agree and agree is often subtle and influenced by an individual's interpretation, and some people are less likely to use the extreme points of scale. Because both written criteria and quantitative criteria are not applicable to the scale owing to the complex factors affecting affordance, the responses of strongly agree and agree were not significantly different.

The sample was a heterogeneous one consisting of teachers who taught different school subjects and at different educational levels, and therefore, the findings were general. Focusing on a single school subject within a certain educational level would reveal more nuances, for example, the effect of different approaches to frame the lessons or a different classroom organisation that attributed to the affordances and the constraints.

4.6 Ethical consideration

This research was carried out in accordance with the ethical procedures of the University of Bristol, School of Education. In the procedure, I filled the GSoE Research ethics form online and had an ethical discussion with a discussant as part of completing the form before proceeding with the data collection. Appendix 4 presents the GSoE Research ethics form with the ethical issues discussed and decisions taken.

Appendix 5 presents Letter of Introduction sent to the schools' information technology officer or coordinator in advance, stating that the inquiry was for academic purposes only and that I had no connection with any software producer and would not use the data for any commercial advantage. Informed consent was needed to ensure that all the participants understood and agreed to the voluntary participation before the interviews. The participants were informed of their right to withdraw at any time. During the

interviews, the interviewees were invited to give their opinions in a free, easy, and relaxed atmosphere. Audio recordings and the researcher's notes were made known to the participants.

The data collected were held in confidence. The school contacts were not used for any purpose other than this research. The identity of the participants and the schools would be anonymised in the dissertation and any subsequent publication. The audio records were stored in my personal and notebook computers with a password login and would be deleted after this research.

An ethical issue raised in the course of this research was about veracity. According to Postgraduate Information Literacy Online Training from Glasgow Caledonian University (PILOT):

> 'Veracity means that researchers should tell the truth and pass on information in a comprehensive and objective way.'
>
> PILOT (2013)

Researchers should always be honest with the participants and keep any promise made. For example, if the researcher says that an interview will take 30 minutes to complete, the interview should take 30 minutes and not longer. However, there was an occasion in which the interview over-ran the scheduled time. This ethical issue was addressed by my time control in the interviews.

4.7 Conclusion

This chapter described the research design and the methods of data collection. Section 4.4.1 discussed the analysis method that used a coding process to map the affordances and the constraints from the data collected to the coding schemes, as shown in Table 3 and Table 4. Section 4.4.2 discussed the coding scheme influenced and shaped by the theoretical framework, the coded affordances and constraints, and the interpretation of

these codes, tabulated in Table 5 and Table 6. Chapter 5 will discuss these affordances and constraints and elaborate on them by using examples from the data collected.

Chapter 5 Findings

Two types of data were collected: quantitative and qualitative. Quantitative data refer to the teachers' responses to Likert-scale questions in the interviews, while qualitative data refer to the teachers' responses to open-ended questions. Qualitative data describe in detail the values and approaches of teachers and how they use the Google applications, while quantitative data allow us to compare across teachers in terms of their perception of affordances and to support the qualitative data. Thus, both types of data are valuable.

The data analysis in Section 4.4 coded the affordances and the constraints from the qualitative data according to the coding schemes in Table 5 for the affordances and Table 6 for the constraints in the coding process. The coded affordances are presented in Figure 12, and the coded constraints are presented in Figure 13. These are the same codes as those presented in Table 5 and Table 6 but presented graphically. These coded affordances will be discussed in Section 5.2 and the coded constraints in Section 5.3 with examples from the data collected. The socio-cultural theory will be used to reflect on the classroom phenomena for the reasons, for example, why the teachers did or did not perceive these affordances in different socio-cultural contexts.

Section 5.4 summarises the findings by how the three research questions (RQ1, RQ2, and RQ3) were answered. Section 5.5 discusses the construction of an evaluation checklist that can be derived from the coding scheme in this research, and how to use the checklist.

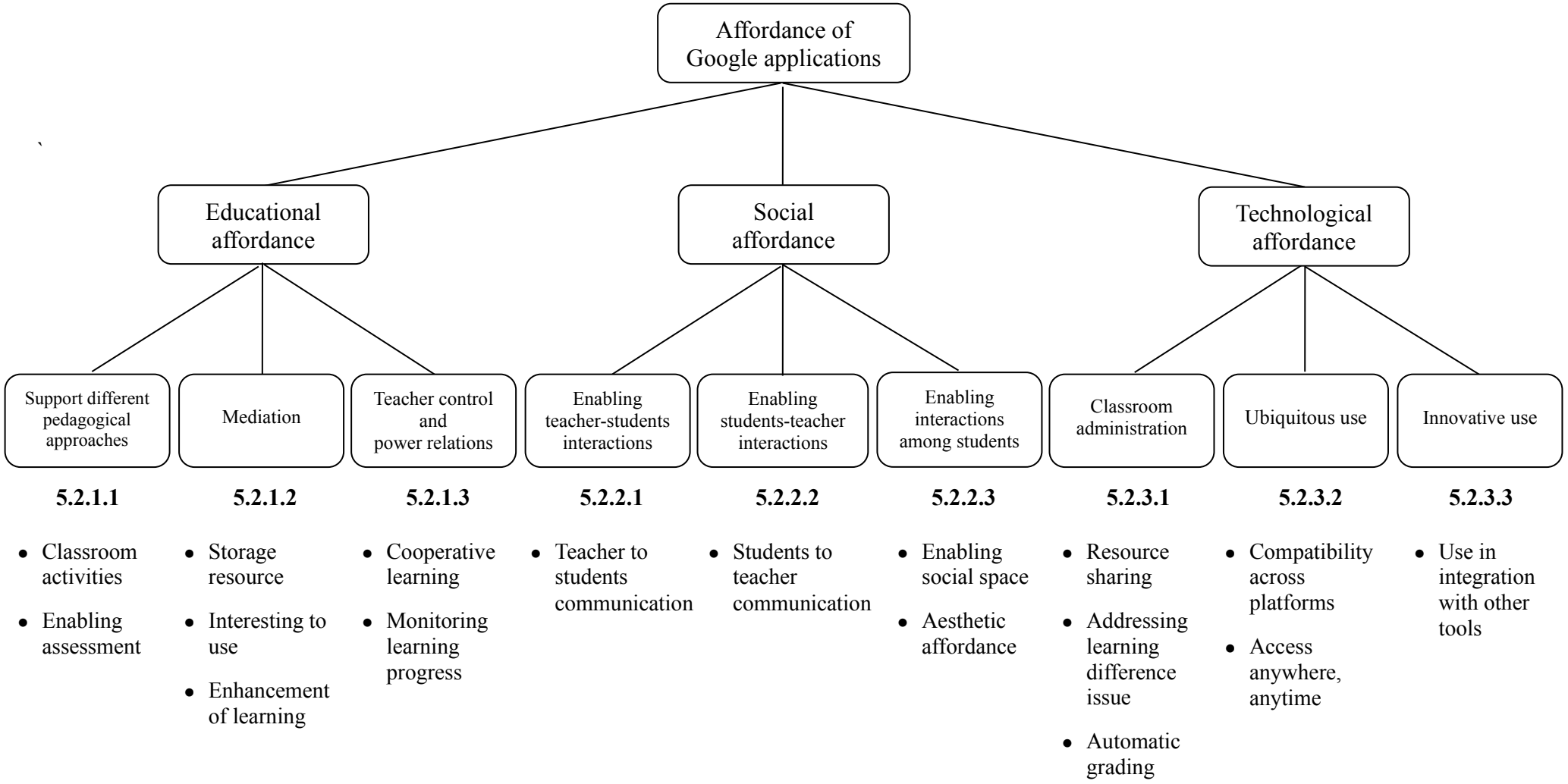

Figure 12 – Coding scheme for the affordance analysis of Google applications

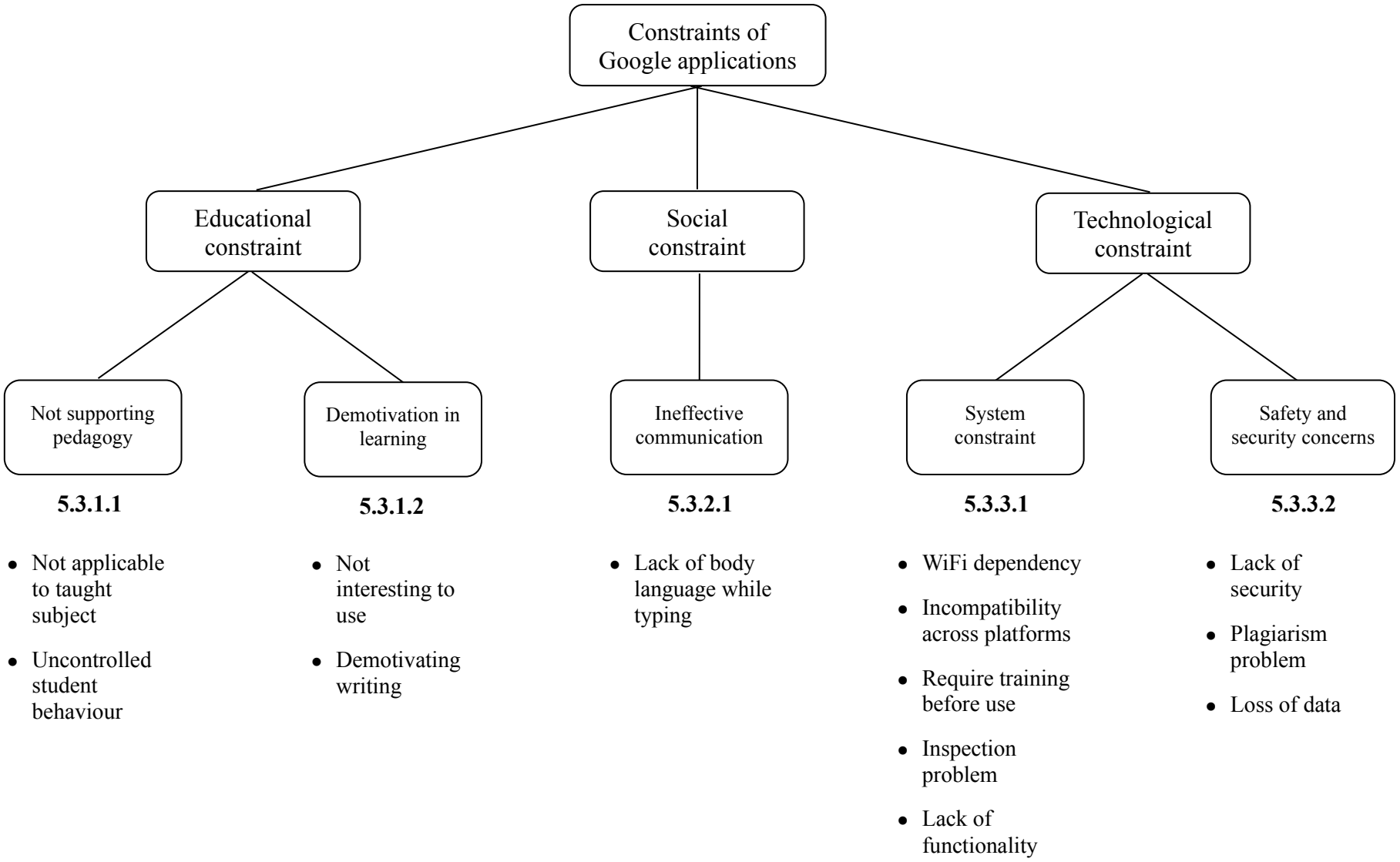

Figure 13 – Coding scheme for the constraint analysis of Google applications

5.1 Prevalence of the use of Google applications

In order to appreciate the affordances perceived by the teachers from Google applications, it is important to know which applications they used and how often they used them.

From the interview question 'How often do teachers use Google applications?', the numbers of teachers who used Google applications against their frequency of use is tabulated in Appendix 3.1 (Table 12) and is presented in the bar chart below. These figures suggest that teachers are individuals who can choose the types of technology appropriate for the lessons they teach.

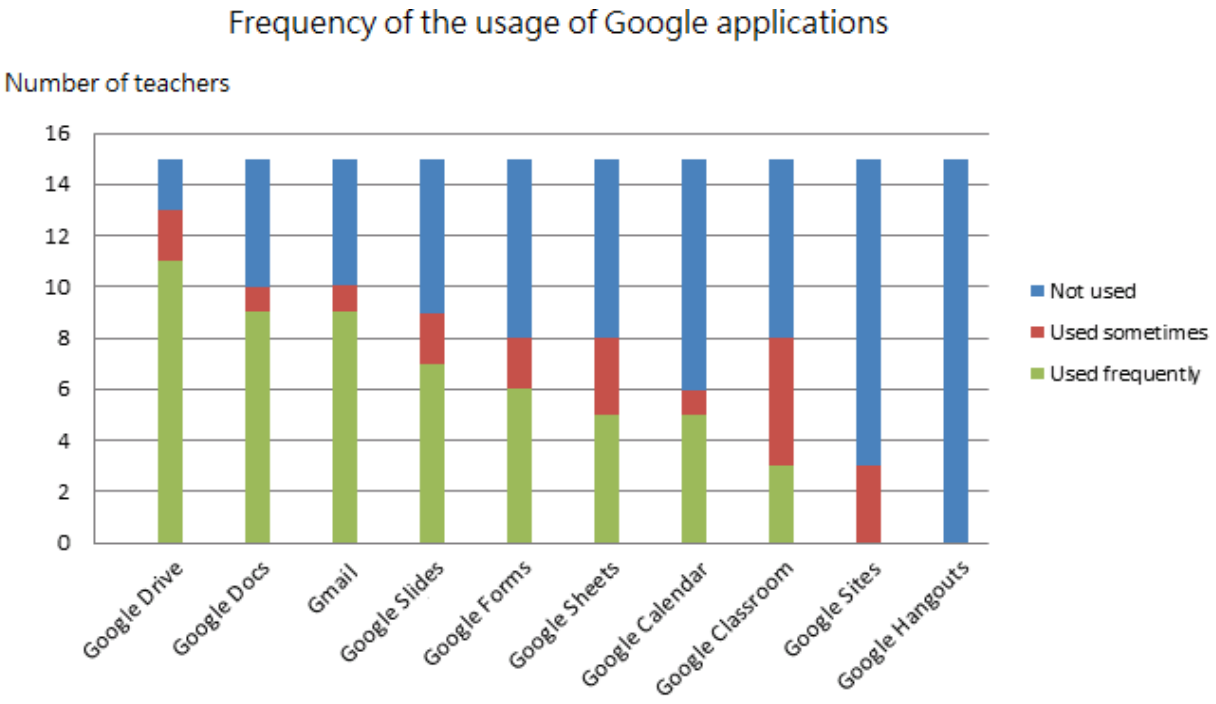

Figure 14 – Bar chart of the number of teachers who used Google applications and their frequency of use

According to the bar chart, the most frequently used Google application was Google Drive (11 teachers). The second most frequently used applications were Gmail and Google Docs (nine teachers for each). The third and the fourth most frequently used applications were Google Slides (seven teachers) and Google Forms (six teachers).

How often a software tool is used could depend on its affordances and constraints. The most frequently used Google application was Google Drive. The teachers talked about Google Drive because they found it useful as a repository of learning materials, a backup medium, and a bridge for transferring files across different software tools. Google Drive offers the 'Storage resource', 'Resource sharing capability', 'Compatibility across platforms', and 'Access anywhere, anytime' affordances, and therefore, it was frequently used. The second most frequently used cloud computing applications were Gmail and Google Docs. Gmail is useful for communications. Gmail offers the 'Teacher to students communication' and 'Students to teacher communication' affordances. Google Docs offers the 'Cooperative learning' and 'Enabling social space' affordances. The third and the fourth most frequently used cloud computing applications were Google Slides and Google Forms; they offer the 'Cooperative learning', 'Enabling assessment', and 'Classroom activities' affordances that support different pedagogical approaches. These Google applications were frequently used because they generated affordances required by the teachers. In other words, they were less frequently used because of their constraints. The following sections discuss these affordances and constraints as perceived by the teachers. These results or information reveal how cloud computing helps or hinders teachers or changes the teaching practices, with the use of Google applications as an example.

5.2 Perceived affordances

This section presents an analysis of the affordances perceived by the teachers for Google applications, guided by the theoretical framework for affordance analysis discussed in Section 2.7 (Figure 7). Figure 15 presents an overview of the number of responses to the affordances shown in Figure 12 perceived by the fifteen participants. Each affordance is then discussed in detail.

The numbers of teachers who perceived these affordances are tabulated in Appendix 3.2 (Table 13) and are presented in the following bar chart. These figures suggested that some affordances were perceived by more teachers than the others.

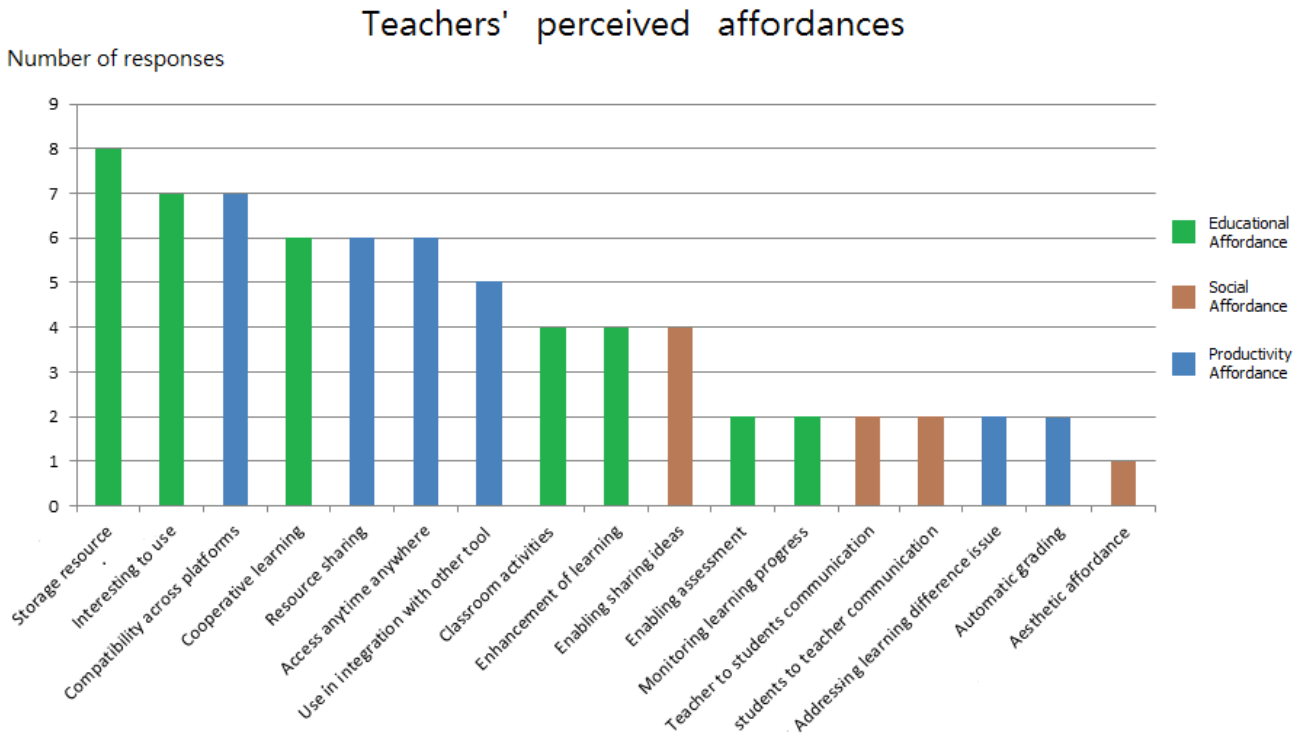

Figure 15 – Bar chart of the number of responses verses coding scheme for the affordances of Google applications

According to the bar chart, the highest perceived affordance was 'Storage resource' (eight teachers). The second highest perceived affordances were 'Interesting to use' and 'Compatibility across platforms' (seven teachers for each). The third highest perceived affordances were 'Cooperative learning', 'Resource sharing', and 'Access anywhere,

anytime' (six teachers for each).

The reason why some affordances were perceived by more teachers could be that these affordances had the more advantageous properties of cloud computing (on-demand self-service, resource pooling, broad network access, rapid elasticity, and measured service, reviewed in Section 3.1.1, for the essential characteristics of cloud computing). These properties led to the 'Storage resource', 'Resource sharing', and 'Compatibility across platforms', and 'Access anywhere, anytime' affordances. Cloud computing providers and developers offer their software tools on the cloud with these properties. The teachers used these tools and found them useful; therefore, these affordances were perceived.

The teachers found them useful because cloud computing supports the pedagogies and learning activities that they need. 'Storage resource' is the most frequently perceived affordance. This affordance allows Google applications to mediate teaching and learning by providing a working memory and information storage for classroom activities in different pedagogical approaches. This affordance facilitates teachers in organising and sharing different types of learning materials with their students. 'Compatibility across platforms' is the next highest perceived affordance because it allows software tools to be used with mobile and tablet devices, such as iPads and different types of computers, such as Microsoft Windows-based and MacBook, enabling cooperative learning to take place. The 'Access anywhere, anytime' affordance is another highly perceived affordance because it allows the teaching strategy to be extended outside of the classroom.

The data analysis attempted to find whether any affordance was valued more by primary school teachers, secondary school teachers, and teachers of different subjects, but did not find a direct relationship between affordances and different school subjects. It appeared that the Google applications were not suitable for certain subjects; for instance, Teacher C15, who taught Chinese Language, thought that these tools were not useful for teaching

because he used the traditional teacher-centred teaching method. However, Google applications offer the 'Cooperative learning' and 'Resource sharing' affordances that are applicable to examples of different subjects. Teacher C1, Teacher C2, Teacher C9, Teacher C10, and Teacher C11 used Google applications for cooperative learning of Integrated Science, Physics, Chinese Language, English Language, and Mathematics. However, a relationship was found between the affordances and the educational levels. Teacher C10 and Teacher C12 perceived different affordances from the Google applications for the different educational levels. For lower-level students (Forms 1 – 3), Google applications were used for cooperative learning, because younger children preferred more classroom interactions. However, for higher-level students (Forms 4 – 5), Google applications were used as personal workspaces (Masud *et al*., 2012), which took advantage of the 'Storage resources', 'Resource sharing', and 'Access anywhere, anytime' affordances, because students needed to prepare for public examinations.

The following sections discuss all the affordances categorised as educational, social, and technological, in detail.

5.2.1 Educational affordance

This section discusses the educational affordances studied from the data collected.

5.2.1.1 Support different pedagogical approaches

The following examples show how the technological tools offer affordances to classroom activities in different pedagogical approaches: behaviourism, cognitivism, constructivism and social constructivism, and assessments.

Affordance: Classroom activities

A behaviourist advocates the educational process to be centred on learning through stimulus → response → reward. Teacher C6, who taught Chinese History in

primary school, offered an example of behaviourist learning with cloud computing. Teacher C6 set up the classroom for students to learn by responding to the teacher's questions cooperatively in groups. The following data of Teacher C6's pedagogic assemblage illustrate this example:

Scene: Teaching Chinese History in the primary school classroom
Agent: Teacher C6, students
Purpose: To enable students to learn by responding to the teacher's questions on Google Slides cooperatively in groups through iPad
Agency: Google Slides, Google Drive, iPad
Act: Teacher C6 set up the slide show online. The students responded by inputting the answer or matching the correct image through iPad.

What Teacher C6 said in this example:

> 'Teaching Chinese History is always a unidirectional communication, mainly the presentation of historical information. However, having some interactions between students and the teacher makes learning easier, for example answering a poll by raising hands.'
>
> 'We arrange four students into a group, and each group is provided with an iPad. With Google Slides, students respond by inputting the answer or choosing one of the several images relevant to a historical event, as in a matching game.'
>
> 'Although the activity is similar to raising hands to answer, it improves the classroom atmosphere.'
>
> 'Primary school students like playing and more interaction in the classroom.'

In this activity, students were asked to complete the task in Google Slides by inputting the answer or by choosing the correct image as in a matching game, by using iPad. The students were interested in playing with the slideshow, and therefore, it provided a 'stimulus' to the students. The matching games navigated students who 'respond' by supplying the missing word or image from the alternatives. If the students input the correct answer, they receive a 'reward' such as a score or thumb appreciation, thus embodying behaviourist learning.

Teacher C10, who taught mathematics and ICT in secondary school, presented an example that offered an example in cognitivist learning by providing categorised and organised information sources with learning designs that enable students to retrieve information and learn efficiently. Teacher C10 produced videos on the use of mathematical techniques on Google Classroom for sharing with students. The following data of Teacher C10's pedagogic assemblage illustrate this example:

Scene: Teaching Mathematics, ICT in secondary school
Agent: Teacher C10, students
Purpose: To produce videos on the use of mathematical techniques and on how to answer different types of questions in the public examination for students because their learning progress may be ahead of or behind that of the others
Agency: Google Classroom, Google Slides
Act: Teacher C10 created materials online. The students interacted with Google Classroom to study these materials at their own pace.

What Teacher C10 said in this example:

> 'For Form 5 mathematics, we produce videos on the use of a basic technique and on how to answer different types of questions in the public examination and share these with students through Google Classroom. Students watch them with an iPad together in the class. Students can also watch them at home again.'

> 'For lower levels, Google Classroom is a platform for cooperative learning. While for higher levels, as the students need to prepare for the public examination, it is a personal workspace.'

A similar example of cognitive learning was from Teacher C11, who taught English Language in secondary school. Teacher C11 uploaded news, extended readings, articles, sample writings, scripts, answers, multimedia, and lessons on Google Classroom for sharing with students. The following data of Teacher C11's pedagogic assemblage illustrate this example:

Scene: Teaching English Language in Form 1, 2
Agent: Teacher C11, students
Purpose: To create English learning materials and organise these materials for students to learn different topics systematically
Agency: Google Classroom, Google Docs, Google Drive
Act: Teacher C11 created materials online. The students interacted with Google Classroom to study these materials.

What Teacher C11 said in this example:

> 'We upload news, extended reading, English articles, sample writing, script, answers, multimedia, and lessons according to the learning goals, objectives or topics on Google Classroom for sharing with students.'

> 'I produce some simple voice recordings for the listening exercises and fill-in-the-blank exercises on a worksheet and upload them to Google Classroom.'

In the above examples of Teacher C10 and Teacher C11, Google Classroom enables the categorisation of these materials providing information sources, for example, on different topics, different types of problems, and different educational levels, allowing the teacher to structure information such that the students can migrate new knowledge to their existing knowledge structure. Google Drive offers a storage for students to organise information, for example mathematical techniques and English Language techniques for transferring to their long-term memories, thereby embodying cognitive learning.

Teacher C8 discussed the experience of his colleague who taught English Language in secondary school, offering an example of constructivist learning in which the students actively constructed new knowledge in terms of prior ideas, concepts, and experiences (Doherty, 2012).

In an English Language lesson, the teacher provided a topic for writing a story cooperatively, and the students created a mind map for the story and wrote it on Google Docs together. The following data of Teacher C8's pedagogic assemblage

illustrate this example:

Scene: Teaching English Language in the secondary school classroom
Agent: The teacher, students
Purpose: To teach English by cooperative writing on a piece of composition in the entire class
Agency: Google Docs, Google Drive
Act: The teacher and students interacted with Google Docs in the cooperative writing

What Teacher C8 said in this example:

> 'In an English Language lesson, we use collaborative writing on a piece of composition. The teacher provides a topic for writing a story cooperatively, and the students create a mind map for the story and write it on Google Docs together.'

The mind map is a brainstorming tool that helps to organise the human agents' thinking and prior knowledge for creating new ideas. The teacher, the students, and Google Docs interact together embodying constructivist learning.

These examples suggest that Google applications offer affordances in classroom activities with different pedagogical approaches. These tools enable (1) behaviourist learning by allowing students to respond to the teacher's questions cooperatively through the iPad, (2) cognitivist learning by producing, organising, and sharing materials about mathematical and English techniques, and (3) constructivist learning by creating a mind map for writing a story in English cooperatively.

Affordance: Enabling assessment

There are two types of assessments: formative and summative. The following are three examples of affordances for an assessment from the data.

First, Teacher B2, who taught in a secondary school, discussed the affordances of Google Sheets for an assessment. The following data of Teacher B2's pedagogic assemblage illustrate this example:

Scene: Formative assessment in secondary school

Agent: Teacher B2, students

Purpose: To enable the teacher to understand the students' learning needs, and to enable the students to understand their learning progress

Agency: Google Forms, Google Sheets

Act: Teacher B2 set up an assessment online. The students took the assessment either before the class or during the class.

What Teacher B2 said in this example:

> 'Being different from summative assessment, formative assessment helps students to understand their learning progress.'
>
> 'Formative assessment includes classroom questions, assignments, quizzes, and projects. These assessments can be carried out in three situations: pre-class preview, classroom interaction, and integration of paper and electronic assessment using Google Forms and Google Sheets.'
>
> 'The teacher can fine-tune teaching by referring to the pre-class preview. The result of the formative assessment is not only a grade but also the students' reflection such that the teacher and the students are more aware of their learning needs.'
>
> 'It must be continuously carried out for the formative assessment to be effective. These technologies provide a platform for formative assessment.'

Teacher B2 suggested that Google Forms and Google Sheets could be used as a platform for formative assessment.

Second, Teacher A4, who taught Chinese Language in secondary school, suggested the reading exercise to be conducted on Google Classroom and Google Forms. The following data of Teacher A4's pedagogic assemblage illustrate this example:

Scene: Teaching Chinese Language in secondary school

Agent: Teacher A4, students

Purpose: To complete a reading exercise before the class such that the students are prepared for the lesson and the teacher can adjust his/her teaching strategy when there are many students weak in certain concepts

Agency: Google Classroom, Google Forms, iPad

Act: Teacher A4 created materials and a quiz online. The students interacted with the tools to study the materials and took the quiz before the class.

What Teacher A4 said in this example:

> 'Reading exercises are often conducted on Google Classroom. We have twelve sample articles shared through Google Classroom for pre-class preparation about the author's information, background, vocabulary, and the message carried on each paragraph of the article. Time will not be consumed on these tasks in the class. Google Forms is used for preparing a quiz. The advantage of Google Forms is that images, YouTube videos, and teaching materials can be embedded in it. When statistics from the quiz shows that many students are weak in certain concepts, the teacher can adjust his/her teaching strategy accordingly. Another advantage of the quiz is that we know whether the students have watched the video, for example, by asking what the actor said in the video?'

Teacher A4 mainly discussed that there were advantages of using cloud computing for assessment as compared to the other technological approaches. For example, it enabled pre-class preparation over the Internet, and it allowed the uploading of images, YouTube videos, and teaching materials to the assessment online.

Third, Teacher C4, who taught Visual Arts in secondary school, used formative assessment after the class for testing whether students had paid attention in the class. The following data of Teacher C4's pedagogic assemblage illustrate this example:

Scene: Teaching Visual Arts in secondary school
Agent: Teacher C4, students
Purpose: To complete formative assessment online after the class to confirm that the students have learnt
Agency: Google Forms, Google Drive
Act: Teacher C4 set up a quiz online. The students took the quiz after the class.

What Teacher C4 said in this example:

> 'After the class, a quiz using Google Forms is useful for testing whether the students paid attention to the class.'
>
> 'However, it (Google Forms) will not be used it in the formal assessment.'

In summary, what Teacher B2, Teacher A4, and Teacher C4 suggested is that assessment can be set up using the considered Google applications, and that this had an advantage over other technological approaches because students could take these assessments online outside the classroom, and therefore, the teacher could have control by knowing whether the students had prepared the lesson or had paid attention in the class. However, because of certain security concerns, cloud computing will not be used for formal, i.e. summative assessment. However, Google applications are very useful for formative assessment.

5.2.1.2 Mediation

This section discusses examples of how Google applications mediate the teaching and learning processes to enable different learning strategies; how teaching and learning are supported through the mediation of storage resource, how students are motivated for using it, and how they can learn more easily from the use of software tools.

Affordance: Storage resource

Google applications mediate teaching and learning by offering a storage resource that supports other affordances in the following four ways:

First, the learning of the children appeared twice: first, at the social level, and later, at the individual level (Vygotsky, 1978). In cooperative learning, the students used Google applications to co-edit their presentation in groups and saved on Google Drive during the class. They first learnt on the social level in the classroom. Google Drive mediated learning by serving as a working memory in cooperative learning. The students review the ideas learnt from the presentation through the Internet after the class. They reflected on what the group had said, decide whether or not an idea is good, it is useful or not and in this the second moment of learning, the students internalise what they had talked about at the individual level.

The teacher could record drawings and texts during the class by using Google applications that saved files on Google Drive for review afterwards (Teacher A1 and Teacher C12). Other software tools such as 'Explain Everything', which is a cloud computing presentation app could save work on Google Drive automatically, and thus students did not lose their work when they forgot to save' it (Teacher C11).

Second, Google Drive provides teachers a repository of categorised and organised information in a meaningful way. Educational process could be the learning designs that enable students to efficiently store and retrieve information (Doherty, 2012). Google Classroom facilitates the teachers to share information with their students according to, for example, different topics, different types of problems, and different educational levels such that the students can migrate new knowledge to their existing knowledge structure. The storage in Google Drive allows the students to remember important facts, for example, about mathematical techniques (Teacher C10), and English Language techniques (Teacher C11), in their long-term memories.

Third, Google Drive is used as a backup medium. The teacher can categorise his/her teaching materials and/or files in the storage. Teacher C4, who taught Visual Arts in secondary school, said that these files could be big. Teacher C2 said that there were many pictures used for Biology and Integrated Science that required considerable storage.

Google Drive can be used for a backup copy of the students' work, to prevent the students from losing their copy (Teacher C2). Google Drive also serves as a memory of the student's assignment records for the teacher to address the students' learning difference issue (Teacher C10). Google Drive provides a storage that can be accessed through the Internet, replacing conventional storage such as USB storage, which is vulnerable to loss (Teacher C1 and Teacher C11).

Fourth, Google Drive serves a bridge for transferring files across the tablet, MacBook and Windows platforms. The teacher prepares teaching materials by using Google Docs, Google Sheets, and Google Slides, and these works can be accessed using an iPad as well as a desktop computer at home by saving files on Google Drive (Teacher C12).

These four examples suggest that the technology promoting learning by (1) facilitating processing in the working memory or transfer to and retrieval from the long-term memory during the private (internalisation) phase of learning. Google Drive offers a storage that can be accessed through the Internet; serving as a working memory in cooperative learning, a repository of categorised and organised information, (2) a historical record of the students' work, (3) a backup medium of teaching and learning materials, and (4) a bridge for transferring files across the tablet, MacBook, and Windows platforms.

Affordance: Interesting to use

The teachers believed that the students were interested in using a tool because of several reasons: the students had not tried the tool before, the students found the tool useful, and the tool facilitated more classroom interactions.

First, the students had not tried the tool before. Teacher A4, who taught Chinese Language in secondary school, discussed that students were very happy to use new tools. Younger students were eager to learn new things, and their motivation could be driven by their curiosity to explore the new tools. For example, the students asked Teacher A4 whether they could use Google Forms for the registration of a singing contest and for polling in games during school activities. Teacher A4 said that being proactive in exploring new tools is what a teacher wishes to see.

Second, the students found the tool useful. For example, Teacher C11, who taught English Language, perceived that the students' motivation for learning was enhanced when they found that Google Classroom was useful for preparing group presentations. The following data of Teacher C11's pedagogic assemblage illustrate this example:

Scene:	Teaching English Language in the Form 1 – 2 classroom
Agent:	Teacher C11, students
Purpose:	To teach English writing through cooperative learning in groups
Agency:	Google Classroom, Google Slides, Google Drive, YouTube, iPad
Act:	Teacher C11 and the students interacted with the tools for cooperative learning in the classroom.

What Teacher C11 said in this example:

> 'I find that the students' motivation for learning is enhanced when they prepare a presentation on Google Classroom.'
>
> 'I upload a video on Google Classroom. Students watch the video and fill in the blanks on a worksheet, for example, about the nine Chinese customs in the video. Each student selects two customs that he/she is the most

interested in and thinks are feasible for him/her to develop a presentation. An example of the presentation file will be provided.'

'The advantage of using cloud computing is that the students can watch the video at their own pace or repeat them on the iPad. If they are watching a video together in the class, I cannot take care of the students' learning difference because some students might learn faster than the others.'

'Then, the students complete the presentation in the class and upload to Google Classroom. Most students, around 80%, can accomplish their task.'

Teacher C11 empowered the students such that they could take more control over their direction, pace, and sequencing of learning (Ingram, 2016). They could generate materials for each other to use and use the materials outside the classroom. For example, students could use YouTube videos, photos, and articles from the Internet, draw their own pictures, and share them on Google Classroom. The students could design their own presentation and therefore were motivated to learn.

Third, the tool facilitated more classroom interactions. Teacher C12, who taught Mathematics in secondary school, discussed that Google applications brought the class more fun and interaction. The following data of Teacher C12's pedagogic assemblage illustrate this example:

Scene:	Teaching Mathematics in the Form 4 – 6 classroom
Agent:	Teacher C12, students
Purpose:	To learn by answering multiple-choice questions (a poll) in the classroom
Agency:	Google Classroom, Google Slides
Act:	Teacher C12 and the students interacted with the tools in the polling activity.

What Teacher C12 said in this example:

'It (a Google application) facilitates classroom interaction by, for example, polling and project presentation. Students, particularly the younger children, like competition. Students answer multiple-choice questions together with the number of responses for each choice displayed. Polling brings the class more fun and interaction.'

> ‘Polling through Google Classroom is better than polling by raising their hands, because, psychologically, students might feel shame, might be afraid of making a mistake before their classmates, or might follow the others’ answers because they are afraid of being blamed for not answering. Students might feel more comfortable answering with a mouse click but need courage before raising their hands.’

These three examples suggest how technology mediates the learning process by (1) the students’ eager to learn new things, (2) empowering the students such that they could take more control over their direction, pace, and sequencing of learning, and (3) promoting motivation through rewarding interactions with the software.

Affordance: Enhancement of learning

Enhancement of learning means that students learn more things and more easily through the mediation of technological tools which help to demonstrate concepts, daily life examples, and domain knowledge from theme apps. The following are examples of affordances for the enhancement of learning.

First, Teacher C12 used Google Sheets, which is spreadsheet software, to demonstrate the calculation with mathematical formulae, for example simple interest, compound interest, the trend of data, the pattern of sequence, and the chart representation of statistical data. The following data of Teacher C12’s pedagogic assemblage illustrate this example:

Scene:	Teaching Mathematics in the Form 4 – 6 classroom
Agent:	Teacher C12
Purpose:	To teach mathematical concepts using a spreadsheet in front of the class
Agency:	Google Sheets
Act:	Teacher C12 interacted with Google Sheets for teaching the class

What Teacher C12 said in this example:

> ‘It is excellent to use Google Sheets to demonstrate the calculation of simple interest and compound interest, and to view the trend of data.’

> ‘In Form 6, we have a topic about the sequence and the observation of patterns. Google Sheets is useful for educational topics, for example the result pattern for the following 100 years according to a mathematical formula.’

Second, Teacher C14 discussed the experience of his colleague who taught Geography in secondary school, offered an example of using Google Earth to teach geography by the visualisation of the concept of contour lines, and the geographical views of a destination from different angles. Teacher C14 said that some students did not like geography because they did not understand the concepts. The teacher found that students learnt more rapidly with the aid of a technological tool. The following data of the geography teacher’s pedagogic assemblage illustrate this example:

Scene:	Teaching Geography in the Form 4 – 5 classroom
Agent:	Teacher C14
Purpose:	To teach geography in front of the class
Agency:	Google Earth
Act:	Teacher C14 interacted with Google Earth to explain geography concepts to the class

What Teacher C14 said in this example:

> ‘Google Earth helps in teaching geography, for example the visualisation of the concept of contour lines, and the geographical views from different angles. We exemplify a contour line by drawing on glasses in the past, which is a more difficult task.’

> ‘Some students do not like geography because they do not understand the concepts.’

Third, Teacher C13 discussed her example of using YouTube and Google Maps, which facilitated learning things about daily life from different channels, making the class more interesting. The following data of Teacher C13’s pedagogic assemblage illustrate this example:

Scene: Teaching General Studies in the primary school classroom
Agent: Teacher C13
Purpose: To teach General Studies in front of the class
Agency: YouTube, Google Maps
Act: Teacher C13 interacted with YouTube and Google Maps to teach the class

What Teacher C13 said in this example:

> ‘Our topics in primary school General Studies are mainly related to daily life…We use YouTube for playing movies, making the class more interesting. Students might get bored if we use only the textbook.’

> ‘We use Google Maps for identifying the names of streets and landscape in Hong Kong. Google Maps is informative and colourful. It improves the atmosphere in the class, because it contains both plain text and pictures, particularly for the younger children.’

Fourth, Teacher C7, who was an information technology officer in secondary school supporting the teachers’ use of technology, suggested using Google Arts & Culture for teaching arts subjects. Teachers and students could visit most of the museums worldwide through it and appreciate the artwork and study the culture of different countries by using this theme app. Teacher C7 said that:

> ‘Google Arts & Culture is useful. We can visit most museums worldwide with it and appreciate the artwork and study the culture of different countries. To visit a British museum, we do not need to go to England. It is useful for teaching history, liberal studies, and arts.’

These four examples suggest that the technology empowers students to interact with the external world to acquire knowledge and understanding; they learn more things and more easily through the mediation of technological tools which help to demonstrate mathematical concepts using Google Sheets, geographical concepts using Google Earth, daily life examples through YouTube and Google Maps, and the arts domain knowledge using Google Arts & Culture.

5.2.1.3 Teacher control and power relations

Cloud computing enables cooperative learning and teacher control in different ways and has an impact on the power relations within the pedagogic assemblage. The teachers mentioned different ways in which they used Google applications to manage learning. These included using Google applications to facilitate cooperative learning and to monitor the learning progress.

Affordance: Cooperative learning

Vygotsky (1978) argued that learning is first at the social level, and later, at the individual level. Teacher C1, Teacher C6, Teacher C9, and Teacher C10 set up groups and used Google applications with an iPad for cooperative learning in the classroom, offering examples in cooperative learning. In these examples, the students used Google applications, such as Google Slides and Google Docs, to co-edit their presentation in groups during the class, and then, they could review individually the ideas learnt from the presentation by using these Google applications through the Internet after the class. With these affordances, the students first learnt at the social level in the classroom. Then, the students were enabled to reflect on what the group had said, decided whether or not an idea was good and whether or not it was useful, and built these ideas into their thinking, and in this second moment of learning, the students internalise what they had talked about at the individual level.

The following data from Teacher C9, who taught Chinese Language in secondary school, are about the teacher's experience in the classroom settings for cooperative learning:

Scene: Teaching Chinese Language in the Form 1, 3 classrooms
Agent: Teacher C9, students
Purpose: To learn cooperatively by responding to the teacher's questions in groups through iPad
Agency: Google Classroom, Google Slides, iPad
Act: Teacher C9 and students interacted in Google Classroom for cooperative learning in the classroom

What Teacher C9 said in this example:

> 'For cooperative learning, students are arranged in groups of 2–3 or 3–5 members sitting next to each other. Group members are provided with iPads. However, the number of iPads used cannot be very larger because of the network bandwidth limitation. In particular, in the lower levels, students need the teacher's help for using the iPad.'
>
> 'It is important that the students learn from each other. For cooperative learning, we post topics in Google Classroom about recent local news for a written discussion. Students need not input too many words but have to share their ideas in short.'
>
> 'We use Google Slides for students to co-edit a presentation in the class, and they can review other classmates' ideas after the class. Microsoft PowerPoint does not allow such co-editing.'

Next, Teacher C10, who taught Mathematics in secondary school, shared his experience in the classroom setting, which was similar to that of Teacher C9:

Scene: Teaching Mathematics in the Form 1, 3 classroom
Agent: Teacher C10, students
Purpose: To learn mathematics cooperatively in groups
Agency: Google Classroom, Google Slides
Act: Teacher C10 and students interacted in Google Classroom

What Teacher C10 said in this example:

> 'Students are arranged in groups of 2–3 or 3–5 members sitting next to each other. Group members are provided with iPads. The number of iPads provided depends on the activity.'
>
> 'For lower-level students, Google Classroom is the platform used for cooperative learning, because it facilitates group interactions.'

Teacher C6, who taught Chinese History in primary school, shared his experience and discussed that:

> ‘We arrange four students in a group, and each group is provided with an iPad.’
>
> ‘Primary school students like playing and more interaction in the classroom.’

Besides cooperative learning in a classroom setting, Teacher C1, who taught Physics and Integrated Science in secondary school, discussed that cloud computing enabled cooperative learning after the class. Teacher C1 said that:

> ‘I think we can use Google applications for cooperative learning after class instead of in the classroom only. When after school, students need to finish assignment projects, it is useful for them because they can produce something together over the Internet.’

These examples suggest that the technology facilitates classroom interactions as well as interactions outside the classroom for cooperative learning; the students work cooperatively to learn over the Internet through cloud computing, and therefore, the use of such technology offers the ‘cooperative learning’ affordance.

Affordance: Monitoring learning progress

The technology is designed to promote collaborative learning and tend to drive pedagogy towards ‘invisible’ controls (Ingram, 2016). The teacher is enabled to control the students’ learning that can be not only ‘visible’ but also ‘invisible’.

For example, Teacher C9, who taught Chinese Language in secondary school, wanted to make sure that the students had prepared the lesson by watching his videos before the classroom teaching. The following data from Teacher C9 illustrate an example of ‘visible’ control with technology:

Scene: Teaching Chinese Language in Form 1, 3
Agent: Teacher C9, students
Purpose: To share a video for the preview of a topic and to make sure that the students have watched the video before the class
Agency: Google Classroom, Google Forms, Google Drive
Act: The students watched the video and responded to the questions about the video before class

What Teacher C9 said in this example:

> 'Google Classroom can share videos for the preview before a lesson. The use of Google Classroom has an advantage, as if the students respond, the teacher knows that they have watched the videos.'
>
> 'Teachers can give a response to their students instantaneously. Teachers can also get the students' response in the class instantaneously. As a result, teachers can teach according to the students' needs.'

Teacher C9 used Google Classroom for sharing videos because Google Classroom enabled the teacher to send a question or a request for the reply, and the students were required to respond to it. The teacher used Google Classroom to exert a 'visible' control over the class, in which the students were expected to respond such that the teacher could adjust the teaching strategy according to the students' needs.

One consequence of using technology to facilitate learning in an assemblage is that it has the potential to alter the power relations between the teacher and the students. Teacher C11, who taught English Language in secondary school, offered an example in which the students could take more control over their direction, pace, and sequencing of learning (Ingram, 2016). Teacher C11 assigned the students to prepare their English Language presentation on how to decorate an Easter basket using Google Classroom. The following data of Teacher C11's pedagogic assemblage illustrate this example:

Scene: Teaching English Language in the Form 1 – 2 classroom
Agent: Teacher C11, students
Purpose: To teach English writing through cooperative learning groups
Agency: Google Classroom, Google Slides, Google Drive, YouTube, iPad
Act: Teacher C11 and the students interacted with the tools to watch a video, to fill in a worksheet for the keywords in the video and to work for a presentation cooperatively.

What Teacher C11 said in this example:

> 'Students work cooperatively on a presentation on how to decorate an Easter basket. They were provided with the worksheet for filling in the blanks together with a YouTube video. Students watch and listen to the video and fill in the keywords mentioned in the video on a worksheet. Then, they present together, using Google Slides with their own videos and photos for how to decorate the Easter basket with the steps on the worksheet incorporating an English introduction, cohesive devices, and conclusion.'

With technology, students could learn from their peers and external sources. Teacher C11 allowed the students to generate materials for each other to use and to use the materials outside the classroom to create their presentations. For example, students could use YouTube videos, photos, and articles from the Internet, draw their own pictures, and share them on Google Classroom. By the observation of the students' communications on Google Classroom, Teacher C11 could exert 'invisible' controls through the software, taking more control over the production of the presentation, for example, in terms of the direction and the pace. Therefore, Teacher C11 said that:

> 'If a collaborative group works faster than the others, I will give them advice on improving their presentation, such as grammar and content, in which case I can take care of the students' learning difference.'

Learning with technology, with invisible controls, is still under the control of the teacher. When the activities do not run in the direction expected, the teacher can step in and exert more visible controls to bring the activity back on task.

In this example, the students took more control over their learning, because they were enabled to make their own choice for when and where to use these materials to organise their presentation. Learning was still being directed by the teacher and there were still controls, but the controls were more 'invisible' because they were being mediated through the software.

5.2.2 Social affordances

For the interview question 'Do you agree that students can work cooperatively and learn from each other by using Google applications?', the numbers of teachers who agreed/disagreed with the question are tabulated in Appendix 3.4 (Table 15) and are presented in a pie chart as follows:

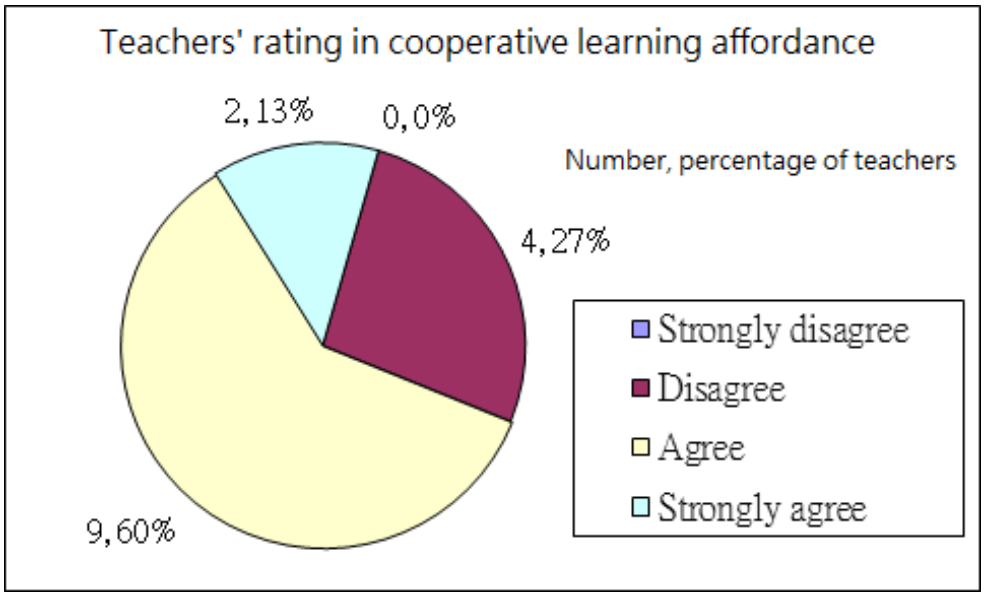

Figure 16 – Pie chart of the number of teachers who agreed/disagreed Google applications can support cooperative learning

From the pie chart, we find that nine teachers agreed and two teachers strongly agreed that students could work cooperatively and learn from each other by using Google applications. However, four teachers did not agree with this.

The data analysis showed that cloud computing facilitates interactions among students,

as well as those between the teacher and the students. The following sections discuss these communications in more detail.

5.2.2.1 Enabling teacher-students interactions

The teachers discussed that cloud computing enables communication between the teacher and their students. There could be bi-directional communication, including teacher-to-students and student-to-teacher communication interactions.

Affordance: Teacher-to-students communication

Google applications facilitated the teacher in communicating with students. For example, Google Classroom provided a platform for communication with students, which was extended outside the classroom (Teacher A1). The teacher shared learning materials and worksheets with students for them to download (Teacher A3). The teacher broadcasted announcements to students regarding their assigned works (Teacher A2) and gave feedback to individual students about the student's issues related to learning (Teacher B2).

The teacher could give a response to his/her students instantaneously through Google Classroom. The teacher could also receive the students' response in the class instantaneously, such that the teacher could teach according to the students' needs (Teacher C9). Outside the classroom, the teacher could provide feedback once the teacher had reviewed the students' work. It was a different practice from the past, when the teacher reviewed all the students' work and then provided feedback to the students in a batch (Teacher C9).

The above examples suggest that technology facilitates the teacher in communicating with students by making it easier to broadcast announcements;

share information, learning materials, and worksheets; and give feedback or respond to students.

5.2.2.2 Enabling students-teacher interactions

Affordance: Students-to-teacher communication

Communication between the teacher and the students could be bi-directional, i.e. one-to-one with the teacher and many-to-one from the students (Teacher A2). While the teacher provided feedback on Google Classroom to an individual student, the student could respond by answering the teacher's questions or sending materials to the teacher or re-submitting an assigned work (Teacher C10).

Google Classroom could be used in the class for answering questions by all the students. In an example from Teacher A4, students were asked to capture the screenshot of their mind map and upload it to Google Classroom and share it with the class, creating a platform for sharing and communication. Then, the teacher reviewed and discussed all the mind maps on the platform with the students.

The above examples suggest that technology facilitates students in communicating either individually or in a group by giving a response to the teacher, asking questions, and sharing information, materials, and their work with the teacher.

5.2.2.3 Enabling communication among students

Social constructivists advocate that knowledge construction is a social process. Cloud computing offers affordance in the communication among students. Fu *et al*. (2011) identified two social affordances from Wiki, which was a technology similar to cloud computing, by sharing information on the Internet: first, 'Communication' and second, 'Motivation':

‘Communication: students can communicate online within a platform
Motivation: students can enhance motivation among group members’

(Fu *et al.* 2011, p.5)

Similarly, the following sections discussed affordances in these two aspects, including the technology’s capability to enable students to share ideas and its aesthetic affordance that motivated the students in groups.

Affordance: Enabling social space

> Teachers discussed that cloud computing enables communication outside the classroom as well as in the class. For example, Google Slides facilitates interactions among students by allowing them to co-edit a presentation in groups online during the class and then reflecting on the ideas of the other classmates after the class (Teacher C9).
>
> Teacher A1 mentioned that students like sharing their thoughts on Google Classroom. Teacher A2 discussed that students could share their feelings and reflections, and there was no need to send files back and forth in emails, as in the past. For example, when preparing a group presentation, the students could now work cooperatively by sharing and co-editing on Google Slides, making communication convenient (Teacher C11).
>
> These examples suggest that software tools enable students to share ideas by enabling them to communicate, learn together, and connect with each other. It is this essential characteristic of cloud computing (Mell & Grance 2011) that allows users to access their work anywhere at any time through the Internet.

Affordance: Aesthetic affordance

Kirschner *et al*. (2004) discussed that usability is related to aesthetics:

> 'Norman (2002) suggested that aesthetics and usability are as connected as affect and cognition. Norman claimed to have evidence that pleasant things work better and are easier to learn, and that attractive things work better.'

(Kirschner *et al*. 2004, p.52)

In the meantime, aesthetics and social affordance are closely connected:

> 'In terms of social affordances, this means that designers should make the social affordance devices not only usable but also attractive. A real-life example of such a social affordance device is the mobile phone. Although most mobile phones have similar functionalities and comparable usability, some can be personalised by choosing a different front cover, making them more attractive for their users. Even when another phone is easier to use, people tend to prefer the more attractive version.'

(Kirschner *et al*. 2004, p.52)

The discussion of Kirschner *et al*. (2004) suggests that one of the success factors for iPhone, a social communication product from Apple Inc., is that iPhone is more attractive in its external appearance than similar products.

Piccolo (2015) discussed that social affordance is related to the idea of how an artefact can stimulate individual or group usage. Soegaard (2017) claimed that we are biased towards aesthetic forms. Soegaard elaborated this claim as follows:

> 'We love looking at beautiful things and are drawn to prettiness, both in the bricks-and-mortar world and in the digital one. In the digital arena, a more attractive website is just one click away. When users visit a website or even try a new app, they make quick decisions on whether to stay on that site/app or keep looking for another one. Much of that decision hinges on the aesthetic appeal of the web page's design.'

Soegaard (2017)

Teacher A1, who taught General Studies in primary school, discussed that the interface design of Google Classroom is attractive and therefore students tend to use it. Teacher A1 said:

> 'The interface design looks like a social networking site, for example Facebook, and therefore, students are interested in playing with it.'

Moreover, Teacher C9, who taught Chinese Language in secondary school, said that:

> 'We are now using Google Classroom more for after class communication, because it looks like a forum.'

The teachers thought that the interface design of Google Classroom was attractive by looking like a forum, and therefore, it offered motivational affordance such that the students would stay on it for social communication.

Kreijns & Kirschner (2001) argued that social affordance could be viewed in the educational and social dimensions. The educational dimension considers the cognitive aspects of group learning, while the social dimension considers the social process that may give rise to social relationships and group cohesion. Using Google Classroom for after class communication (Teacher C9) enhanced social interactions by creating a social space (Kreijns & Kirschner, 2001) for students.

5.2.3 Technological affordances

The following technological affordances were studied from the data collected. These included using Google applications to facilitate classroom administration, to enable ubiquitous use across different hardware devices, to access anywhere at any time, and to use innovatively in integration with other technological tools.

5.2.3.1 Classroom administration

Teachers found classroom administration affordance from Google applications because they thought that these allowed resource sharing, addressed learning difference issues, and offered automatic grading of assessments.

Affordance: Resource sharing

Google applications allow resource sharing in the following examples:

Teacher C9, Teacher C10 and Teacher C11 shared materials on Google Drive with students. Teacher C9, who taught Chinese Language, shares news and extracts with his students through Google Classroom. Teacher C10, who taught Mathematics, shares videos on mathematical techniques and how to answer different questions in the public examination with his students. Teacher C11, who taught English Language, shares news, extended reading, articles, sample writing, script, answer, multimedia, and lessons with her students.

Teacher C10 shared with his colleagues of other classes teaching the same subject by joining each other's Google Classroom, such that they were informed of each other's teaching progress and could share resources such as assignments designed for students and teaching strategy, eliminating the duplication of work in preparing a lesson.

Teacher C14 shared videos through YouTube channels. Teacher C14 said that:

> 'The advantage of YouTube is that everyone can access the videos through the hyperlink. These ready-made videos explain concepts; for example, students visualise how light passes through the lens, causing reflection and refraction, and the diffusion effects of a wave. Students are also taught in this approach of the background; for example how scientists discovered these phenomena.'

These examples suggest that the tools facilitate classroom administration by resource sharing such that teachers can easily share information and materials with their students and colleagues, who can download these materials over the Internet. If these are shared through YouTube channels, everyone finds it easier to access them through hyperlinks.

Affordance: Addressing learning difference issues

There might be students whose learning progress is ahead or behind of the others'. Cloud computing helps in addressing the learning difference issues by providing a working memory or repository for the teacher and the students.

Teacher C10, who taught Mathematics and ICT in secondary school, discussed that he addressed the learning difference issues by keeping records of student assignments. Teacher C10 said that:

> 'Students have learning differences in my taught subject, and therefore, I keep the students' submissions and re-submissions with comments on them.'

Teacher A4, who taught Chinese Language in secondary school, discussed that he allows students to download all the lesson handouts for revision, enabling the students to search for information on the Internet, for example images, necessary data, and information on topics such as how to write their opinion or arguments for writing a piece of composition.

Teacher C11, who taught English Language in secondary school, used Google Drive and iPad for the English conversation exercise after listening to a passage, to take care of students who were relatively weak in spoken English. The Google Drive and the iPad worked as a working memory and allowed a delayed response to the conversation such that the students could pause the conversation before they responded. The following data of Teacher C11's pedagogic assemblage illustrate

this example:

Scene: Practising English conversation in Form 1 – 2 groups
Agent: Teacher C11, students
Purpose: To address the learning difference issue in English speaking
Agency: Google Drive, iPad
Act: Students interacted with the iPad for the English conversation exercise. The teacher helped the students in using the iPad.

What Teacher C11 said in this example:

> 'We use the iPad to help practise English conversation, so we can take care of weaker students. Students take turns using the iPad to respond and record the conversation. If necessary, the student can pause the recording and think about it before responding. When playing back the recording, it looks like a complete conversation. As a result, the satisfaction of students is higher, although the standard has not been reached as on a TSA test. Students can practise from lower levels with broken down conversations that they can manage. Being able to manage the conversation is important because it allows students to improve progressively. Therefore, we provide iPad to lower-level students for exercise but do not provide iPad to higher-level students because the latter need to prepare for the TSA test.'

Teacher C11 discussed that the learning satisfaction of students was higher, although the standard had not been reached, and the students could start with this exercise if they were relatively weak in spoken English at the beginning.

From the above examples, we can infer that Google applications such as Google Drive mediate teaching and learning by providing a memory to address the learning difference issues. In the example of Teacher C10, Google Drive serves as a memory of the student's assignment records for the teacher to address the learning difference issue. The teachers could therefore remember these issues of their students. In the example of Teacher A4, Google Drive serves as a repository of lesson handouts such that students whose learning progress is behind that of the others can catch up by repeated revision. In the example of Teacher C11, Google Drive serves as a working memory of the English conversation, the students pause and think before

their response to it, and as a result, the weaker students can also complete the conversation exercise.

Affordance: Automatic grading

Teacher C4, who taught Visual Arts in secondary school, discussed the automatic grading function from the Google applications training that she attended:

> 'The trainer demonstrated an example of an English Language composition assessment with the full marks for each criterion—for example, syntax has 3 marks, and content has 5 marks—for the system to calculate the grade awarded. We inputted the criteria for each grade and the marks for each student, and then the system generated the assessment result as A, B, C, etc. grades, which was convenient for teachers.'

Teacher C4 further discussed that she could use this automatic marking function for her subject:

> 'It is useful for a class quiz to determine whether the students paid attention in the class.'

However, Teacher C9, who taught Chinese Language in secondary school, discussed that grading could only be applied on multiple-choice questions and not on fill-in-the-blank and short open questions. Teacher C9 said that:

> 'We often use Google Forms for a quiz that can be automatically graded. However, grading can only be carried out on multiple-choice questions and not on fill-in-the-blank ones, because the input might have a minor difference from the model answer and the application is incapable of assessing open questions.'

The above examples suggest that the tools make grading easier, but there is a drawback; for example, the Chinese Language teacher found that he could not automatically grade the fill-in-the-blank and short open questions.

5.2.3.2 Ubiquitous use

Teachers found affordance in the ubiquitous use of Google applications because they thought that there was compatibility across platforms and software tools could be accessed anywhere at any time:

Affordance: Compatibility across platforms

From the data collected, compatibility affordances were perceived at the following three levels:

First, across computer operating systems. Google Classroom could be used across Windows, Mac OS, Linux computer systems, Android and iOS mobile systems (Teacher B1). Students used a single login account for all authentications, irrespective of the application, saving the teacher's time (Teacher A1). This facilitated student in working cooperatively with less compatibility and technical problems (Teacher C10).

Second, across different devices, such as mobiles and tablets. Students could receive the announcements from their devices (Teacher A2). Gmail could be used on both Apple and Android devices, and its emails were synchronous on the mobile phones (Teacher C1). This helped students in revision, because materials could be available on their mobile devices through Google Classroom (Teacher C9). Teachers could use iPad in addition to desktop computers to prepare the teaching materials at home (Teacher C12).

Third, across software tools from different vendors. Teacher C2 used both Google and Microsoft presentation software and spreadsheet software, for example, to record the students' grades, and thought that the format distortion was not very serious during the file exchanges across these software tools. Teacher C4 thought that the difference in using them (Google Docs and Microsoft Word) was small.

Teacher C6 and Teacher C13 used Google Slides for presentation with files saved on Google Drive at home, and retrieved these files using Microsoft software at school. They said that it (Google Slides) is compatible with Microsoft PowerPoint, which was convenient by eliminating the use of USB storage for the file exchange.

These examples suggest compatibility affordances across computer operating systems, mobile and tablet devices, and software tools from different vendors.

Affordance: Access anywhere, anytime

Teachers agreed that the advantage of using cloud computing is that it is accessible on the Internet. For example, a teacher could use Google applications outside school when there was no installed software on the computer (Teacher C1). It was convenient to use, if there was a computer and Internet access, or by borrowing a colleague's computer when on a trip, a teacher could still access his own documents and share them with others (Teacher C4). There was no need to take home the heavy paper assignments for grading (Teacher A2).

Teachers A4 discussed that when there was insufficient time for a lesson, one of the strategies was to make use of the time before the class, during the class, and after the class. Google Classroom served as a platform that extended the teaching strategy to pre-class preview, classroom interaction, and post-class extension (Teacher B1). Google Classroom could be used for sharing videos for the preview before a lesson, and it had an advantage over the other platforms because the teacher could set up questions about the video on it. If the students responded to the teacher's questions before the class, the teacher knew that they had watched the video (Teacher C9).

These examples suggest that teachers and students benefit from cloud computing, which can be accessed anywhere at any time, when there is no installed software on

the computer, and the teaching strategy can be extended to pre-class preview, classroom interaction, and post-class extension.

5.2.3.3 Innovative use

Teachers find the innovative use affordance from Google applications because they think that these can be used in integration with other technological tools and equipment as follows:

Affordance: Use in integration with other tools

Teachers use Google applications in integration with the iPad in the following different ways:

First, for increasing group interactions in the classroom. For example, Teacher C9, who taught Chinese Language in secondary school and Teacher C10, who taught Mathematics and ICT in secondary school, discussed that they arranged students in groups of 2–3 or 3–5 members sitting next to each other. Group members were provided with iPads for cooperative learning. The number of iPads provided depends on the activity. Teacher C6, who taught Chinese History in secondary school, thought that some interactions between students and the teacher made learning easier, and therefore he used Google Slides in integration with the iPad for cooperative learning about historical events using matching games.

Second, teachers used other software tools with Google applications: for example ‘flubaroo’, which is grading plugin software in Google Forms for increasing productivity (Teacher A3). An interactive whiteboard app ‘Explain Everything’ is used together with a pen tablet for producing videos and uploading them to YouTube, with their URLs shared with students through Google Classroom (Teacher A3).

These examples suggest that cloud computing allows teachers to use different software tools in integration with other hardware such as iPad and pen tablet. Teachers can also use plugin software for Google applications and other web apps innovatively to design their lessons.

5.3 Perceived constraints

The numbers of teachers who perceived the constraints, conceptualised as negative affordances, of Google applications are tabulated in Appendix 3.3 (Table 14) and are presented in the following bar chart. These figures suggested that some constraints were perceived by more teachers than the others.

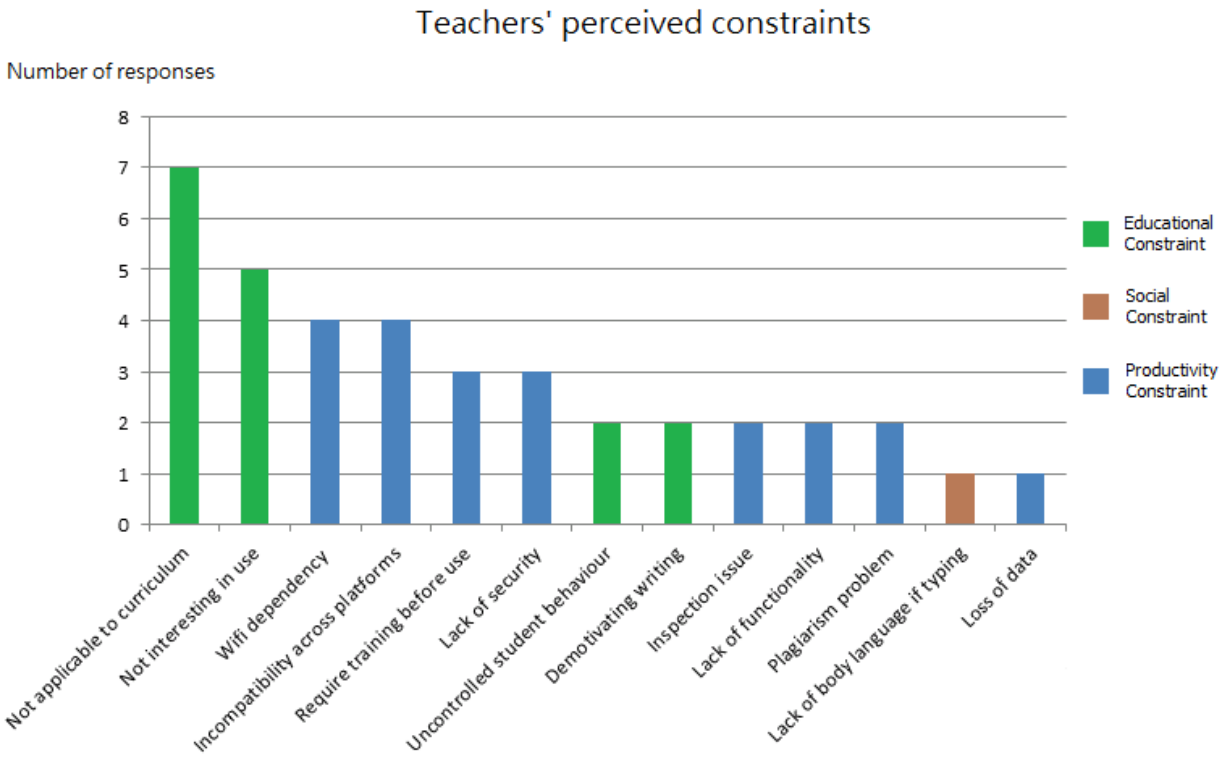

Figure 17 – Bar chart of the number of responses verses the coding scheme for the constraints of Google applications

From the bar chart, we infer that seven teachers believed that Google applications were 'Not applicable to taught subject'. Five teachers perceived that Google applications could not motivate students because they were 'Not interesting to use'. With respect to 'WiFi dependency' and 'Incompatibility across platforms', each of these constraints was

perceived by four teachers. The ‘Requirement for training before use’ and the ‘Lack of security’ constraints were perceived by three teachers each.

The first law of technology by Kranzberg (1986) states that technology is neither good nor bad; nor is it neutral. Along with affordances, it might bring constraints under some circumstances. For example, the use of the keyboard might demotivate students from writing by hand; teachers cannot freely use their hands in the meantime to emphasise their message, and this affects the way the students write a piece of composition. There might be uncontrolled student behaviour and plagiarism problems with the use of the computer. There might be security and WiFi dependency concerns as well.

Some constraints could be attributed to the teachers’ lack of training and experience of using software tools, or the fact that the teachers do not use the tools in the socio-cultural context for which they were designed. For example, students may find the tools ‘Not interesting to use’ because of the fact that the tools had not been used for the age, or educational level, that they were designed for. In some examples, the teachers found ‘Incompatibility across platforms’ because the tools had not been designed in such a way as to help the teachers and the students in their socio-cultural context. For example, the online tools do not facilitate the use of mathematical symbols and equations, which is to be discussed later. The teachers also did not perceive affordances because they rejected the use of the tools, for example, because of the threat to the traditional methods of teaching.

The following sections discuss these constraints categorised as educational, social, and technological in detail.

5.3.1 Educational constraints

The followings are educational constraints studied from the data collected.

5.3.1.1 Not supporting pedagogy

For the interview question 'How do you rate the usefulness of using Google applications in supporting your teaching?', the teachers' ratings on whether Google applications support teaching are tabulated in Appendix 3.7 (Table 18) and are represented in a pie chart as follows:

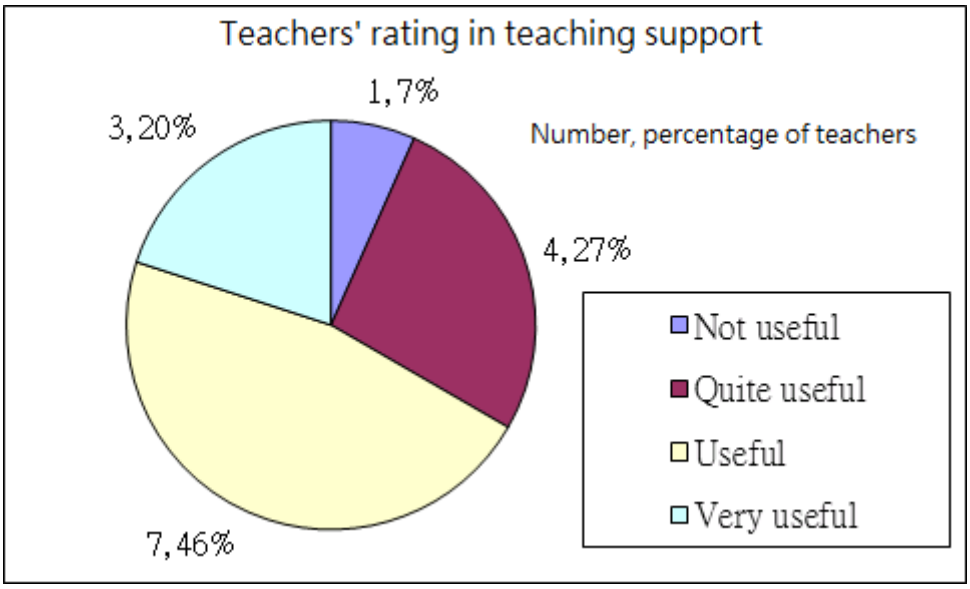

Figure 18 – Pie chart of teachers' ratings for whether Google applications can support teaching

From the pie chart, we infer that three teachers think that Google applications are very useful for supporting their teaching instructions and seven teachers think that they are useful, but four teachers think that they are quite useful only, while one teacher thinks that they are not useful. These figures give us an overall impression of the teachers' belief in the usefulness of Google applications.

With reference to Section 5.2 for perceived affordances, the subject teachers agreed that Google applications support their teaching. However, the above pie chart reveals that

some subject teachers did not agree that Google applications supported their teaching. These teachers thought that Google applications were not applicable to their curriculum and led to uncontrolled student behaviour as follows:

Constraint: Not applicable to taught subject

Teachers believed that Google applications were not applicable to their curriculum because of the following different reasons:

First, the teacher thought that technology couldn't help in inspiring knowledge. For example, Teacher A4, who taught Chinese Language in secondary school, said that:

> 'E-learning plays an auxiliary role in Chinese Language teaching. Whether the learning objective is achieved is based on whether students can produce a good composition and can answer the questions in the comprehension test.'

Moreover, Teacher C15, who taught Chinese Language in secondary school, said that:

> 'We mainly require teacher-to-student teaching. Google applications can be used for administrative work for reducing paper consumption but cannot inspire knowledge.'

Both Teacher C15 and Teacher A4 argued that Google applications could not help teaching Chinese Language in secondary school.

Ingram (2016) argued that:

> 'This is evidence of a tension between the teacher and the ICT that is at the heart of the mediation process. Teachers are used to working in visible pedagogy with hierarchical one-to-many relations and having control over the pace and sequence of learning. ICT acts as a potential threat to this order.'
>
> (Ingram 2016, p.16)

> 'This tension can lead to ICT being marginalised or discredited by teachers.'
>
> (Ingram 2016, p.1)

Teacher C15 said that Chinese Language mainly required teacher-to-students teaching and believed that Google applications were not applicable to his curriculum, offering an example that supported the above claim from Ingram (2016).

However, the data analysis showed that even the sharing capability of Google applications can inspire students' knowledge, which is against the belief of Teacher C15. For example, Teacher C9, who also taught Chinese Language in secondary school, shared news and extracts with his students to initiate their thinking and trigger discussion. The interactions between Teacher C9, the students, the software tools, and the news and extracts were all parts of the pedagogic assemblage. Teacher C15 does not see this possible point of knowledge inspiration because his classroom is a different assemblage from that of Teacher C9, which means that the teacher, the students, and the software interact in different ways. Teacher C9 and Teacher C15 might have different beliefs regarding the methods of teaching and competence in using technological tools. The teacher, to some extent, has a powerful input in shaping what the assemblage will look like; the teacher designs the lesson aims and the use of software tools. Teacher C9 and Teacher C15 operate effectively within their own pedagogic assemblage according to the interests, needs, and capabilities of the teachers and students, and therefore, they perceived different affordances.

Second, some teachers think that they need a tool that can help to teach their school subject. For example, Teacher C3, who taught Mathematics in secondary school, said that:

> 'We focus on solving the mathematical problem in the class. Form 3 students focus on the IGSE examination, and Form 5 students sit for the Extended Mathematics examination, and therefore, it is not quite useful unless it has the capability of concept visualisation or simulation. For example, what is a centroid, orthogonal, triangles, or a tetrahedron?'

Furthermore, Teacher C12, who taught Mathematics in secondary school, said that:

> 'Because of the time limitation, there is little group work and exploration for higher-level students; learning focuses on the solving of mathematical problems by individuals. In Form 5, we need to explain, for example, the locus of a moving point under some geometrical condition, in which case, some mathematics software does help. We cannot emulate it on the blackboard, however. Google applications cannot help with such topics.'

Teacher C14, who taught Physics in secondary school, said that:

> 'We need to visualise some physics concepts, for example electromagnetic fields, and emulate object motions under forces. We need some software for these. Google applications cannot help with such topics.'

Third, Google applications might have their own technological constraints. For example, Teacher C4, who taught Visual Arts in secondary school, said that:

> 'Presentation using Google Slides is mainly in text and, therefore, is not suitable for my taught subject. In my lesson, Google applications might not be useful because drawing a picture with them is difficult, unless the teacher and students grasp the use of auxiliary equipment such as the mouse and the drawing board.'

Teacher C6, who taught Computer Literacy in primary school, said that:

> 'I think Google applications might be less useful for teaching a computer subject which is based on skill acquisition; i.e., students learn how to use the computer or to acquire the skills, for example typing English and Chinese characters. Computer literacy is like doing an experiment; students need to practise and submit the result, but it does not have many interesting things to play with as many students imagine.'

These examples suggest the different reasons teachers believed that Google applications were not applicable to their curriculum: (1) the traditional ways of teaching are more suitable for their taught subjects, (2) the tools might have their own constraints such as hardware limitations, and (3) teachers think that they need a tool which can help to teach their domain knowledge.

Constraint: Uncontrolled student behaviour

Teachers expressed their concern regarding uncontrolled student behaviour because they were doing something the teacher did not want in the class when Google applications were used. For example, Teacher C5, who is an information technology officer in secondary school, said that:

> 'We cannot control the students' behaviour and what they do in the classroom. The students are naughty, open the document files, and input incorrect things into them...'

> 'Google Search might give unexpected results for instant search. For example, when we search with the keyword "telephone", it displays many results that are not related to the communication device "telephone". It might display results showing sexy models that embarrass the teacher or affect the students or cause student uproar. Although there are advanced options for a safer search, the teachers, even the skilled ones, are not aware of the problem until the result is displayed.'

> 'There is a worry when the students play online because they believe they can do everything on the Internet and do not have a sense of guilt or legal offence and think that no one can control them.'

Teacher C9, who taught Chinese Language in secondary school, said that:

> 'Google facilitates cooperative learning, but the teacher must be skilled in the use of technology. Students' behaviour cannot be controlled, and they will do their own things sometimes during the class.'

The statements of Teacher C5 and Teacher C9 also imply that the issue is not only in Google applications but is also generally found when technological tools are used in the classroom.

5.3.1.2 Demotivation in learning

For the interview question 'Do you agree that students have increased their motivation for learning by using Google applications?', the numbers of teachers who agreed/disagreed with the question are tabulated in Appendix 3.5 (Table 16) and are

presented in a pie chart as follows:

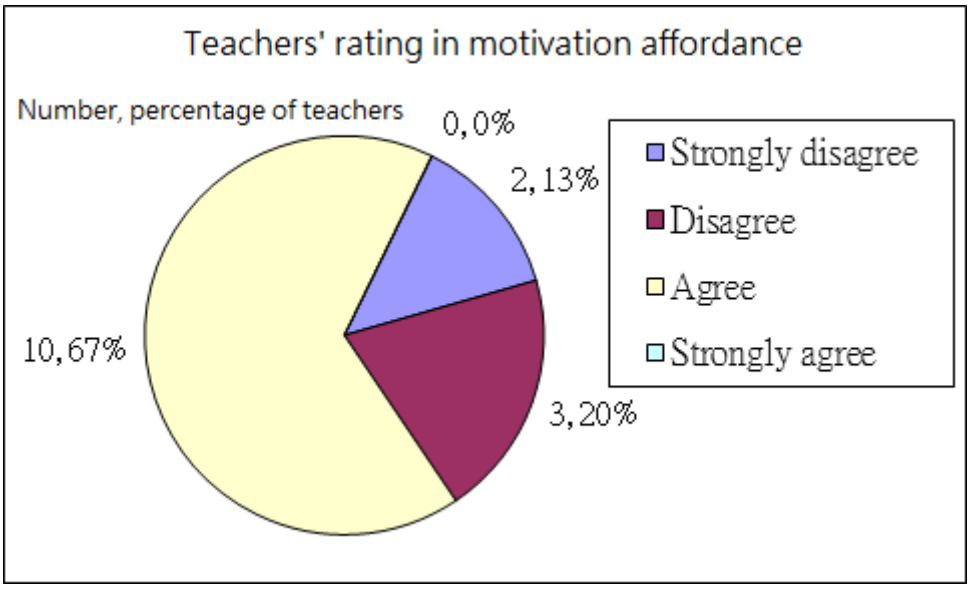

Figure 19 – Pie chart of the number of teachers who agreed/disagreed Google applications can motivate learning

From the pie chart, we infer that ten teachers agreed that students have increased their motivation for learning by using Google applications. However, three teachers did not agree, and two teachers strongly disagreed with the same.

Teachers did not agree that Google applications have increased the students' motivation for learning and found learning constraints because they thought that the tools were not interesting to use and the tools demotivated writing by hand, as discussed below:

Constraint: Not interesting to use

Students are not interested in using Google applications because of the following three reasons:

First, the students thought that the tools were not new things. Teacher C1 and Teacher C4 set up formative assessments for students to complete online using Google Forms, but the teachers found that if the tools were often used, say in every class, the students did not like to use it. The teachers found that Google applications

motivated the students in the beginning, because students had not tried them before. For example, Teacher C1 said that:

> ‘If we occasionally use it, the students will be very happy and leap with joy even when you start up the computer. However, if the tools are often used, students might lose interest in them.’

Teacher C4 said:

> ‘I believe it motivates students to learn because they have not tried it before.’
>
> ‘It will motivate students at the beginning. However, if I often use it, say in every class, the students will get bored.’

Teacher C1 and Teacher C4 said that if the tools were used often, students might lose interest in them. This unintended consequence is attributed to the different aims of the teachers and the students. Younger students are eager to learn new things, and their motivation could be driven by their curiosity to explore the new tools.

Second, the teachers believed that there were other more interesting things for the students than Google applications. For example, Teacher C7 said:

> ‘Students might not necessarily be motivated to learn by Google applications; they can be motivated by other means.’

Teacher A1 said:

> ‘The motivation of a student to learn at home is questioned when compared with other interesting games.’

Teacher C8 discussed in more detail the perception of students that affected whether Google applications were accepted for use. Teacher C8 said that:

> ‘Students will not use a tool if it does not benefit them. Games also bring enjoyment to children and motivate students. There might be excitement from new things at the beginning and in the short term, but then, they will not use these after a while.’
>
> ‘Children have different needs at different ages: for example, younger teenagers need excitement; they like playing with stylish things as their peers, while the

> older students need more practical things, for example, the things that are free-of-charge and the tools that help in their learning, and therefore, the usefulness depends on the benefit to them.'

Teacher C6, who is a primary school teacher, said that:

> 'Primary school students like playing and more interaction in the classroom.'

Therefore, a software tool can only be used appropriately in the socio-cultural context of the classroom by the age group or the educational level for which it is designed.

Third, the students found that the tools were not useful for them. For example, Teacher C6 said that:

> 'When the students grow up, they are attracted not by interesting or colourful things but by the usefulness of the tools.'

Teacher C3, who taught Mathematics in secondary school, offered another example of the students not being interested in using online tools:

> 'There are online assessments from publishers, e.g. Oxford and Chinese University of Hong Kong, in which random questions are generated. Students participate optionally. The teacher found that some students are not very enthusiastic about online assessments (approximately 40%). They are more interested in submitting assignments on paper. Most students would work for the paper version of an assessment.'

The situation might be attributed to the fact that the online tools do not facilitate the use of mathematical symbols and equations, but paper assessments are more flexible for presenting the answers. In this example, the online tools have not been designed for presenting mathematics answers, and the students believed that the tools are not useful for them and were therefore not interested in using these tools.

In summary, the tools create a negative affordance – the students feel that (1) these are not interesting to use because they think that these tools are not new things, (2)

there are other more interesting things for the students than Google applications, and (3) the tools are not useful to them.

Constraint: Demotivating writing

Teacher C4 and Teacher C15 were concerned about the use of technological tools in teaching and learning, which use the keyboard for data input. This concern was not only for Google applications but also for using technological tools in general.

Teacher C15, who taught Chinese Language in secondary school, was concerned about the decreased writing practice because of the use of the keyboard input. Teacher C15 said that:

> 'In a Chinese class, handwriting is also an important skill; i.e., writing Chinese characters requires one to follow the correct sequence of strokes. The data input device seems to not work satisfactorily for authentic Chinese characters. I think that the existing data input method by keyboard might work better for the alphabet, but not for characters such as Chinese ones. Students will not write good Chinese if the learning depends too much on a computer.'
>
> 'Examination is now paper based. We find a situation in which some students are not good at writing by hand and they are not good at inputting Chinese characters through a keyboard. In this circumstance, they input another word pronounced with the same sound or write with the spoken language.'

Teacher C4, who taught Visual Arts in secondary school, believes that students are more serious in writing down their opinions on paper than when typing the same with the keyboard during a group discussion. Teacher C4 said that:

> 'For example, during reflection after group projects, the students might not write seriously because the keyboard input is too easy; in particular, when they input their opinions in text, they just input simple text or sometimes do not input the text. However, if I provide them with a paper to write down their opinions, they tend to write something substantial.'

Teacher C4 did not like writing using the computer. The style of writing is changed because of the use of the keyboard input, and the teacher thought that it was not as

good as it would be if written by hand.

Teacher C4 and Teacher C15 offered examples in which technology was not neutral (Kranzberg, 1986) because it affected the way the students wrote and the students composed, which was something the teachers did not want. If the teachers liked the kind of writing the students produced using a computer, it would be a positive affordance. However, in these examples, the technology demonstrated a negative affordance, and therefore, the teachers rejected the use of technological tools for the students to write Chinese or to write down their opinions. This is an example of technology mediation not supporting teaching.

5.3.2 Social constraints

This section discusses the social interaction constraints studied from the data collected.

5.3.2.1 Ineffective communication

Teachers perceived the ineffective communication affordance of Google applications because the applications do not facilitate some body language when the input is typed with the keyboard along with a verbal discussion during cooperating writing.

Constraint: Lack of body language while typing

Teacher C1 discussed that although cooperative writing in Google Docs and writing by hand in a group discussion have similar outcomes, there are advantages for writing by hand over collaborative writing through typing with the keyboard. Teacher C1 who prefers writing by hand in cooperative learning said the following:

> 'When we write with a pen, we can express our feelings, for example, through facial expressions, gestures, and body language. However, collaborative writing does not facilitate these interactions and prompts.'

Moreover, keyboard typing affects interactions among group members when the

students write cooperatively with their own device. Teacher C1 said that:

> 'While we are thinking and have not finished speaking, we type on Google Docs through the keyboard very quickly and instinctively. In contrast, as writing by hand could be a slower and more easily controlled action along with the verbal discussion, it allows the students more time to think before responding to the teacher's questions.'

Teacher C1 tried to use technology to exert some power and to guide students to present ideas and to respond to questions through cooperative writing using Google Docs in the classroom. However, she found that the software hindered body language if much keyboard typing was needed. In contrast, as writing by hand was a slower and more easily controlled action along with the verbal discussion, it allowed the students more time to think before responding to the teacher's questions. Teachers could also freely use their hands in the meantime to emphasise their message during the classroom interaction. Therefore, Teacher C1 preferred writing by hand for cooperative writing along with a verbal discussion in the class. In this example, the perceived affordance of the teacher was to interact with the students with her opinions, expressions, and body language, but the technology appeared to fail in this affordance.

Technology demonstrated the social constraint of 'Lack of body language while typing', because Teacher C1 believed that she could guide the cooperative writing by writing by hand. Writing by hand allowed her to use more body language than typing with a keyboard. These body language cues include body movement, standing position, and gestures such as the natural and purposeful use of hands to support the teacher's verbal messages.

5.3.3 Technological constraints

The following are the technological constraints studied from the data collected.

5.3.3.1 System constraint

Teachers perceived a 'system constraint' from Google applications because they were concerned about the WiFi dependency, incompatibility across platforms, the requirement for training before use, inspection problems, and the tools' lacking the required functionality.

Constraint: WiFi dependency

Teachers expressed their concern for the WiFi dependency of a cloud service as follows. For example, Teacher C7 said that:

> 'It is convenient to use if there is Internet access. However, if there is a place where there is no Internet access, for example a meeting room that has no WiFi access, we cannot use Google Docs. Then, we can only use Microsoft products instead, because they are installed on my computer and are not Internet dependent.'

Teacher C8 said:

> 'We do not use Google Slides for presentation because if the Internet is not accessible, everything is impossible.'

Teacher C9 said:

> 'the effectiveness of iPad is limited by the network bandwidth.'

Teacher C12 said:

> 'Our existing WiFi does not cover the entire school, and therefore, I cannot use an iPad in many situations.'

These technological constraints limit the places for cooperative learning. Both Teacher C7 and Teacher C12 discussed how their existing WiFi does not cover the

entire school, and therefore, students cannot collaborate in many locations.

Constraint: Incompatibility across platforms

From the data collected, incompatibility constraints were perceived in the following two situations:

First, incompatibility across file formats for similar software tools from different vendors. For example, Teacher C1, who taught Integrated Science in secondary school, said that:

> 'I use Microsoft products instead of Google Slides, Google Docs, and Google Sheets in school because the format is distorted when we save and open between Microsoft documents and Google applications.'

Teacher C10, who taught ICT in secondary school, said:

> 'Lower-level students use Corel Draw with the laser cutter for drawings. However, Google applications cannot open a file in the Corel Draw format, and therefore, the teacher needs to download the file and then upload it back after commenting on it, which is time consuming.'

Teacher C11, who taught English Language in secondary school, said:

> 'Google Docs cannot read the "Notes" on a Microsoft Word file, and therefore, it needs to download the file on a desktop computer to read the "Notes" now.'

In these examples, the software tools were not designed in such a way as to help the teachers in their socio-cultural context for teaching, and therefore, the teachers perceived 'Incompatibility across platforms'. For Teacher C1, the context was that the teacher had to exchange files between Microsoft documents and Google applications because her school was using the former software. For Teacher C10, the context was to read Corel Draw files for drawings from students and write comments on them. For Teacher C11, the context was that the teacher needed to write English Language comments on students' assignments written in Microsoft

documents. However, Google applications have not been designed with these affordances.

Second, Google applications, such as Google Hangouts, have not been used for social communication because users at the other end were not using them. The communication was not compatible across different software; for example, Teacher C7, who is an information technology officer in secondary school, said that:

> 'We use Skype, instead of Google, for video-conferencing. We have IB (International Baccalaureate) curriculum for which we need to communicate with foreign professors, and they use Skype instead of Google.'

People cannot communicate if they use different communication software, as these software applications cannot talk with each other. Therefore, people will use one of the most popular used software for social communication. Social affordance is dependent on whether other people are using the same software. Most peer students and teachers are now using WhatsApp in Hong Kong, which is communication software for social communication on cloud for mobile devices, (Teacher C2, Teacher C3, Teacher C11, and Teacher C12). However, the communication is not compatible across WhatsApp and Google applications.

Constraint: Require training before use

For the interview question 'How do you rate the ease of use for Google applications?', the teachers' ratings for the ease of use are tabulated in Appendix 3.6 (Table 17) and are presented in a pie chart as follows:

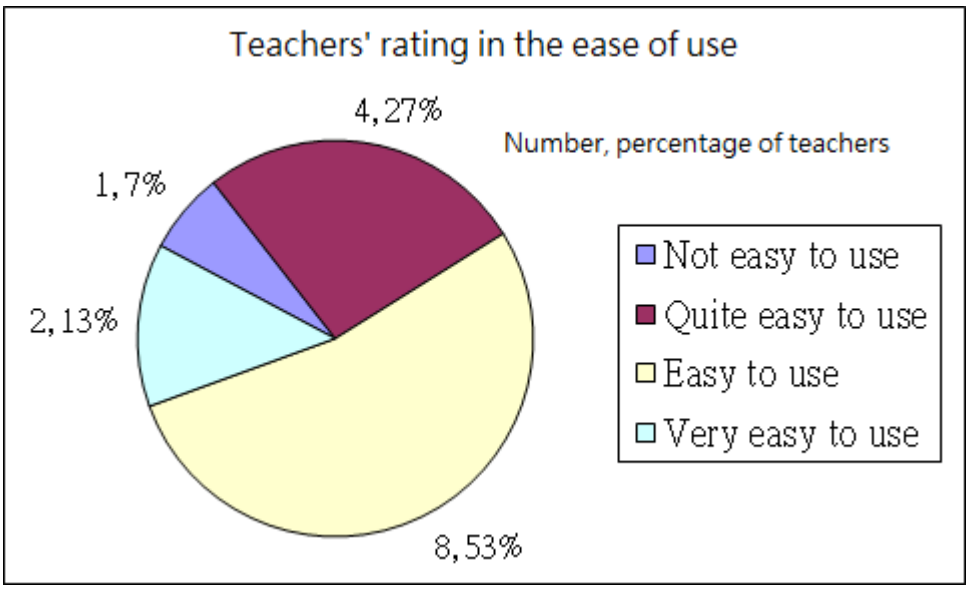

Figure 20 – Pie chart of teachers' ratings for the ease of use

From the pie chart, we infer that two teachers thought that Google applications were very easy to use and eight teachers thought that they were easy to use, but four teachers thought that they were quite easy to use and one teacher thought that they were not easy to use. The result showed that more than half of the teachers in the sample population thought that the tools were easy to use, but there were some teachers who did not think so.

Referring to Table 2 (Section 4.3.2) for the list of participants invited for interviews, we infer that seven interviewees had received no training, seven had received some training by attending courses and seminars, and one was a certified Google teacher. These figures suggested that around half of the teachers in the sampled population had received no training on the use of Google applications, as Teacher C7, who is an information technology officer, discussed:

> 'New teachers might not be very interested in them (Google applications), particularly as training will not be provided to them when they are hired.'

The following examples reveal two reasons for the teachers' problems with the use of the technological tools:

First, the teachers lack training. For example, Teacher C4 said:

> 'When I use Google Forms, I do not know how to remove a form. There is no delete function on the right click (as in most Microsoft software), and nobody could tell me how to do so. It took me some time before I found the trash option.'

Teacher C7, who is an information technology officer, discussed the user experience of his teachers:

> 'The main reason teachers do not use Google Docs and Google Slides is that they do not know how to use these applications. They cannot get the functions from the user menu as in Microsoft products… My estimation is that only 10% of my colleagues can use Google Docs right now.'

UX Planet is a website for sharing articles related to the user experience. A writer who used the pen name Tubik Studio in 2018 wrote in the article 'UX Design Glossary: How to Use Affordances in User Interfaces' discussed the affordance as follows:

> 'Affordance is a property or feature of an object which presents a prompt on what can be done with this object. In short, affordances are cues which give a hint regarding how users may interact with something, whether physical or digital.'
>
> (Tubik Studio 2018)

The discussion of Teacher C4 and Teacher C7 showed that there was no affordance because they could not find the cues from the user interface, and therefore, they could not interact with the software tools successfully.

Second, the computer knowledge of students might not be adequate, and the teachers might not be skilled enough to assist students in the class. For example, Teacher C6, who taught Chinese History in primary school, set up cooperative

groups for students to learn by responding to the teacher's questions using Google Slides and iPad as tools, but the teacher perceived a constraint. Teacher C6 said:

> 'When the children have a problem in operating the iPad, I need to take care of them. I have trouble when more iPads are used in the class. I need to seek help from colleagues although I am a computer teacher. In a 35-min class, there is insufficient time for my lesson plan because I need to take care of all the students. Therefore, we can only work on small tasks and with one iPad for each group. Supporting four to five iPads in the class is the maximum for me.'

This example suggests a constraint if the students lack familiarity with the technological tools. Technologies might impose limitations and constraints on cooperative learning. Teacher C6 found that he needed extra time to take care of the students if they had a problem with operating the iPad. He had trouble when there were many iPad used in the class in the hands of inexperienced users. In this situation, he needed to seek help from colleagues.

Constraint: Inspection problem

Subject lead and parents could not monitor students' work on assignments, or they cannot view and annotate the assignments because these are now stored digitally. Teacher C2 and Teacher C15 discussed the problem of the inspection of assignments on Google Classroom as follows. Teacher C2 said:

> 'If the students' assignments are stored digitally, the subject lead and parents cannot easily inspect the quality of work as they would a conventional hard copy of the student assignments. Parents can see the students' work easily when it is in the form of a conventional hard copy, such as an exercise on handwriting, or an assignment corrected by the teacher with a pen. Parents are particularly concerned with their children's work.'

Teacher C15 said:

> 'We still use a paper-based format for assessment. The major reason is that it needs to be visible to parents and all students should be asked the same questions in the assessment, because of the equity issue.'

However, Teacher A4, who is a more experienced Google applications user, provided a workaround for this issue. Teacher A4 discussed that:

> 'How can assignments in Google Classroom be available for inspection? There are two methods: i) put the comment and grade below the student's response before printing it out for inspection, or email it to the student through Google Classroom, which can be printed for record when necessary, and ii) all the assignments can be printed at once with a mouse click.'

Therefore, some teachers perceived the inspection problem as a constraint, but another teacher might not perceive this situation as a constraint. Affordance can only be studied taking into consideration both the technology and its agent, as Wertsch (1994) said:

> 'Any attempt to reduce this basic unit of analysis to the mediational means or to an individual in isolation is misguided.'
>
> (Wertsch 1994, p.205)

Constraint: Lack of functionality

According to the teachers' discussion, the constraint is because of the lack of some functions that the teachers needed as in the following examples:

First, there is less functionality than in other software tools. Teacher A1 said:

> 'You do not know whether the students have really watched the video. There is other software such as EDpuzzle with which questions can be asked during the video and students need to respond before completing the video.'

> 'The "Feedback to students" function in Google Classroom has a limitation: it allows the submission of text, URLs, and images, but one cannot upload videos or audio recordings directly. A workaround is to place the media file in Google Docs and then share the Google Docs file with the students.'

Second, the tool does not provide some functions such that it is flexible, like the manual operation in traditional teaching. For example, Teacher C8, who preferred paper-based assessment to computer-based assessment, said:

> ‘Teachers get used to marking assignments with ticks and crosses. Teachers can easily write comments and strikeout or encircle things on a paper-based assessment. We hope that there is a fast grading process in the future similar to this. Meanwhile, the tool cannot interact with a student for the students to respond whether they agree or disagree with the teacher’s comment.’

Teacher C8 further said:

> ‘In an English Language lesson, we use collaborative writing on a composition. The teacher provides a topic, and the students write on Google Docs together. However, there are deficiencies: If there is too much text on the screen, students might not be interested in it. Moreover, the contents grow fast and roll down to the bottom, making it difficult for students to view their sentences. The teacher writes his appreciation only in text but cannot, say, draw a tick for a good point alongside the composition.’

In summary, the teachers thought that Google applications lack some functionality as compared to other software tools such as EDpuzzle, and the tool is not flexible like the manual grading by using ticks and crosses.

5.3.3.2 Safety and security concerns

Teachers have a safety and security consideration with respect to Google applications because they are concerned about the lack of security, loss of data, and the plagiarism problem.

Constraint: Lack of security

Teachers discussed the following two security problems:

First, there is a loss of privacy. Teacher C8 said:

> ‘There is an advantage in which everyone in the school can use it, share things, and free-of-charge.’

> ‘Being free of charge might have an impact; for example, a possible loss of privacy and security are a big concern. Teachers think that there are certain risks related to the use of such technology.’

According to the opinion of Teacher C8, teachers in Hong Kong find the benefits of the lowered cost in the computing capacity because there is no need to acquire expensive computing infrastructure (Anderson *et al*., 2008) from cloud computing, but the argument from Teacher C8 agrees with Johnson (2012) who discussed that there is a concern regarding whether files are secured and whether files are private for the 'free' services. Teacher C8 further said:

> 'There is a security consideration in conducting the assessment with Google applications: First, it is managed by Google, which is a third party, and second, if someone discovers my password, say, when I login with my account in a public place, the students or someone will steal or change everything in it.'

Secondly, data might be changed unexpectedly. There might be a harmful data change in a multi-user environment. Teacher C9 said:

> 'There was an incident in which a student deleted a folder which I wanted to keep. The folder permission had to set to either "view" or "edit" to let the students put files in there, but the 'edit' permission also allowed deletion. Therefore, I needed to remember to change permissions at certain times, thereby increasing my workload.'

The above examples show that teachers have security concerns because they are afraid of a loss of privacy and there is a user experience in which data are changed unexpectedly. These security concerns discussed by Johnson (2012) were found in this research.

Constraint: Plagiarism problem

Teachers discussed their concern with the plagiarism problem because they thought that technological tools made it easier for the students to copy answers from each other. For example, Teacher C1 found that the students shared answers with each other in an assignment outside the classroom. The following data of Teacher C1's pedagogic assemblage illustrate this example:

Scene: Teaching Physics, Integrated Science in Form 1 – 3
Agent: Teacher C1, students
Purpose: To conduct a quiz outside the classroom
Agency: Google Forms
Act: Teacher C1 set up the quiz online. The students took the quiz at home.

What Teacher C1 said in this example:

> ‘Google Forms is useful, but if we use it for home assignments, I am afraid that students will copy from each other because it makes copying easy. If the software can change some figures in the questions such that the students cannot copy answers from each other, I will use it. Some software tools have this function, but Google Forms does not have it.’

Teacher C1 set up a quiz online for students to complete outside the classroom using Google Forms. The teacher wanted her students to complete the quiz on their own. However, what she discovered was that the students could share their answers with each other, which was against the teacher’s intention by turning individual learning into collaborative learning, which was an unintended consequence. This is an example in which the technology changes the power relation in the classroom (Ingram 2016).

In this example, the technology cannot achieve the teacher’s aim because it has not been used by the teacher in the socio-cultural context for which it was designed. By framing the lesson so that it occurred outside of the classroom, in a less structured environment at home, the software facilitated collaboration and the sharing of the answers.

The teacher can decide that the students should work individually. In order to give the teacher’s intended affordance for having the assignment to be completed individually, a question bank is required for the students to draw the questions from. Alternatively, she would have to get them to complete the quiz in the class under test conditions, in which case, each student is provided with a laptop computer and

the students complete the quiz on their own with no collaboration. In this situation, the teacher can exert more 'visible' control over the classroom activity. However, in this example, because of the way the teacher set the class up, the students could collaborate, which is not what the teacher wanted. The idea of the pedagogic assemblage was the interaction between the teacher, the technology, and the students, which broke down because the teacher wanted something to happen, i.e. for them to work individually, but she had not framed the lesson in the right way for the desired act to happen.

Whether there is affordance from the technology depends not only on the agency and the agents interacting with it, such as the aims and the purposes of the teacher, who will have to determine what is accepted and what is not accepted in terms of how the technology is used but also the way the teacher sets the class up. This example has an unfortunate consequence because the teacher did not want the students to collaborate. If the next time when the teacher is giving the quiz on Google Forms and wants her students to collaborate, to share their thoughts, and to come up with a set of answers and explain why these answers are given, and if the teacher has framed the lesson in such a way to include the element of collaborative learning, the affordance can work very well.

As another example of plagiarism, Teacher C4 found that the students copied personal opinions during cooperative learning in the classroom. Teacher C4, who taught Visual Arts in secondary school, said:

> 'Students can see each other's opinions immediately. It is a disadvantage when they copy each other's ideas. For example, nearly all the students said that the picture had much colour and was beautiful, in their opinion. Being afraid of contributing at any point in the group discussion, they gave similar opinions to the others', and therefore, their answers had no uniqueness.'

The above examples suggest that teachers are concerned about plagiarism because they have found that technology makes the copying of answers easier.

Constraint: Loss of data

The teachers discussed the following two problems:

Teacher C4 said:

> 'I will only upload documents with less impact when lost.'

Teacher C8 said:

> 'Google's Terms of Use state that Google is not liable for any loss of stored content. Whether it is safe is a consideration for whether they (Google applications) are used.'

The teachers were concerned about the possibility of data loss. This security concern discussed by Johnson (2012) was found in this research.

5.4 Summary of findings

This section summarises the findings to answer the three research questions below.

5.4.1 RQ1: What do teachers perceive to be the affordances of Google applications with respect to supporting their teaching?

To answer this question, this research coded affordances from the qualitative data and organised them in coding schemes. The theoretical framework in Figure 7 of Section 2.7 provides a model that shapes the coding scheme in the qualitative analysis.

The first-level categories of the coding scheme group affordances, according to the different roles of ICT in teaching and learning, into educational, social, and technological. Educational affordance refers to the properties of Google applications that support different types of learning. Social affordance refers to the properties of Google applications that support different levels of social interactions and the creation of a social space for students, recognising that learning is a social process. Technological affordance refers to the technical capability of cloud computing that makes pedagogic actions successful.

Affordances are both derived from the literatures and deduced from the data. They are grouped into second-level categories under different themes. Educational affordance includes the properties that (1) enable different types of learning, (2) facilitate learning activities through different mediation methods, and (3) maintain the power relations in classroom activities. Social affordance includes the properties that support social interactions: (1) between the teacher and his/her students, (2) between the student(s) and his/her(their) teacher, and (3) among the students for a social space. Technological affordance includes the capabilities from the essential characteristics of cloud computing that allow teachers to design teaching and learning activities accessible outside of the classroom. These are affordances derived from the literature, and the data analysis found

examples from the data collected to support these codes. Some technological affordances emerged from the data, including the capabilities that enable teachers to design activities in integration with other hardware and software innovatively, address the learning difference issue, and automatically grade assessments.

Table 5 and Table 6 in Section 4.4.2 tabulate the coding scheme, the coded affordances and constraints from the qualitative data, and the interpretation of these codes. Figure 12 and Figure 13 display the coded affordances and constraints from Table 5 and Table 6 graphically. Section 5.2 and Section 5.3 discuss these affordances and constraints, and elaborate on them by using examples from the data collected.

The statistics of affordances shows that some affordances were perceived by more teachers than the others, probably because these affordances were more advantageous to teaching and learning. The most frequently perceived affordance was that it provided a storage resource to mediate learning as a working memory such that the students could learn cooperatively and effectively. It also mediated learning by providing a repository of organised information and a back-up medium for materials. The next frequently perceived affordance was the compatibility for software tools to be used across platforms, for example mobiles, tablets, iPads, and different types of computers, such as Microsoft Windows-based and MacBook, facilitating cooperative learning. The next frequently perceived affordance included its accessibility anywhere at any time, allowing teaching strategies to be extended outside of the classroom.

These findings inform the ways in which cloud computing supports teaching according to the teachers' perceptions.

5.4.2 RQ2: How do teachers perceive the affordances of Google applications for different school subjects and at different educational levels?

5.4.2.1 Perceived affordances for different school subjects

Some teachers thought that Google applications offer affordances in the school subject they taught, but the other teachers thought that Google applications were not useful for the subject they taught.

Teacher A4 and Teacher C15, who taught Chinese Language in secondary school, thought that the traditional methods of teaching to transmit knowledge from the teacher are more suitable for their taught subject. They discussed that e-Learning plays an auxiliary role in Chinese Language teaching because whether the learning objective is achieved depends on whether a student can produce a good composition and can answer the questions in the comprehension test.

Teacher C15, who taught Chinese Language in secondary school, discussed his concern regarding the decreased handwriting practice, as technological tools require the use of the keyboard for the input. He believed that handwriting is an important skill in learning Chinese because the writing of Chinese characters requires one to follow the correct sequence of strokes. He found that some students are not good at writing by hand, and they are also not good at inputting Chinese characters through a keyboard. In such a case, they input another word pronounced with the same sound or write with the spoken language.

Teacher C4, who taught Visual Arts in secondary school, thought that Google applications are not suitable for her taught subject because she found that the technological tools have hardware limitations. She said that drawing a picture with these tools was difficult, unless the teacher and the students grasped the use of auxiliary

equipment, such as the mouse and the drawing board. These are examples in which Google applications hinder the teaching of a school subject.

The data analysis also revealed that Google applications help students to learn more and more easily in some school subjects. For example, Google Earth is useful for teaching geography in secondary school (Teacher C14). Google Arts & Culture is useful for teaching arts subjects in secondary school (Teacher C7). Google Sheets is useful for teaching some mathematics topics in secondary school (Teacher C12). YouTube and Google Maps are useful for teaching General Studies in primary school, as they provide daily life examples (Teacher C13).

5.4.2.2 Perceived affordances at different educational levels

Teacher C1 and Teacher C14 believed that the motivation for younger students also depends on how often the technological tools are used. Younger students are eager to learn new things, and their motivation could be driven by their curiosity to explore the new tools. The teacher found that the tools would motivate students at the beginning. However, if they are often used, say in every class, the students might not be interested in them.

Teacher C6 discussed that younger students were attracted by interesting, colourful things and like more interaction in the classroom. Teacher C8 thought that when children grow up, they might not be attracted by interesting or colourful things, but by the usefulness of the tool. Examples from the data collected show that affordance is only effective and perceived in the socio-cultural context, such as the age group and the educational level, for which the technological tool is designed; otherwise, the motivation for learning affordance cannot be perceived.

Teacher C10, who taught Mathematics in secondary school, believed that collaborative modes of learning are more suitable for lower levels. There are affordance differences

between teaching lower levels (primary school and Forms 1 – 3 in secondary school) and higher levels (Forms 4 – 5) from an educational perspective. The teacher discussed that there would be little group interaction and exploration for higher levels, but mainly the solving of mathematical problems by individuals because they needed to prepare for the public examination. However, in the lower levels, younger students like more interaction in the classroom and there would be more time for cooperative learning. Therefore, for mathematics in the lower levels, Google Classroom is a platform for cooperative learning, while for the higher levels, it is a personal workspace for individual learning, and there is less group interaction.

5.4.3 RQ3: What are the teachers' opinions of the usability of Google applications in supporting their teaching?

Usability could mean the degree to which a tool is easy to use. Usability could also mean the degree to which the tool is able or fit to be used. If there is a tool that is easy to use but is not fit for use, or it is fit to be used but is not easy to use, there is no usability. Therefore, both fit to be used and ease of use should exist for usability to be meaningful.

To answer this research question, two Likert-scale questions were asked in the interviews: First, 'How do you rate the ease of use for Google applications?'. The teachers' responses to this question provided an overview of the teachers' perceptions of the ease of use for Google applications. Second, 'How do you rate the usefulness of Google applications in supporting your teaching?'. The teachers' responses to this question provided another insight into usability, which was about the fit to use.

The findings revealed that the usability of Google applications was affected by different factors, including the training received, the teachers' experience of similar tools, the similar design of software tools that the teachers had used before, the computer knowledge of their students, and the agencies that the teachers used to access software tools, such as WiFi network bandwidth and iPad, which are important for the use of Google applications.

5.5 Evaluation checklist for affordances and constraints

This research studied the empirical experiences of teaching professionals. This section discusses an evaluation checklist constructed from these experiences for use as a diagnostic tool to evaluate the affordances of an educational technology, and how to use the checklist. The tool assembles the positive and negative affordances in this study and turns them into a checklist of questions for the socio-cultural study on pedagogic assemblage and affordance analysis.

5.5.1 Construction of checklist

There are seven parts of the checklist: Part A is a socio-cultural study on the classroom. This part asks the five questions in Burke's pentad: scene, agents, and purpose in order to understand the socio-cultural context in the classroom. Parts B, C, and D are questions for each category: educational, social, and technological in the affordance analysis, asking whether the user finds these affordances, by referring to the coding scheme from this research. Parts E, F, and G are questions for each category of negative affordance, asking whether the user finds these constraints and concerns in use.

Part A – Socio-cultural study on pedagogic assemblage

Scene:	What is the teaching and learning context? e.g. educational levels, school subjects, classroom setting, size of the class, and learning groups setting
Agent:	Who are involved in the pedagogic actions? e.g. teachers – their methods of teaching, competence in using technological tools, students – their age groups, accessibility to computers, authors of learning materials
Purpose:	What are the learning objectives and motivations of the pedagogic actions? e.g. behaviourist learning, cognitivist learning, constructivist and social constructivist learning. the type of assessment – formative, summative
Agency:	Which tools allow these pedagogic actions to take place? e.g. the tools and their technical capability offered to the users
Act:	What pedagogic actions should take place between the teacher and the students? e.g. the flow of classroom discussion; decide when to speak something, not to speak something, when to allow the discussion to flow because it is generating good ideas, and when to intervene

Table 7 – Affordance evaluation checklist for an educational tool

Part B – Educational affordance

Positive properties		Evaluative question under the socio-cultural context of pedagogic assemblage
Support different pedagogical approaches	Classroom activities	How does it enable activities that create a stimulus, eliciting desired responses and then reward? (behaviourism) How does it enable students to store and retrieve meaningful and useful knowledge efficiently? (cognitivism) How does it enable students to actively construct knowledge in terms of prior knowledge? (constructivism)
	Enabling assessment	Does the tool enable formative assessment, i.e. for monitoring the learning progress of students or tuning the teaching strategy according to the students' needs, e.g. classroom questions, assignments, and quizzes? Does the tool enable summative assessment, i.e. for checking what the students have achieved, e.g. end-of-unit tests and examinations?
Mediation	Storage resource	Does the tool offer a working memory for the transfer to and retrieval from the long-term memory during the private phase of learning? (cognitivism) Does the tool offer a repository of categorised and organised information? A backup medium? A bridge for transferring files between the tablet and the computer?
	Interesting to use	Does the tool mediate learning to promote motivation by rewarding interactions with the software? (behaviourism)

Table 7 – Affordance evaluation checklist for an educational tool (cont'd)

Part B – Educational affordance (cont'd)

Positive properties		Evaluative question under the socio-cultural context of pedagogic assemblage
Mediation	Enhancement of learning	Does the tool empower students to interact with each other and the external world to acquire knowledge and understanding? (social constructivism)
Teacher control and power relations	Cooperative learning	Does the tool facilitate classroom interactions as well as interactions outside of the classroom for cooperative learning?
	Monitor learning progress	Does the tool enable the teacher to take more control, both visible and invisible, over the students' learning?

Part C – Social affordance

Positive properties		Evaluative question under the socio-cultural context of pedagogic assemblage
Enabling teacher-students interactions	Teacher to students communication	Does the tool facilitate more effective communication with students, to broadcast announcements, give feedback, and respond to and share information and materials with them?
Enabling students-teacher interactions	Students to teacher communication	Does the tool facilitate students to communicate by giving a response, asking questions, and sharing information, materials, and their works with the teacher?
Enabling communication among students	Enabling social space	Does the tool enable students to learn in groups collaboratively with shared competence? Does the tool create a social space that may give rise to social relationships and group cohesion?
	Aesthetic affordance	Is the interface design attractive, and therefore, offering motivational affordance such that the students would stay on it for social communication?

Table 7 – Affordance evaluation checklist for an educational tool (cont'd)

Part D – Technological affordance

Positive properties		Evaluative question under the socio-cultural context of pedagogic assemblage
Classroom administration	Resource sharing	Does the tool facilitate teachers to share information and materials in their taught subjects with their students, colleagues or everyone?
	Addressing learning difference issue	Does the tool mediate teaching and learning by providing a memory of student records and a repository of hangouts for repeating exercise or revision by the weaker students?
	Automatic grading	Does the tool enable teachers to grade a quiz automatically? How does it grade fill-in-the-blank and open-ended questions?
Ubiquitous use	Compatibility across platforms	Is the tool compatible across computer operating systems, tablets, mobile devices, and software tools from different vendors?
	Access anywhere, anytime	Does the tool enable a teaching strategy extended to pre-class, classroom, and post-class learning activities?
Innovative use	Use in integration with other tools	Does the tool enable a teacher to use it in integration with different hardware or plugin software innovatively to design their lessons?

Table 7 – Affordance evaluation checklist for an educational tool (cont'd)

Part E – Educational constraint

Negative properties		Evaluative question under the socio-cultural context of pedagogic assemblage
Not supporting pedagogy	Not applicable to taught subject	Why do the teachers believe that the tool is not applicable to their taught subject? Any constraint such as specialised hardware needed? Will an experienced teacher find it useful?
	Uncontrolled student behaviour	Will the tool make it easier for the students to do something that the teacher did not want in the class, e.g. can teachers manage the result such as an Internet search?
Demotivation in learning	Not interesting to use	Will students lose curiosity when the tool is used too often? Will students think it is not an interesting thing? Will students believe it is not useful for them?
	Demotivating writing	Is there side effect of using the tool? For example, the Chinese Language teachers discussed that it decreases the handwriting practice of Chinese characters or it affects the way the students write a composition.

Part F – Social constraint

Negative properties		Evaluative question under the socio-cultural context of pedagogic assemblage
Ineffective communication	Lack of body language while typing	Will the tool adversely affect the classroom interactions with students? Can the teacher manage the class while using the tool for teaching?

Table 7 – Affordance evaluation checklist for an educational tool (cont'd)

Part G – Technological constraint

Negative properties		Evaluative question under the socio-cultural context of pedagogic assemblage
System constraint	WiFi dependency	What is the impact when WiFi disconnected? Is there any contingency plan if disconnection happens, e.g. use installed software or use standby equipment?
	Incompatibility across platforms	Is there any incompatibility across software tools from different vendors, such as the file format? Do all school members need to use the same software for successful communication?
	Require training before use	How much training is needed for the teachers and the students to use the tool? What pre-requisite knowledge is needed for using the tool?
	Inspection problem	How does the tool facilitate the inspection of students' work by the subject lead and the parents because these are stored digitally?
	Lack of functionality	What functions does the tool lack as compared to other software tools? Is the tool flexible to use?
Safety and security concerns	Lack of security	Is there any concern related to the loss of privacy, referring to the service agreement with the cloud provider? Does the tool safeguard unauthorised data changes in a multi-user environment?
	Loss of data	What security setup such as data access rights and user permissions does the tool allow? Does it require data backup to prevent the loss of data?
	Plagiarism problem	Does the tool facilitate students copying their work or answers from each other? If yes, how to frame the class to prevent plagiarism?

Table 7 – Affordance evaluation checklist for an educational tool (cont'd)

5.5.2 Use of the checklist

The evaluation checklist can be used in different ways, and the following are some suggestions for how to use the checklist:

Teachers may want to evaluate whether the technological tools will be useful for them. Teachers choose the shape of their pedagogic assemblage by defining the learning objectives, the power relations, the levels of visibility of the controls, the framing of the classroom activities, and the use of the technological tools. They do this by answering the questions in Part A for a socio-cultural study on the pedagogic assemblage and then Parts B to G for an affordance analysis in this socio-cultural context. This approach could be used to assess the usefulness of the tool for the school subject and the educational level that they teach, according to the interests, needs, and capabilities of the teacher and his/her students.

IT professionals or system developers may want to evaluate whether the technological tools are useful for the different styles of lessons they plan. The first step is to identify all the different educational use cases, such as classroom teaching and collaborative writing for certain school subjects and at certain educational levels. Then, Part A will be a study of the socio-cultural context for each use case, and each use case will have its own Parts B to G for the affordances and constraints, for a systematic evaluation of the usefulness in these use cases.

Some questions in Parts B to G could simply be answered by ‘Yes’ or ‘No’ for whether an affordance or a constraint exists, while the others are open-ended questions for an observer who may be the teacher or the IT professional to study how and whether an educational tool supports teaching. The observers can diagnose the tool or talk with each other regarding whether the tool is useful or what they need from the tool with a range of questions that are empirical experiences of the teaching professionals.

5.6 Discussion

Affordances are complex, owing to their high dependence on different elements within the pedagogical assemblage; therefore, the same agency (the technological tool) can have very different affordances in different classrooms, as well as the contingent nature of an affordance. The findings confirmed the argument that affordances of technological tools can best be studied within a specific socio-cultural context, particularly that of the human agents (the teachers and students) who use the tools that mediate learning.

Drawing on the idea of a pedagogic assemblage, each class is a unique assemblage, with the personality and competence of teachers influencing their preferred teaching style and approach, and students who have different needs and motivation at a different age or level. The findings agree with Ingram (2016) who argued that successful use of ICT tend to favour collaborative modes of learning, in which students are empowered to learn from themselves and from each other. Some teachers are comfortable teaching in collaborative modes with invisible controls, while the other teachers seek strategies which have much more visible controls and more visible authority. To some extent, the ways in which teachers choose to use the new technology reflect their preferred teaching styles.

This finding showed that even two teachers teaching the same school subjects at the same educational levels perceived different affordances. Teacher C15, who taught Chinese Language in secondary school, thought that teaching with the mediation from technology was not suitable for his taught subject, but Teacher C9, who also taught Chinese Language in secondary school, did not think so. Teacher C15 thought that the traditional teacher-centred teaching method in which knowledge is transmitted from the teacher to the students was more suitable to his taught subject. However, Teacher C9 used Google applications to share news and extracts with his students to initiate their

thinking and trigger discussion. The interactions between Teacher C9, the students, the software tools, and the news and extracts were all parts of the pedagogic assemblage. These two teachers were actually operating in a different assemblage from each other, which implied that the agents and agencies were interacting in different ways. This example showed that affordance was dependent on the teachers, who had different beliefs regarding the methods of teaching and competence in using technological tools.

Teacher C1 and Teacher C14 found that the students lost interest in the software tool when it was used often. This unintended consequence was attributed to the different aims of students from those of the teacher. Younger students are eager to learn new things, and their behaviour might be driven by their curiosity. Affordance might be lost if the tool is used often. Teachers believed that there are more interesting things for the students than Google applications, and the students might believe that the tools are not useful to them. This example showed that affordance is also dependent on the students, who have their own needs and motivation according to their age group.

These findings agree with Wertsch (1997), who argued that mediated action involved focusing on agents and their cultural tools (technological tools are types of cultural tools) and that the use of culture tools involves an irreducible tension between the agents and the cultural tool. Irreducible tension means that these are the fundamental unit of analysis (Wertsch, 1994), and we cannot study the affordances of a technology in isolation with the teachers and the students.

5.7 Conclusion

This chapter discusses the findings of how and whether Google applications make a contribution to primary and secondary schools by an analysis of the affordances perceived by the teachers in Hong Kong.

To answer the question of what the teachers perceived to be the affordances of Google applications with respect to supporting their teaching (RQ1), the affordances and the constraints were coded from the qualitative data. The coded affordances and the code constraints are presented in Figure 12 and Figure 13, respectively. Section 5.2 and Section 5.3 discuss these affordances and constraints in detail. Drawing on examples from the data, the socio-cultural theory was used to reflect on the classroom phenomena for the reason why the teachers agreed or did not agree with the affordances in different socio-cultural contexts, say, different school subjects and different educational levels (RQ2), and the reasons why the teachers agreed or did not agree with the usability of Google applications, i.e. whether they were fit for use and were easy to use, in supporting their teaching (RQ3).

These findings related to the affordances are important because if teachers do not use technology in the socio-cultural context for which it is designed, or if the technology is not designed to help teachers in their socio-cultural context of teaching, it is possible that no affordance will be perceived. For example, some teachers believed that the applications are not applicable to their curriculum because they lack some of the functions they want. There is also no affordance when the teacher does not frame the lesson appropriately, as the use of ICT has the potential to alter the power relations between the teacher and the students. Teachers also believed that the applications were not designed for younger age groups and educational levels, and as a result, the students were demotivated to work with them. With the use of technology, the teacher's role is changing from that of a sole voice of authority controlling the transmission of knowledge to that of a facilitator of the emerging knowledge. The students are empowered to learn from themselves and from each other. Teachers who are able to run these types of classes will find a huge advantage of the use of technology. Otherwise, teachers will reject it.

The next chapter is a conclusion of the findings.

Chapter 6 Conclusion

This chapter concludes by presenting a discussion on the implication of findings, contribution to new knowledge, limitations of the research, recommendations for future investigations, and my personal reflections.

6.1 Implication of findings

This section discusses the implication of findings with respect to (i) the role of cloud computing in teaching and learning, (ii) the policies encouraging the use of ICT in teaching and learning in schools, and (iii) the practice of the use of technology for teaching.

6.1.1 Theorising the role of cloud computing in teaching and learning

The theoretical framework in Figure 7 of Section 2.7 offers a model that theorises the different roles of cloud computing in teaching and learning into educational, social, and technological. Under these roles, there are different themes of affordances in the study discussed in Section 2.6. These themes of affordances are both derived from the literatures and deduced from the data, as shown in Table 5 of Section 4.4.2, and are new from this research.

Educational affordances are those that enable different types of learning. The data analysis identified these affordances under different themes including the following: (1) support a variety of classroom activities promoting the different modalities of learning and the different roles of assessment, (2) facilitate learning activities through different mediation methods, and (3) empower students in collaborative modes of learning, while maintaining power relations in the classroom using both visible and invisible pedagogies. Social affordances are those that enable social interaction, recognising learning as a social process. The data analysis identified the affordances that support social

interactions at different levels: (1) between the teacher and the students, (2) between the student and the teacher, and (3) creating a social space for the students. Technological affordances are the technical capability of cloud computing. The data analysis identified these affordances under different themes including the following: (1) its ubiquitous use such that teaching strategy can be extended outside of the classroom, (2) classroom administration, and (3) its innovative integration with other hardware and software.

The findings showed that different affordances are perceived under this model in different socio-cultural contexts of the classroom. This theoretical model is novel in that it brings together socio-cultural theory and affordance analysis. By doing so, it highlights the situated nature of the affordances of technologies. How an application on the cloud contributes to learning depends not only on the application, or the technology, itself but also on all elements of the pentad, including the subject being taught, the age of the students, and the teachers' beliefs regarding teaching and learning.

Software developers who design or improve their software and IT technicians who support teachers in the use of technology need to recognise the different roles of cloud computing in teaching and learning, and the situated nature of the affordances of technologies in different socio-cultural contexts of the classroom theorised in the model.

The empirical research confirmed this model. Table 5 tabulates the coded affordances that fit into the theoretical model, and the interpretation of these codes. Figure 12 in Chapter 5 presents these coded affordances, which are the same as those presented in Table 5 but displayed graphically. Section 5.2 discusses these affordances under the theoretical model with examples of different pedagogic assemblages from the collected data that support them.

6.1.2 Policies encouraging the use of ICT in teaching and learning in schools

Owing to the government policy (ITE4) to extend the use of educational technology, schools are supported by funding to equip all the public sector schools in phases by installing WiFi connections. In the school survey on ITE 2016/2017 (Section 3.3), 58.6% of the schools had WiFi in classrooms only. Therefore, some teachers experienced the technological constraint from the WiFi dependency. As training on the use of technology had not been provided to the teachers when they were hired, some teachers found that they needed more training.

This research revealed that the use of cloud computing was in the beginning stage when the data were collected for this research in May–June 2017. Some teachers believed that either the software was not useful or it was quite useful (Section 5.3.1.1, Figure 18). Some teachers believed that the tools were not applicable to their curriculum because of different reasons (Section 5.2.2, Figure 16). There were teachers (who taught Chinese Language in secondary school) who believed that collaborative modes of learning were not suitable for their taught subjects and preferred the traditional teacher-centred teaching method that transmits knowledge from the teacher to the students. There were teachers who thought that the software was not easy to use or that it was quite easy to use (Section 5.3.3.1, Figure 20). These findings implied that some teachers are not prepared for the use of cloud computing for teaching and learning when it is required.

In February 2020, all face-to-face classes in the schools of Hong Kong were suspended to fight the coronavirus pandemic. The Education Bureau announced a move ‘suspending classes without suspending learning’ that requires all schools to use online teaching in which both teachers and students access lessons from home. The user experience in online teaching during the pandemic reveals more insight into its affordances. Wertsch (1997) argued that the use of culture tools involves an irreducible

tension between the agents, which are the teacher, students, and the agencies, which are the technology. Successful teaching and learning are based not only on the agencies but also on the agents. The user experience of online teaching reveals the following tensions from the agents who are the students.

Li & Lalani (2020) discussed, in World Economic Forum, that the effectiveness of online learning varies among different age groups. This research found examples of teachers in Hong Kong about this tension. Seven teachers discussed that their students were interested in using Google applications for learning, but five teachers discussed that younger students were not interested in them. Ten teachers agreed that Google applications increased the motivation for learning. However, five teachers discussed that students were not motivated because of different reasons: First, younger children prefer traditional classes that have more colourful things in the classroom. Second, teachers found that there were other more interesting things for children than Google applications, such as interesting games, and third, students believed that these applications were not useful for them. Two teachers discussed whether the students' interest in using a tool was situational; for example, when the applications were used often, say in every class, the children lost interest in them because younger children are eager to try new things and their motivation could be driven by their curiosity to explore the new tools. Students in the lower levels were not interested in using them, because younger children found them neither a colourful and interesting thing nor something useful for them. These examples showed that the effectiveness of online learning was influenced by the age group or the education level.

Loeb (2020) discussed, in Education Week, that in online teaching, students might have more distraction and less oversight, which can reduce their motivation. My former colleague, who is an in-service teacher in a secondary school (hereinafter referred to as 'Teacher D') discussed this constraint of online teaching according to his experience. He

found that students might be distracted from online teaching because they accessed the lesson at home. Teacher D discussed that the traditional teaching method to transmit knowledge from the teacher to the students was not effective in online teaching because students might not be paying attention, particularly when they accessed the lesson at home. Students got distracted during the online class by, for example a phone ringing or their family member, which caused the students to pay less attention to the class. In order to minimise the students' distraction, Teacher D set up a group discussion online, a collaborative mode of learning, for ideas to come from students, instead of from the teacher, in order to engage the students.

Loeb (2020) argued that students who struggle in in-person classes are likely to struggle even more online. This research found examples of this tension from the teachers in Hong Kong. Some teachers believed that only students self-motivated for learning through technology will find it useful. For example, Teacher C1 said:

> 'The effectiveness of using technology depends on the students' self-motivation for learning. Students who are eager to learn find it useful because learning materials can be accessed easily, including on a mobile phone.'
>
> 'However, for most students who just sit down and hear your teaching, the technology might not help their learning.'

Teacher C9 said:

> 'For students with low motivation for learning, technology might be a burden, for example information overload and extensive communication.'
>
> 'It is very important that the students learn from each other, and this is our wish. However, this motivation is not found in all the classes.'

The teachers believed that only students with the self-study capability and self-discipline benefit from the technology. However, this tension does not mean that it is impossible, as Loeb (2020) said,

> ‘Online teacher will need to consider the needs of less-engaged students and work to engage them.’
>
> Loeb (2020)

The followings are examples from a school teacher, who taught Chinese in a primary school in Hong Kong, for engaging students in online learning during the pandemic:

> ‘Praise from teachers to students can reinforce good online behavior, which can help students stay engaged and focused during instruction. Sometimes, I share examples of good student work online to provide recognition for a job well done.’
>
> ‘I gave out rubrics that students can use to evaluate each other's work. Students then modify and improve their work after participating in peer evaluations.’
>
> (Ng 2020)

Ng (2020) recommended praise from teachers to students and peer evaluations to engage students in online learning, which suggested that the teacher’s experience is an important element of the pedagogic assemblage for successful teaching and learning.

Government policy is needed for professional support to encourage the use of ICT in teaching and learning in schools. The findings revealed that teachers need professional support, particularly when teachers and students are required to work at home in the pandemic context. Which applications on the cloud are the most useful will depend on the age or the level of students, the school subject, and the teachers’ belief regarding the methods of teaching. Teachers themselves are variously prepared to use the applications, in terms of their knowledge of what function is available, their experience of using the applications, and their confidence in the effectiveness of online learning. Allowing time and space for teacher collaboration, supporting subject-based collaboration within and across schools may help all the teachers to better facilitate learning for students.

6.1.3 Implications for practice of the findings

Importance of communication between software developers and teachers, and within schools between IT technicians and teachers

This research takes the theoretical ideas of socio-cultural study and affordance analysis and turns them into an evaluation checklist that can be used by an observer who may be a teacher or an IT technician to study how and whether an educational tool supports teaching. The observers can diagnose the tool or talk with each other regarding whether the tool is useful or what they need from the tool with a range of probing questions.

If software developers want to design better software, they need to recognise the different roles of cloud computing in teaching and learning (Section 6.1.1), the socio-cultural study and Burke's pentad as the ways to describe the pedagogic assemblage. The evaluation and the development of applications on the cloud need to be responsive to teachers using these applications on the ground. Open channels of communication are recommended by using the evaluation checklist as a bridge for the dialogue between the software developers and the teachers regarding what is needed from the technology in a specific socio-cultural context. Teachers within a school may use the cloud applications in very different ways, and therefore, software developers need to communicate with them to understand what affordances they want from these applications and the ways that they use these applications.

Teachers design teaching strategies and classroom activities with different pedagogical approaches and the underpinning learning theories, but they are not experts at technological affordance and usability. Software developers and IT technicians design and support the tool according to the technological affordance and usability, but they are not experts at different pedagogical approaches and learning theories. This checklist serves as a bridge for the dialogue between the teachers, the IT technicians and the software developers.

When we assess the usefulness of a technology, we always evaluate what the provider or what the technology offers to the users. However, it is the teachers who use technology to facilitate their educational process according to their interests, needs, and capabilities to promote learning through different pedagogical approaches. It is also the students who have more access to computers, and their motivation for learning could benefit from the use of technology. This checklist provides a systematic approach to view the affordances and the constraints in the socio-cultural context of the classroom. It also allows non-experts in affordance theories, such as teachers, who have not done research such as this one, to see the different roles that technology plays or can play in the classroom.

Role of teachers in collaborative modes of learning

The findings showed that the use of cloud computing facilitates collaborative modes of learning that contain discovery elements between students with shared competences. In these modes of learning, the students are empowered to learn from themselves and from each other, with the role of teachers becoming that of a facilitator of the emerging knowledge. The students can take more control over the sequence of their learning. The teachers perceived that collaborative modes of learning enhance the motivation of students because younger students like more interactions in the classroom, designing their own presentations, and sharing their thoughts when they work together. Therefore, teachers who are able to run these types of classes will find the advantage of using technology. However, when using online learning, the teacher needs to frame the lesson considering the potential change of power relations in the classroom when the learning is mediated by the technology, while teachers can maintain power relations in the classroom using both ‘visible’ and ‘invisible’ pedagogies to take to control over the direction and the pace of learning with the technology.

6.2 Contribution to knowledge

The contribution of this research is both theoretical and practical.

In terms of theory, this research contributes to academic debate by bringing together the socio-cultural theory from Vygotsky, mediation theory from Wertsch, Burke's pentad, the concept of pedagogic assemblage, the concept of visible and invisible pedagogies and the power relations in the classroom from Bernstein, different learning theories, and the concept of perceived affordances introduced by Norman into a single unified approach for affordance analysis (Section 2.7).

Recent research on a technology similar to cloud computing in Hong Kong include Chu & Kennedy (2011), Fu *et al.* (2011), Deng & Yuen (2010), and Yuen & Ma (2008), which studied the affordances of Wiki entries and blogs for undergraduate and school education. In contrast, this research provided an insight into the use of cloud computing for teaching in primary and secondary schools in Hong Kong.

In terms of practice, the findings suggested that affordance can best be studied within a specific socio-cultural context, particularly that of the human agents (the teachers and students) who use the technological tools that mediate learning. This research created an evaluation checklist of different types of affordances identified in this study (Section 5.5), to guide the affordance analysis and socio-cultural study with probing questions to diagnose whether the tool was useful or what was needed from the technology.

6.3 Limitations of the research

There are some limitations of this research (limitations caused by the research method have been discussed in Section 4.5).

An opportunity sample of fifteen participants was invited for the interviews. The teachers and the information technology officers provided valuable data from their personal experience of using Google applications and cloud computing but imposed limitations in the research result. The data relied on the teachers' reporting of their practices rather than a direct observation or analysis of the documentary evidence, and the validity of the result was based on the background of these teachers, such as their years of experience in teaching and in using the tools and their competence in using technology and teaching practices. Therefore, the results of the data analysis do not represent the majority of the school teachers of Hong Kong.

Affordances and constraints change with time, and these changes are rapid for technological tools. If Google upgrades the software tools of the considered applications, the findings will be different. For example, Google may choose to change the functions, features, and the visual design of Google applications at any time. Google may also change its Terms of Service at any time, and as a result, the privacy or security concerns will be different. Therefore, the findings from the affordance analysis in this study have a certain shelf-life.

The user experience in online teaching in response to the pandemic revealed that affordance might depend on the contextual contingency in the pedagogic assemblage and needs more elaboration. Teacher D discussed that there were voice and video distortions, and disconnection from the student side during online teaching that were related to the stability of the ICT systems. The videoconferencing tool is an active agency for learning to be successful. However, the stability of the ICT systems is not a property of the

agency but is something that occurs at an indeterminate frequency and is something that cannot be controlled. Therefore, there is a lack of detail, or blind spots, for Burke's pentad to conceptualise the elements in a pedagogic assemblage for successful teaching and learning, by not taking into account the stability of the ICT systems, which affects successful teacher-students interactions. This example showed the possibility of additional elements that were neither an attribute of the agents nor an attribute of the agencies not any component of the Burke's pentad, that needed to be considered in the socio-cultural study during the affordance analysis.

6.4 Further research

Since the data collection for this research in May–June 2017, Google applications have moved on considerably. Some constraints identified in this study might no longer exist and affordances may be different, as the applications have been upgraded. For example, Google Slides introduced a Q&A feature such that the presentation can interact with the audience. Students can ask a question during the class, and their question will be displayed on the presentation, which implies that more interactive elements might emerge in the educational affordance. Google introduced a new component Google Meet in 2017 to replace Google Hangouts for the latter to retire in 2019. Google Meet aims to allow more users (100 members for the basic version of the Google suite) in video conferencing. Google Meet allows a change in video quality to preserve the network bandwidth such that interactive classes can use less bandwidth, which implies that social affordance might be extended to larger groups and the constraint from the bandwidth limitation on the student side can be reduced. Google Suite (a new name for Google applications) allows an offline mode of operation. Users can download Google Docs, Google Sheets, Google Drive, and Google Slides for later use when there is no WiFi available, which implies that the technological constraint of 'WiFi dependency' might no longer exist.

The use of technology in Hong Kong is now focused on online teaching and learning in response to the coronavirus pandemic and requires teachers and students to access the learning materials from home. The negative affordance for online teaching and learning might outweigh the constraints identified in this study. For example, the 'Lack of body language when typing' constraint, which is associated with face-to-face classroom teaching, might no longer be significant.

In the traditional teacher-centred teaching, the teacher is the main actor within the pedagogic assemblage. Remote teaching and learning empowers students to take more control over the direction, pace, and sequence of their learning. The power of a teacher might attenuate when the teacher's role is changed from that of a sole voice of authority controlling the transmission of knowledge to that of a facilitator of the emerging knowledge. Is there any implication for students of different ages and educational levels when teachers want to maintain the power relations in the classroom? The findings of this research cannot answer this question. This question needs further research that attends to the teacher-students communication and communication among students when cloud computing becomes the major technology mediating the learning and social interactions.

The expansion of technological capacity and the exposed need of remote teaching and learning have significant impacts on the educational, social and technological affordances. These need further research to reflect our belief in order to generate action in response to a new problematic situation (Section 4.2).

This research studied affordances from the teachers' perceptions. However, successful teaching and learning also depends on other factors such as the speed of the broadband network at the students' home when an online class is accessed at home and the self-motivation of the students for learning, as discussed in the findings. We need further research to study affordances from the perception of other education stakeholders such as the students, for the whole picture of whether technology supports teaching and learning.

The theoretical framework created in this research provides a model that integrates the socio-cultural study on pedagogic assemblage into an affordances analysis and can be a foundation for further research.

6.5 Personal reflections

From this research, my understanding of affordance has changed. Affordance is not only what the technology offers, as Gibson (1979) discussed. Affordance is not only the perceived properties of the technology, as Norman (1988) discussed. Instead, affordance should be understood in the socio-cultural context of the classroom. The socio-cultural theory helps us to explain the classroom phenomena for the reason why teachers do or do not perceive affordance in different socio-cultural contexts during the affordance analysis.

Education is a complex environment in which teachers and students have their beliefs regarding the methods of teaching and the learning needs. As I am an information technology consultant, this research provides me an insight into the diversity of the classroom and teaching practices that influence the usefulness of an educational technology. This insight facilitates me in the communication with teachers and allows me to view usefulness from the teachers' perspective, and in the communication with my IT colleagues as the educational environment might be much more complex than we thought.

The findings of this research confirmed that the affordances of a technology are related to the extent to which it facilitates the pedagogic assemblage in teaching and learning. For example, the online teaching in response to the pandemic reveals that the pedagogic assemblage now includes students working from home rather than sitting next to each other in the classroom. Teachers might want to maintain power relations in the classroom while these work in a different way. The software needs to be designed taking into consideration the socio-cultural context, say online learning at home and collaboration for different age groups and educational levels. In the meantime, we cannot separate the role of teacher from that of technology because they are both equally important for

successful teaching.

This research benefits me in my learning journey in terms of my understanding of the research methodologies and the valuable user experience of how teachers use technology in teaching and how they evaluate it, through their participation in the interviews.

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Appendix 1 - Components in Google applications

The following tables describe the components in Google applications referring Google's product web sites. These components are referred to as "Technology" in the theoretical framework in Section 2.7.

Purpose of component	Name of component	What capabilities does this component offer?
Collaboration	Google Docs	Allow creating and editing text documents through the web browser. Multiple people can work on the same document at the same time.
	Google Sheets	Allow creating and editing spreadsheets through the web browser, and handle simple task lists, data analysis with charts, filters and pivot tables.
	Google Forms	Allow creating custom forms for surveys and questionnaires through the web browser. Gather data from a spreadsheet and analyse them in Google Sheets.
	Google Slides	Allow creating and editing presentations in the web browser – no software required. Multiple people can work on the same presentation at the same time such that everyone always has the latest version.
	Google Sites	Allow launching an Intranet for an organisation, a project site or a portal for a team or a group with a site builder tool, without writing any line of code.
Storage	Google Drive	Allow keeping all works in one place with online file storage. Allow Accessing the work when it is needed, from a laptop, tablet or phone.

Table 8 – Capabilities of Google applications for licensed users

Source: https://www.Google.com/work/apps/business/products/

Purpose of component	Name of component	What capabilities does this component offer?
Collaboration	Google Docs	Allow creating and editing text documents through the web browser. Multiple people can work on the same document at the same time.
Communication	Gmail	Allow sending, receiving and storing emails. Gmail is compatible with other email client software, for example Microsoft Outlook.
	Google Calendar	Allow planning with shareable calendars that integrate with Gmail, Google Drive, Google Sites and Hangouts such that the users always know the next schedule.
	Hangouts	A social network with video-conferencing feature that connect people who are distant apart via voice, text and webcam for sharing and collaboration with group members.

Table 8 – Capabilities of Google applications for licensed users (cont'd)

Source: https://www.Google.com/work/apps/business/products/

Name of component	What capabilities does this component offer?
Google Maps	A web-based service that provides detailed information about geographical regions and sites around the world. Besides conventional road maps, Google Maps offers aerial and satellite views of many places.
Google Earth	A geo browser that accesses satellite and aerial imagery, ocean bathymetry, and other geographic data over the Internet to represent the Earth as a three-dimensional globe. Geo browsers are alternatively known as virtual globes or Earth browsers. Google also refers to Google Earth as a "geographic browser".
Google Arts & Culture	An online platform through which the public can access high-resolution images of artworks housed in the initiative's partner museums. The platform enables users to tour virtually partner museums' galleries, explore physical and contextual information about artworks, and compile their own virtual collection.
Google Keep	A note-taking service developed by Google, available on the web, and has mobile apps for the Android and iOS mobile operating systems. Google Keep offers a variety of tools for taking notes, including text, lists, images, audio and set reminders.
YouTube	A popular video sharing website where registered users can upload and share videos with anyone able to access the site. These videos can also be embedded and shared on other sites.

Table 9 – Capabilities of Google applications for public users

Sources: http://whatis.techtarget.com/definition/Google-Maps
https://serc.carleton.edu/sp/library/Google_earth/what.html
https://en.wikipedia.org/wiki/Google_Arts_%26_Culture
https://en.wikipedia.org/wiki/Google_Keep
https://www.techopedia.com/definition/5219/youtube

What capabilities Google Classroom offer?
Classroom is a new tool that helps teachers create and organise assignments quickly, provide feedback efficiently, and easily communicate with their classes. Classroom helps students organise their work in Google Drive and communicate directly with their teachers and peers.
Create and collect assignments: Classroom weaves together Google Docs, Drive and Gmail to help teachers create and collect assignments paperlessly. They can quickly see who has or hasn't completed the work, and provide direct, real-time feedback to individual students.
Improve class communications: teachers can make announcements, ask questions and comment with students in real time – improving communication inside and outside of class.
Stay organised: Classroom automatically creates Drive folders for each assignment and for each student. Students can see what's due on their Assignments page.

Table 10 – Capabilities of Google Classroom

Source:https://chrome.Google.com/webstore/detail/Google-classroom/mfhehppjhmmnlfbbopchdfldgimhfhfk?hl=zh-TW

Appendix 2 – Interview schedule

The following interview schedule is designed to guide through the 30-min interview. The interview schedule links to research questions as follows:

	Questions in the interview schedule	**Answer which research question?**
1	Which educational levels do you teach? 你任教哪些班級?	Question 2
2	Which subjects do you teach in which you can use Google applications? 你教哪些科目可以使用 Google 應用程式?	Question 2
3	How long have you used Google applications? 你使用了 Google 應用程式多久	Question 1 Question 3
4	Your years of teaching 你的授課的年期 • 4 or below • 5 - 9 • 10 - 14 • 15 or above	Question 1
5	What are your: • Frequently used Google applications? • Sometimes used Google applications? • Not used Google applications? 甚麼是你: • 經常使用的 Google 應用程式? • 非經常用的 Google 應用程式? • 不使用的 Google 應用程式? Have you used Google Classroom? (Yes/No) 你曾否使用 Google Classroom? (是/否)	Question 1 Question 3
6	How much training is received before you could use Google applications efficiently? 你可以有效地使用 Google 應用程序之前需要多少培訓?	Question 3

	Questions in the interview schedule	Answer which research question?
	For example: • I had no training • I had some training • I had a lot of training	
7	What classroom activities you have found Google applications useful, or believed useful, for them? What activities do you suggest using Google applications? 你發現、或相信 Google 應用程式對哪些課堂活動是有用的? 有甚麼課堂你建議可以使用 Google 應用程式? For example: • Conference, including student lead conference • Brainstorming idea • Collaborative writing, image editing, or authoring Games • polling, survey, or questionnaire	Question 1
8	Do you agree that students can work cooperatively and learn from each other by using Google applications? 你是否同意學生可以通過使用 Google 應用程式協同工作並相互學習? ○ Strongly disagree ○ Disagree ○ Agree ○ Strongly agree	Question 3
9	Please describe the reasons you think Google applications effective or not effective for students working cooperatively and learning from each other 請描述你同意學生可以通過使用 Google 應用程式有效地協同工作並相互學習的原因	Question 1
10	Do you agree that students have increased their motivation in learning by using Google applications? 你是否同意學生通過使用 Google 應用程式增加了學習動機?	Question 3

	Questions in the interview schedule	Answer which research question?
	○ Strongly disagree ○ Disagree ○ Agree ○ Strongly agree	
11	Please describe the reasons you think Google applications can or cannot increase the motivation of students in learning 請描述你認為 Google 應用程式可以或不可以增加學生學習動機的原因?	Question 1
12	What do you think the usage difference of Google applications for different school subjects? 你對使用 Google 應用程式於不同科目教學有什麼觀點?	Question 2
13	What do you think the usage difference of Google applications for different educational levels? 你對使用 Google 應用程式於不同班級教學有什麼觀點?	Question 2
14	How do you use Google applications for the preparation and the presentation of course materials? 你如何使用 Google 應用程式準備及展示教材?	Question 1
15	How do you use Google applications for the assessment of students' learning? 你如何使用 Google 應用程式來評估學生的學習? For example: • Student project • Written assignment or essay • Quiz • Final examination • Self-assessment • Reflection	Question 1
16	Which problems have you experienced in using Google applications for the assessment of student learning? 哪些是你使用 Google 應用程式評估學生學習所遇到的問題? For example:	Question 1

	Questions in the interview schedule	Answer which research question?
	• Lack of functionality • Inability in some types of assessment question • Inability in the analysis of assessment result • Difficulty in use, or it takes many steps to accomplish an assessment • Malfunction, i.e. do not work as told	
17	How is Google applications used for social communication by students? e.g. for talking, chat, videoconference 如何利用 Google 應用程式於學生的社交溝通? 例如談話,聊天,視像會議	Question 1
18	What issues are the serious barrier to the use of Google applications for student communication? 什麼問題是嚴重阻礙你使用 Google 應用程式讓進行學生溝通? For example: • Lack of the use of body language that carries meaning • Students talk about unimportant things • Students are in fact learning in isolation • Loss of humanity because of the lack of interpersonal contact • Indulge in the virtual world	Question 1
19	What do you think the advantages of using Google applications for teaching? 你覺得使用 Google 應用程式教學的優點是什麼?	Question 1
20	What do you think the disadvantages of using Google applications for teaching? 你覺得使用 Google 應用程式教學的缺點是什麼?	Question 1
21	What are your commendable design and functions in Google applications? 哪些是 Google 應用程式中你讚賞的設計或功能?	Question 1
22	What are your criticised design and functions in Google applications?	Question 1

	Questions in the interview schedule	Answer which research question?
	在 Google 應用程式中有哪些你批評的設計或功能?	
23	How do you rate the ease of use for Google applications? 你如何評價 Google 應用程式的容易使用程度? ◯ Not easy to use ◯ Quite easy to use ◯ Easy to use ◯ Very easy to use	Question 3
24	Please describe examples of your recent difficulty in using Google applications. How do you get help? 請描述你最近在使用 Google 應用程式時遇到的困難 For example: • Need to take many steps in Google applications to accomplish a teaching task, leading to inconvenience in work or lowering productivity 降低工作效率 • Navigation icons are misleading 誤導的圖示 • It is easy in making mistakes 容易錯誤 • It is difficult to recover after making a mistake 錯誤後不容易恢復	Question 2
25	How do you rate the usefulness of using Google applications in supporting your teaching? 你如何評價使用 Google 應用程式支援你教學的可用性? ◯ Not useful ◯ Quite useful ◯ Useful ◯ Very useful	Question 3

Table 11 – The linkage between interview schedule and research questions

Appendix 3 – Statistics from interview

Appendix 3.1 – The use frequently of Google applications

From the interview question "Now often do teachers use Google applications?" the number of teachers who use Google applications against their frequency of use are tabulated as follows:

Number of teachers	Not used	Used sometimes	Used frequently
Google Classroom	7	5	3
Gmail	5	1	9
Google Drive	2	2	11
Google Calendar	9	1	5
Google Slides	6	2	7
Google Forms	7	2	6
Google Sheets	7	3	5
Google Docs	5	1	9
Google Sites	12	3	0
Google Hangouts	15	0	0

Table 12 – Number of teachers in different frequency of use

Appendix 3.2 – Count of coded affordance

The following table tabulates the number of responses from interviewees to each coded affordance in the coding scheme Chapter 5 (Figure 12):

First-level category	Second-level category	Coded affordance	Number of responses
Educational affordance	Supporting different pedagogical approach	Classroom activities	4
		Enabling assessment	2
	Mediation	Storage resource	8
		Interesting to use	7
		Enhancement of learning	4
	Teacher control and power relations	Cooperative learning	6
		Monitoring learning progress	2
Social affordance	Enabling teacher-students interactions	Teacher to students communication	2
		Students to teacher communication	2
	Enabling communication among students	Enabling social space	4
		Aesthetic affordance	1
Technological affordance	Classroom administration	Resource sharing	6
		Addressing learning difference issue	2
		Automatic grading	2
	Ubiquitous usage	Compatibility across platforms	7
		Access anywhere, anytime	6
	Innovative use	Use in integration with other tools	5

Table 13 – Number of responses to coded affordance

Appendix 3.3 – Count of coded constraint

The following table tabulates the number of responses from interviewees to each coded constraint in the coding scheme in Chapter 5 (Figure 13):

First-level category	Second-level category	Coded constraint	Number of responses
Educational constraint	Not supporting pedagogy	Not applicable to taught subject	7
		Uncontrolled student behaviour	2
	Demotivation in learning	Not interesting to use	5
		Demotivating writing	2
Social constraint	Ineffective communication	Lack of body language while typing	1
Technological constraint	System constraint	WiFi dependency	4
		Incompatibility across platforms	4
		Require training before use	3
		Inspection problem	2
		Lack of functionality	2
	Safety and security concerns	Lack of security	3
		Plagiarism problem	2
		Loss of data	2

Table 14 – Number of responses to coded constraint

Appendix 3.4 – Ratings for cooperative learning affordance

From the interview question "Do you agree that students can work cooperatively and learn from each other by using Google applications?" the teachers' responses are tabulated as follows:

	Strongly disagree	Disagree	Agree	Strongly agree
Teacher C1			✓	
Teacher C2			✓	
Teacher C3			✓	
Teacher C4			✓	
Teacher C5		✓		
Teacher C6			✓	
Teacher C7		✓		
Teacher C8			✓	
Teacher C9				✓
Teacher C10				✓
Teacher C11			✓	
Teacher C12			✓	
Teacher C13			✓	
Teacher C14		✓		
Teacher C15		✓		
Number of teachers:	0 (0%)	4 (27%)	9 (60%)	2 (13%)

Table 15 – Teachers' ratings for cooperative learning affordance

Appendix 3.5 – Ratings for motivation in learning affordance

From the interview question "Do you agree that students have increased their motivation in learning by using Google applications?" the teachers' response from are tabulated as follows:

	Strongly disagree	Disagree	Agree	Strongly agree
Teacher C1			✓	
Teacher C2			✓	
Teacher C3		✓		
Teacher C4		✓		
Teacher C5			✓	
Teacher C6			✓	
Teacher C7	✓			
Teacher C8			✓	
Teacher C9			✓	
Teacher C10			✓	
Teacher C11			✓	
Teacher C12			✓	
Teacher C13			✓	
Teacher C14		✓		
Teacher C15	✓			
Number of teachers:	2 (13%)	3 (20%)	10 (67%)	0 (0%)

Table 16 – Teachers' ratings for motivation in learning affordance

Appendix 3.6 – Ratings for the ease of use

From the interview question "How do you rate the ease of use for Google applications?" the teachers' responses are tabulated as follows:

	Not easy to use	Quite easy to use	Easy to use	Very easy to use
Teacher C1			✓	
Teacher C2			✓	
Teacher C3		✓		
Teacher C4			✓	
Teacher C5			✓	
Teacher C6			✓	
Teacher C7			✓	
Teacher C8		✓		
Teacher C9			✓	
Teacher C10				✓
Teacher C11				✓
Teacher C12			✓	
Teacher C13			✓	
Teacher C14	✓			
Teacher C15		✓		
Number of teachers:	1 (7%)	3 (20%)	9 (60%)	2 (13%)

Table 17 – Teachers' ratings for the ease of use

Appendix 3.7 – Ratings for the usefulness in supporting teaching

From the interview question "How do you rate the usefulness of using Google applications in supporting your teaching?" the teachers' responses are tabulated as follows:

	Not useful	Quite useful	Useful	Very useful
Teacher C1			✓	
Teacher C2			✓	
Teacher C3		✓		
Teacher C4			✓	
Teacher C5			✓	
Teacher C6			✓	
Teacher C7		✓		
Teacher C8			✓	
Teacher C9				✓
Teacher C10				✓
Teacher C11				✓
Teacher C12		✓		
Teacher C13			✓	
Teacher C14		✓		
Teacher C15	✓			
Number of teachers:	1 (7%)	4 (27%)	7 (46%)	3 (20%)

Table 18 – Teachers' ratings for the usefulness in supporting teaching

Appendix 4 – GSoE Research ethics form

GSoE RESEARCH ETHICS FORM

Name(s): Chi Wing, NG
Proposed research project: Teaching with Cloud Computing in Schools: an affordance analysis of Hong Kong teacher perceptions
Proposed funder(s): Self
Discussant for the ethics meeting: Dr Neil Ingram
Name of supervisor: Dr Neil Ingram
Has your supervisor seen this submitted draft of your ethics application? Y/~~N~~

Please include an outline of the project or append a short (1 page) summary:

This research studied perceived affordances of cloud computing in qualitative and quantitative inquiry with fifteen primary and secondary school teachers who use Google applications, a suite of cloud computing tools for the educational purpose, in their teaching. During the interview, teachers are invited to give their opinion in whether affordances and constraints differ between school subjects and between educational levels, and how do they appraise the usability of Google applications in teaching.

Ethical issues discussed and decisions taken (see the list of prompts overleaf):

1. Researcher access/ exit:
   - Teachers interviewed are contacted through the school's information technology officers, or coordinator, who arrange the access of school and arrange the meeting place for an interview.
   - Letter of Introduction from my supervisor is sent to the school's information technology officer, or coordinator in advance stating that the inquiry is for academic purpose only and I had no connection with any software producer and will not use the data for commercial advantage.

2. Information given to participants:
   - Before starting the interview questions, teachers are informed that the purpose of inquiry is for my academic research and my dissertation only.
   - Teachers are informed that the interviews are audio-recorded for the recap during data analysis, and the audio-recorded will be erased after the research.

3. Participants right of withdrawal:
   - The participation of teachers in the interview and answering of questions are voluntary and

participants are informed of their right to withdraw anytime.

4. Informed consent:
   - Teachers are fully informed before their consent to participating in the interview.

5. Complaints procedure:
   - Supervisor's email contact is included in the Letter of Introduction from supervisor, for the case the interviewee wishes to pass on a comment on the research.

6. Safety and well-being of participants/ researchers:
   - Interviewees are invited to give their opinions in a free, easy and relaxed atmosphere

7. Anonymity/ confidentiality:
   - Data collected are held in confidential. The identity of schools and teachers will be anonymised in the dissertation and any subsequent publication.

8. Data collection:
   - Feedback to the interviewees about our understanding to make sure that the interviewee's point of view is received and understood.

9. Data analysis:
   - Data collected are tabulated with double checking.

10. Data storage:
    - Audio-recorded is stored in my laptop and notebook computers with password login and will be deleted after this research.

11. Data Protection Act:
    - The school contacts will not be used for a purpose other than this research.

12. Feedback /14. Reporting of research
    - Participant teachers will be informed that the result of research is beneficial to them, on leaving their email contact.

13. Responsibilities to colleagues/ academic community

If you feel you need to discuss any issue further, or to highlight difficulties, please contact the GSoE's ethics co-ordinators who will suggest possible ways forward.

Signed: Ng Chi Wing (Researcher)

Signed: Neil Ingram (Discussant)

Date: 05/05/2017

Appendix 5 - Letter of Introduction

The following letter of introduction was sent to teachers and the IT Head/Officer before interview:

Dr. Neil R. Ingram
Senior Lecturer Science Education
Graduate School of Education
University of Bristol
35 Berkeley Square
Bristol
BS8 1JA
UK
Tel: +44 117 331 4445
E-mail: neil.ingram@bristol.ac.uk

09/05/2017

Dear Sir or Madam

Letter of introduction for Mr Lawrence Ng [吳 梓 榮]

I write to you as the supervisor of Mr Ng for his EdD degree. Mr Ng is researching into the use of Google application software in schools. He is especially interested in schools in Hong Kong. Mr Ng is inquiring whether you would allow him to interview some teachers in your schools.

I write in support of this research, which is for academic purposes only. Mr Ng has no links with any software producer and will not use his data for commercial advantage. The identity of all schools and teachers will be anonymised in the dissertation and any subsequent publications. Mr Ng is willing to share his research protocols with you in advance of any interviews.

I do hope you will feel able to support Mr Ng's research. He is willing to share his general findings with you, which might be valuable in informing your future ICT planning.

Yours faithfully

Dr. Neil Ingram