Chapter 6

Methods for investigating the factors affecting teachers' use of ICT after an ICT innovation (Phase 2)

The initial phase of the study revealed a number of factors which impacted on how teachers use ICT for teaching and learning. The introduction at the case study school of the *Digital School Project* promoting the use of technology for instruction, explained in Section 6.1, allowed the study to move into a second phase. Three factors which had emerged during the first phase could thus be investigated further, and with a larger sample of teachers. The first factor is the **impact of in-service training** provided by the school for the implementation of the project. The second factor is the **impact of the time made available for using technology** for teaching and learning, especially the introduction of days devoted to the use of technology for instruction. The introduction of the project also provided an opportunity for investigating **teachers' levels of innovativeness** based on how they used technology. The relevant research questions and sub-questions which directed this phase of the study are repeated here.

Research question 2: To what extent and in what ways did teachers' use of technology change after the introduction of the *Digital School Project*?

Research question 3: What general factors influenced teachers' use of technology after the innovation?

3.1 To what extent, and in what ways, did the amount and nature of the ICT training provided affect teachers' use of technology, according to the teachers?

3.2 To what extent, and in what ways, did the amount of time provided for using technology for instruction affect teachers' use of technology?

3.3 To what extent, and in what ways, did their level of innovativeness affect teachers' use of technology?

This chapter provides background information about the *DigiSchool Project* and discusses the methods used to gather and analyse data on teachers' use of ICT for instruction, during the second phase of the study.

6.1 Background information about the innovation

It is imperative for readers to have some idea of the events surrounding the adoption of the innovation, to better understand the context of the second phase of the study. The school's Executive Committee, comprised of the CEO and the headmasters and deputy heads of the preparatory school and college, had, for a number of years, been promoting the use of ICT, especially for instruction. Some of their major initiatives are shown in Figure 66, on the next page.

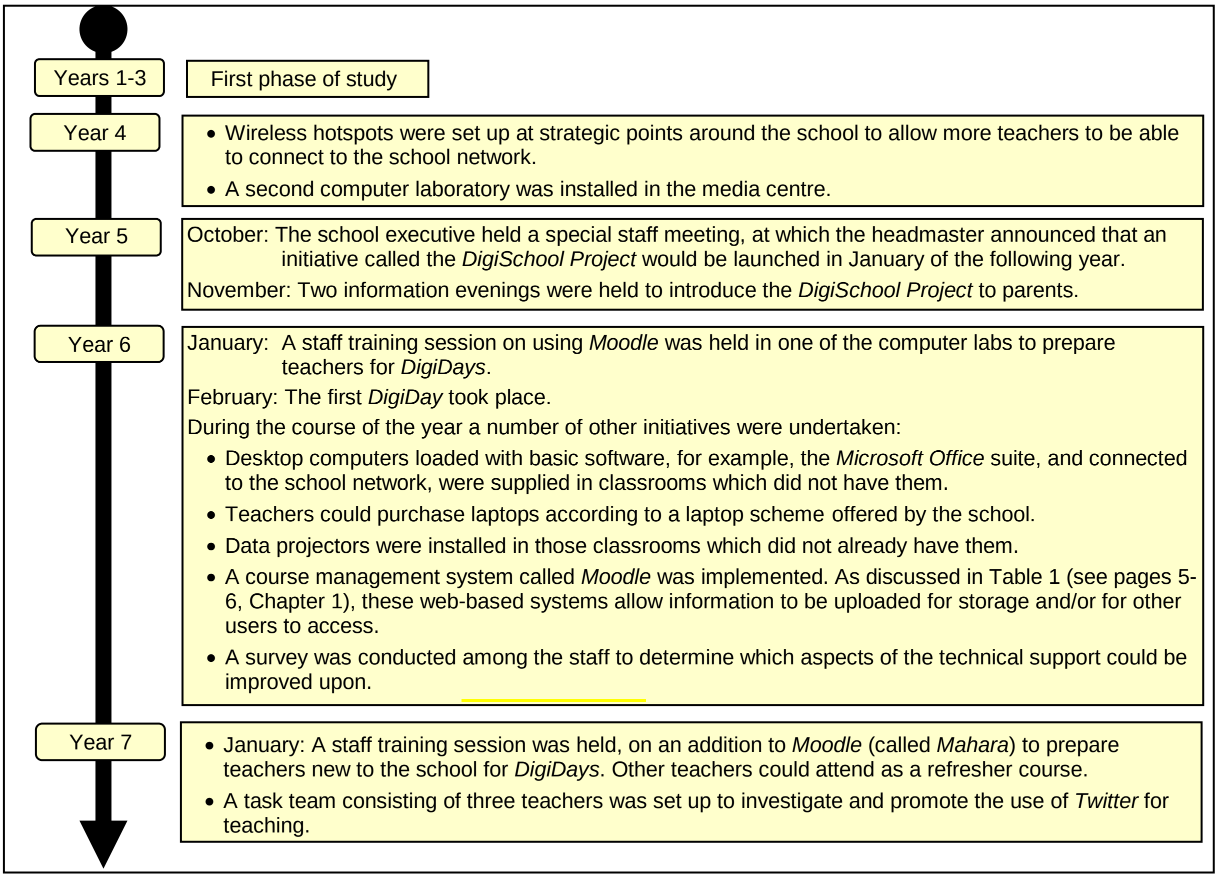

Figure 66. Timeline showing events at the school relevant to the introduction of the innovation, at the beginning of the second phase of the study

During the early part of this study, the committee's efforts to promote the use of technology focused on increasing connectivity and providing ICT hardware. In the sixth year of the study, the Executive Committee introduced a multifaceted initiative called the *DigiSchool Project* (see Figure 66). One of the facets of this initiative was to provide hardware for teachers who still did not have a computer or laptop and/or data projector in their classrooms. Another facet involved encouraging learners to use their own laptops during lessons, for taking notes. Part of the project involved the provision of the web-based learning platform, *Moodle.* As discussed in Table 1 (see Chapter 1, pages 6-7) learning management systems such as *Moodle* provide a platform for the dissemination of work and resources via the Internet.

In an effort to promote the use of ICT in general, and the use of *Moodle* specifically, digital technology days, or '*DigiDays*', dedicated to the use of ICT for instruction were introduced. On *DigiDays* teachers and learners are required to use *Moodle* for the uploading and downloading of digital tasks. *Information Box 5* (on the next page) is an extract from an article, written for a local magazine by the headmaster, outlining the rationale behind the *DigiSchool Project* and *DigiDays*, while *Information Box 6* provides relevant information about what happens on *DigiDays*, based on interviews with several teachers.

Information Box 5: Extract from an article written for a local magazine by the headmaster about the *DigiSchool Project* and *DigiDays*

The rationale has been to:

- *educate meaningfully, employing current technology*
- *use technology appropriately in teaching*
- *continue Making School Cool, by making it attractive to pupils*
- *entice learning by using what is immediate to young people*
- *compete with pupils' home and play environments.*

Teachers have been encouraged to augment the lessons by introducing visual stimuli (à la YouTube) and incorporating technological content as much as possible. Pupils can now choose to bring laptop computers, notebooks or netbooks to class. These are used in the normal course of events: to take notes, do exercises, present work and maintain notes in a logical order.

More importantly, a system has been developed to establish direct contact between pupils and teachers, using Moodle software. Work, queries and marked exercises now flow digitally. A monthly DigiDay focuses attention on working via computer. Emulating the principle that our school leavers are entering some professions in which product is more important than presence, DigiDays are reserved for electronic work only. Work assigned for DigiDay may be done anywhere – not even necessarily at school. So, pupils may work at home and submit the assignments via Moodle to their teachers by the end of each DigiDay.

Information Box 6: Information about what happens on *DigiDays*, based on interviews with teachers

- *Formal classroom lessons are suspended on DigiDays. Instead learners have to complete digital tasks set by teachers and uploaded to Moodle. Each DigiDay focuses on three subjects according to a roster drawn up at the beginning of each term.*
- *Learners access the digital tasks on computer. Learners who have access to the Internet at home do not have to attend school and are allowed to complete the tasks at home. Those who are not able to work at home, usually because they lack the necessary equipment, use the school computers in the computer laboratory during supervised sessions held between 7:30 am and 2:30 pm on DigiDays. Some learners may only have one or two tasks to complete on a particular DigiDay, depending on their individual combination of subjects.*
- *Teachers are not required to be at school on DigiDays, unless they have volunteered to supervise one or more sessions in the computer laboratories.*
- *With regard to the DigiDays tasks, teachers are required to set tasks which would take learners the equivalent of one lesson to complete, that is, about 45 minutes. The tasks must be loaded on to Moodle by midnight on the Thursday prior to a DigiDay. Teachers are required to notify learners, via email, when the tasks have been loaded, and the date and cut-off time by which learners have to submit the tasks, by uploading them to Moodle.*

The introduction of the innovation allowed further investigation of two external factors (factors independent of teachers' beliefs, attitudes, and/ or behaviours) which had emerged from the literature, and from the first phase of the study, as impacting on teachers' use of technology for instruction. The first of the external factors addressed by the innovation relates to the time set aside for the use of ICT for instruction, on *DigiDays*. The second factor relates to the in-service training provided for teachers on how to use *Moodle*, in preparation for *DigiDays*. The manner in which each of these factors is addressed by the innovation is discussed below:

- ***DigiDays*, and the 'time' issue:** The review of 48 papers (see Chapter 2) revealed 'time to prepare lessons using technology' and 'time to use technology during lessons' as important factors affecting teachers' decisions to use technology for teaching. The same two factors emerged when interviewing teachers during the first phase of the study. Firstly, four of the five teachers participating in the first phase indicated that preparing lessons using technology is time-consuming. Secondly, the issue of the amount of lesson time lost when using technology underpinned many of the concerns expressed by teachers. Teacher 1 wanted assistance from the computer teacher with setting up the computer lab in preparation for lessons, both to minimise the time she would have to spend preparing the computer lab and also the amount of time lost during lessons from having to set up technical devices. Teacher 2 was discouraged from using computers by the amount of lesson time it took having to take a class to the computer lab. She made the following comments in this regard:

  > *… and I find it a waste of my time and then we come back to class and we've wasted 10 minutes.*
  >
  > *… I'd rather, then, be in class – I don't have 10 minutes to lose in class time.* (Teacher 2)

  The introduction of the innovation promoting technology use at the school raises the question of how the amount of time devoted to using technology impacts on teachers' technology usage and how teachers make use of the time.

- **Training on how to use *Moodle* for *DigiDays***: During the first phase of the study, in-service training was identified, both in the literature review and when interviewing teachers, as an important factor affecting teachers use of computers for teaching. The provision of in-service training aimed at equipping teachers to better use technology for instruction impacts on teachers' level of ICT competence and on their level of confidence when using technology for teaching. During the first phase of the study one of the teachers (Teacher 1) had indicated a need for training so that she could be properly equipped to prepare lessons using technology "*in the shortest possible time frame*". In preparation for the introduction of *DigiDays*, the school provided training for teachers in the use of the new *Moodle* software, which is integral to the functioning of *DigiDays*. Thus, the in-service training provided by the school on how to use *Moodle* would impact not only on how teachers used it on *DigiDays*, but also how they used it outside of *DigiDays*.

  The following in-service training was provided by the school:

  - Prior to using *Moodle* on the first *DigiDay*, teachers attended a 90-minute training session on how to use *Moodle*. The training session took place after school, on a Friday afternoon, in January of Year 6 of my study. It was run by the IT teacher (Teacher 31) and Technical person 4 in one of the computer laboratories. Technical person 4 was using the introduction and use of *Moodle* at the school as the basis for his IT Honours research project. According to the teachers I interviewed, teachers were seated in pairs at the computers, and were then taken through the process of logging on to *Moodle* using their school network passwords, and creating personalised profiles, including uploading a profile picture. Teachers were also shown how to use some of the features on *Moodle*, for example, how to create a course to which they could upload documents, and then how to upload documents. Printed handouts on how to use *Moodle* were provided for future reference. Tutorials were also put up on *Moodle* for teachers to use if they needed further assistance.

- At the beginning of Year 7, another *Moodle* training session was held to introduce the software to newer teachers. Teachers who had previously received training on how to use *Moodle* were invited to attend the session as a 'refresher course'. This training session included training on another web application, called *Mahara*[16], which can be used in conjunction with *Moodle*.
- A task team of three teachers was formed in Year 7, at the request of the headmaster, to explore the use of *Twitter* in the classroom. The idea behind this was that the task team, once they had attempted to use *Twitter* in their classrooms, would report back to other teachers on how to do so and how effective they had found it for teaching and learning purposes.
- Other training provided by the school to improve teachers' ICT knowledge was that teachers' were provided with information on how to use *PowerPoint*[17].

The introduction of the innovation thus allowed an investigation of how teachers responded to the time set aside for using technology for instruction on *DigiDays*, and whether teachers had received in-service training that adequately equipped them to use computers for teaching and learning. The introduction of the broader innovation, that is, the entire *DigiSchool Project*, allowed a third factor which had emerged in the literature review and during the first phase of the study as an important internal factor (one which arises from within teachers) impacting on teachers' use of computers. As previously discussed in this thesis, individuals differ in their rate of uptake of innovations, which Rogers (1964) associates with their innovativeness. The introduction of the *DigiSchool Project* allowed an investigation of how teachers' levels of innovativeness affected their use of ICT for instruction.

6.2 DATA COLLECTION METHODS

Two methods were used to collect data on the factors affecting teacher's use of ICT after the ICT innovation was introduced at the school – a series of four questionnaires and interviews with 29 teachers.

6.2.1 Questionnaires

Fraenkel et al. (2012) point out that questionnaires are useful techniques to collect data about important events, behaviours and attitudes in an educational institution. Questionnaires are often compared to interviews in research methodology books to highlight the relative advantages and disadvantages of each method. Fraenkel et al. (2012, p. 399) regard the two methods as "*virtually identical, except that the questionnaire is usually self-administered by the respondent, while the interview schedule is administered verbally by the researcher*". The question of who is administering the data collection method gives rise to a significant difference between questionnaires and interviews: the respondent is typically in control when completing a questionnaire because they can decide when and in what order they answer the questions, whereas the interviewer is in control during an interview

[16] *Mahara* is a web application that can be used to create an electronic portfolio which can be shared online, e.g. via social networking sites ("Mahara: Open source eportfolios," n.d.).

[17] One teacher described this as "*a virtual training session*", because a *PowerPoint* presentation, detailing how to use *PowerPoint* effectively, was loaded on to *Moodle* for teachers to access.

(Gall et al., 1996). Table 31 summarises the main advantages of questionnaires over interviews. The advantages questionnaires offer over interviews influenced my decision to use questionnaires to gather preliminary data on how teachers at the case study school were using computers and to explore teachers' attitudes towards using computers, before interviewing teachers to gather more detailed explanations.

Table 31. Advantages of questionnaires over interviews

Questionnaires	Interviews
Absence of the researcher minimises the influence of the researcher on the respondent.	It is difficult to standardise the interview situation to minimise the influence of the researcher on the respondent (McMillan & Schumacher, 2010)
Can be conducted over a distance without researcher being present (Leedy, 1993).	The researcher must be present during the interview.
May require less time to administer (Gall et al., 1996).	Interviews take longer to conduct to gather the same amount of data from the same sample (Cohen et al., 2000; Creswell, 2012; McMillan & Schumacher, 2010).

Developing the questionnaires

Four questionnaires were used during Phase 2 of the study to collect different types of data about teachers in the sample and their use of technology for teaching (see Table 32, on the next page). Leedy (1993) emphasises the importance of researchers having a clear purpose for their questionnaires. Table 32 gives the purpose of each of the four questionnaires used in this study, based on type of data needed at a particular stage of the study.

I decided to use online questionnaires rather than paper-based ones. Christensen and Knezek (2008, p. 350) claim that "*online data acquisition systems have created a revolution in the amount of data that can be gathered from technology in education projects*". These authors point out that online questionnaires allow large quantities of data to be collected in a short time. Other advantages of online questionnaires mentioned by Fraenkel et al. (2012, p. 399) are that they allow "*greater convenience, lower costs, faster turnaround, multimedia interface, [and] mobile administration (using portable devices)".* Also, in light of the broad purpose of the study (teachers' use of computers), it seemed more fitting to use online questionnaires than paper-based ones. Although there have been contentions that data collected using online methods may not be as reliable as paper-based surveys, Christensen and Knezek report on an earlier study in which they found "*no significant differences in the reliability of data gathered from students via paper versus online*" (Christensen & Knezek, 2008, p. 350). One teacher in my study who was not very comfortable using computers preferred to use paper-based questionnaires, which were made available to her. Fraenkel et al. (2012) also highlight another potential problem with using online questionnaires. These researchers point out the possibility of respondents incorrectly entering data without realising their mistakes, or not being able to correct mistakes, due to the fast response times offered by computers and other technological devices.

The development of two of the questionnaire listed in Table 32 is discussed later in more detail. The development of Questionnaire 3 is discussed in more depth in Chapter 8 (Developing a method for identifying adopter categories), as this questionnaire was used to develop a diagnostic tool to place teachers into adopter categories. The development of Questionnaire 4 (Teachers' computer use before and after the innovation) will be discussed in more depth in Section 6.3 on page 221, since the data from this questionnaire was analysed to investigate the impact of the innovation on teachers' use of technology.

Table 32. Summary of the questionnaires used in Phase 2 of this study

Name of questionnaire	Purpose	Types of questions used
Questionnaire 1: Background information (see Appendix AP)	Short questionnaire to gather biographical and other background information about the teachers participating in the study. Also included some exploratory questions about teachers' feelings towards using computers and their computer use, before the innovation.	• open-ended • dichotomous • multiple-choice with single and multiple responses
Questionnaire 2: Teachers' computer use inside and outside of school (see Appendix AQ)	Exploratory questionnaire designed to collect data about teachers' confidence using computers; their personal computer use; their computer use for school-related tasks and exploratory questions about their interest in finding and using new software applications. Data from this questionnaire was used as a basis both to design Questionnaire 3 and to develop the interview schedule.	• open-ended • multiple-choice with single responses • checklists
Questionnaire 3: Teachers' levels of innovativeness (see Appendix AR)	To place teachers into one of five adopter categories based on their willingness to use ICT for r teaching.	multiple-choice with single response
Questionnaire 4: Teachers' computer use before and after the innovation** (see Appendix AS)	To gather information on the frequency of teachers' use of computers for different school-related purposes, e.g. for administrative purposes (e.g. recording marks) or for lesson preparation (e.g. preparing worksheets).	checklists with five frequency categories: 'never', 'a couple of times a year', 'about once a month', 'about once a week' and 'about once a day'

I used a free survey programme called eSurveysPro (www.eSurveysPro.com) to develop and administer my on-line questionnaires. Creswell (2012) points out that the use of online questionnaires is increasingly becoming popular because the use of survey programmes offers many advantages, including templates and sample questions. For example, the programme I used allows questionnaire designers to choose from a variety of question types including single-choice questions, multiple-choice questions and free-form questions. The programme also offers a choice between horizontal or vertical formats for question options, which offers some flexibility with regard to the layout of the questionnaire. I found it useful to be able to easily change the layout of the questionnaires, especially since Fraenkel et al. (2012) emphasize the importance of organising questions in a clear and uncluttered way to make it easier for respondents to read the questions. I tried to keep the questionnaires brief and the questions simple so that the questionnaires did not take up too much of respondents' time, as advocated by Leedy (1993). Another feature of the free survey programme which I found particularly useful was the option to restrict the number of options respondents can select for multiple-choice type questions. I used this feature to ensure that respondents could not erroneously choose two options when the question required them to select one. Once designed the questionnaires were face validated by a researcher with many years of experience in developing and administering questionnaires. The second researcher checked the wording and sequence of the questions, resulting in many cycles of rewording the questions and changing the sequence of the questions, until we were sure the questions were easy to understand and that the order of the questions was logical.

According to McMillan and Schumacher (2010), it is important to test questionnaires for how long they take to complete, and to check the clarity of questions before they are sent to respondents. eSurveysPro allows questionnaires to be previewed online to see what they will look like to respondents. I tested each questionnaire by answering it online to identify potential problems respondents may encounter. I also emailed the link to the questionnaire to another researcher to check for potential problems. Fraenkel et al. (2012) suggest testing the questionnaire on a small, similar group of people to the respondents who will answer the final version (pilot testing). As explained by Creswell (2012), the purpose of pilot testing an instrument is to receive feedback based on which the researcher can modify the instrument for final use. I emailed the link to two colleagues from different private secondary schools, asking them to provide feedback on whether they had any difficulty accessing the questionnaire, whether they had any difficulty understanding the questions, and how long it took them to complete the questionnaire. Both teachers reported that they accessed the questionnaire without any problems. Based on the feedback given by one of the teachers I reworded one of the questions to further clarify what the question was intended to ask. Both teachers answered the questionnaire in a much shorter time than I had anticipated, which was useful, since I intended including this information in the covering email I would send to potential respondents.

Administering the questionnaires

The questionnaires were administered in the order in which they are named in Table 32 (see previous page), over an eight month period starting in August of Year 6 of the study (see Figure 66 on page 212).

Before administering each of the four questionnaires for this phase of the study, I emailed the headmaster of the case study school requesting permission to distribute the questionnaire to the teachers. Once permission had been granted, I sent a covering email to each teacher inviting them to complete the questionnaire by clicking on the link provided. The covering email contained the following points suggested by Fraenkel et al. (2012) as being important in such correspondence: it was addressed to the individual concerned, explained the purpose of the questionnaire within the context of the larger research study, and assured the respondent of the confidentiality of the information they disclosed. Leedy (1993, p. 146) emphasizes that the initial correspondence between the researcher and respondent should be "*carefully and thoughtfully structured, and it should stress the concerns of the person receiving the letter rather than the selfish interests of the sender".* In my covering emails I therefore tried to be as courteous as possible e.g. by advising respondents approximately how long it would take to complete the questions. I also invited teachers who preferred to fill in hard copies of the questionnaires to contact me so that I could arrange for printed copies to be delivered to the school. I was able to track the response status of the questionnaires, using a eProSurvey option. I tracked the submissions for a week, after which I followed up by sending a reminder email to teachers who had not yet completed the questionnaire. Twenty-nine of the 34 teachers in the College responded to the first questionnaire, giving a response rate of 85%. These 29 teachers subsequently completed the remaining three questionnaires.

6.2.2 Interviews

As discussed in Chapter 2 (see page 78) semi-structured interviews were used in this study, to gain a deeper insight into factors affecting teachers' use of computers not readily evident from my observations and the data collected from questionnaires.

Development of the interview schedule

The interview schedule for the second phase of the study (see Appendix AT) was developed from the schedule used during the initial phase (see Appendix I), and data obtained from Questionnaire 2, which explored teachers' attitudes and beliefs regarding ICT use (see Table 32, page 217). The original interview schedule used in the first phase was adapted for use in the second phase as follows: Firstly, some questions were omitted as they were no longer relevant during the second phase of the study, e.g. the questions relating to teachers' use of the SMART board. Secondly, questions were added to the interview schedule for the second phase to explore teachers' usage of computers outside of school; their attitudes towards, and beliefs about, the use of computers for teaching; their feelings about the introduction of the ICT innovation at the school; and what impact this had had on their use of computers for teaching and learning. I specifically focused on obtaining information needed to answer the second research question relating to the impact of the introduction of the innovation on teachers' use of computers: teachers' attitudes towards the usefulness of the training provided for the implementation of *Moodle* on *DigiDays*; how teachers were spending their time on *DigiDays*; and how teachers' levels of innovativeness influence the use of computers for meaningful teaching.

Conducting the interviews

Sixteen of the 29 participating teachers were interviewed face-to-face, in their classrooms, during visits I made to the school on three *DigiDays*. The procedure for conducting the interviews was the same as that used for the interviews conducted during the first phase of the study (see Chapter 3, page 98).

I was not able to arrange interviews with 13 of the 29 teachers when I visited the school on the three *DigiDays*, because of time constraints and my own duties as teacher. I therefore arranged to interview these teachers over the telephone. I used a speakerphone and voice recorder to record the telephone interviews so that I could transcribe them at a later stage. The telephone interviews were conducted using the same interview schedule as for the face-to-face interviews (see Appendix AT). Emails were sent to individual teachers requesting dates and times when it would be most convenient for me to phone them, and their telephone numbers. At the beginning of each telephone call, I checked with the teacher being interviewed whether they agreed to the telephone call being recorded. The recordings of the telephone interviews were transcribed and their accuracy checked in the same way as the face-to-face interviews.

6.3 DEVELOPMENT AND ANALYSIS OF THE QUESTIONNAIRE ON HOW TEACHERS WERE USING COMPUTERS BEFORE AND AFTER THE INNOVATION

An online questionnaire called *Teachers' computer use before and after DigiDays* (see Appendix AS) was used to collect data on the changes in teachers' use of computers before and after the innovation was introduced. The development of this questionnaire was described in the general discussion on questionnaires on page 215. However, the development of the response categories used in the questionnaire warrants further discussion because of its methodological significance.

My questionnaire asked teachers about how frequently they used different types of computer-based tasks, before and after the innovation. This meant I had to develop a range of frequency categories from which teachers could choose. Reviewing the literature suggested that there are two important aspects relating to the response categories chosen by researchers: "*the labelling of response categories and the number of response categories offered*" (Weijters, Cabooter, & Schillewaert, 2010, p. 236). Some researchers believe that although deciding on "*the range of categories to be presented to respondents is usually left to the intuition of the researcher"*, respondents use the number of categories and the names of categories to guide them when selecting their answer (Schwarz, Hippler, Deutsch, & Strack, 1985, p. 388). I therefore considered the two aspects discussed below in more detail before deciding on the frequency categories I would use in my questionnaire.

6.3.1 The number of categories and the presence of a median category

It appears that having too few categories is as much of a problem as having too many. Schaeffer and Presser believe that "*the choice of the number of categories represents a compromise between the increasing discrimination potentially available with more categories and the limited capacity of respondents to make finer distinctions reliably and in similar ways*" (Schaeffer & Presser, 2003, p. 78). Weijters et al. (2010) report the use of five and seven categories as the most popular formats when using Likert-type rating scales. Having a larger odd number of categories (e.g. seven rather than five) increases the number of "*intermediate options",* making them "*more salient*" (Weijters et al., 2010, 238) Having a larger odd number of categories (e.g. seven rather than five) increases the number of "*intermediate options",* making them "*more salient*" (Weijters et al., 2010, 238). However, a potential problem with an odd number of categories is that, as shown by Kulas, Stachowski and Haynes (2008), respondents often choose the middle category when they are unsure of which category to use. Reviewing the literature revealed that while some educational researchers have used five categories (Sahin & Thompson, 2006; van Braak, Tondeur, & Valcke, 2004), other researchers appear to favour a four-point scale (e.g. Peeraer & van Petegem, 2012; Ward & Parr, 2010). There have been claims (e.g. Payne, 1951; Peeraer & van Petegem, 2012) that using an even number of categories *"avoids the selection of a default median frequency"* (Peeraer & van Petegem, 2012, p. 1251). Although Ward and Parr used a four point response scale in their 2010 study, one of the researchers, in a personal communication, indicated that this did not allow for sufficient differentiation:

> *… if I was doing it again I probably would not use a four point scale - there was not enough room for differentiation ... I did it to make it easy for them to fill in - and others do use four point scales ... but have my doubts now ...* (L. Ward, personal communication, 15 May, 2011)

She forwarded me a copy of a questionnaire being developed for use in later research that used a five-point response scale. Since a five-point scale seemed to allow for sufficient differentiation, this is what I used in my questionnaire.

6.3.2 Naming the categories

When developing response categories, Schaeffer and Presser suggest that *"the goal is to select names that are easy to understand and that will be understood similarly by all respondents* (Schaeffer & Presser, 2003, p. 76). Stopher (2012, p. 184) emphasises "*taking care in setting response categories"* because vague category names could contribute to unreliable data. In my questionnaire, I asked teachers about how often they used different types of computer tasks. I then had to decide whether to use absolute frequencies (e.g. twice a week) or relative frequencies as names for the response categories. Although some researchers have used relative descriptors like 'sometimes' and 'often', when naming response categories relating to how frequently an action is carried out (e.g. Ward & Parr, 2010; Peeraer & van Petegem, 2012), my decision to use absolute descriptors was influenced by the work of van Braak et al. (2004), and that of Sahin and Thompson (2006). van Braak et al. used the descriptive categories 'never', 'every term', 'monthly', 'weekly' and 'on a daily basis'. These absolute descriptors seemed less likely to be open to misinterpretation by respondents than relative descriptors. Another source of influence came from Sahin and Thompson (2006), who, although they used relative descriptions like 'rarely', also provided respondents with explanations for the category descriptions e.g. the category 'rarely' was defined as 'roughly once a semester' and 'very often' was defined as 'nearly daily'.

The questionnaire on teachers' computer use before and after the introduction of the innovation (see Appendix AS) asked teachers about how often they used each of 19 types of computer tasks. I used absolute but approximate descriptors for the response categories: 'never', 'about once a day', 'about once a week', 'about once a month', and 'about once a year'.

6.3.3 Analysis of data on how teachers were using computers, before and after the innovation

The data from my questionnaire showed some clear differences in the frequency of ICT use before and after the innovation but were these statistically significant or just a matter of chance? This data was analysed in two ways[18]. Firstly, the data was analysed **by task**, to see whether the before/ after differences in usage for the whole group of teachers for a particular task, were statistically significant. Secondly, the data was analysed **by teacher** to see whether the changes in individual teacher's total computer usage – measured in usage units – were statistically significant and therefore not due to chance.

Analysis by task

To find out whether the differences in task usage were statistically significant, I had to select a suitable statistical test. A number of researchers and authors emphasise that the choice of an appropriate test depends on the type of data being analysed (Agresti, 2013; Creswell, 2012; Jamieson, 2004; McElduff, Cortina-Borja, Chan, & Wade, 2010; Mitchell, 1997; Stevens, 1946). The argument presented by these researchers is based on mathematical theory originally expounded by Stevens (1946), and focuses on improving the validity of inferences by using a test appropriate for the type of data being analysed. Stevens (1946) identified the following data, which he had arranged hierarchically into types (starting at the lowest level) according to the statistical tests permissible for each. As one moves up the hierarchy, the range of statistical tests permissible includes those permissible at the lower levels.

- **Nominal data** is derived from named response categories which have no "*natural ordering*" e.g. 'homeschooling', 'private school' and 'public school' for the type of school attended (Agresti, 2013, p. 2). Agresti emphasises that the order of the categories is not relevant, and is not

[18] Whilst once 'data' was considered to require the plural verb "were" it is now acceptable to use the singular form "was" (Hornby, 1998). I will use the singular verb in this thesis.

considered for purposes of analysis. Permissible statistical analyses for this type of data are frequency counts of responses, and calculation of modes and contingency correlations (Stevens, 1946). Inferential tests which are based on counts, like the chi-square test, are also suitable for nominal data (Corder & Foreman, 2009; Watkins, Scheaffer, & Cobb, 2008).

- **Ordinal data** is derived from named response categories which have a particular ranked order, e.g. 'none, 'high school', 'bachelor's' 'master's' and 'doctorate' when asking a respondent about the highest educational qualification they have (Agresti, 2013). Agresti points out that for ordinal data the 'distances' between the categories are not known. Additional permissible statistical analyses for ordinal data are calculations of medians and percentiles (Stevens, 1946). Non-parametric inferential tests based on these measures (e.g. the sign test) are permissible. The data from my questionnaire is ordinal, because the response categories are named and arranged in order of increasing frequency of use.
- **Interval data** arises from numerical response categories with known distances between categories, e.g. the categories '0, '1, '2, '3' … to indicate the number of years of education completed (Agresti, 2013). For a true interval scale the actual numbers must be measurements, and not just numbers allocated by the researcher to score named categories. Both descriptive statistics (e.g. means and standard deviations) and inferential statistical tests, which are used to test for statistical significance of differences between two groups, are permissible for this type of data (Agresti, 2013; Stevens, 1946).
- **Ratio data** is produced when category responses can be compared by their ratio, meaning that a number can "*be compared meaningfully by saying that it is twice or three times another number or one-half or one-fourth of a number*" (McMillan & Schumacher, 2010, p. 150). In addition, ratio scales must include a zero value (Creswell, 2012). Ratio scales occupy the highest level in the measurement hierarchy, allowing all the descriptive and inferential statistics permissible for the lower levels of measurement, as well as coefficients of variation (Stevens, 1946).

My aim was to analyse my data to see whether there was "*any real difference*" (Corder & Foreman, 2009, p. 4), before and after the innovation, in the types of computer-based tasks teachers were using or whether the changes were due to chance alone. Any change that could not be attributed to chance alone would be considered 'statistically significant'. Statistical analysis requires the selection of a suitable statistical test "*based on characteristics of the data*" (Corder & Foreman, 2009, p. 5). The ordinal nature of my data meant that frequency counts of responses, medians, percentiles and certain of the nonparametric inferential tests were the only permissible types of analysis. Agresti (2013, p. 3) points out that "*analysts often utilize the quantitative nature of ordinal variables by assigning numerical scores to the categories*". For example, I could have used a parametric test (like the *t*-test) to test for significant differences between teachers' mean usage of a task before and after the innovation by assigning scores to my qualitative categories to convert my ordinal data into interval data. However, this was not possible given that the exact distances between the categories used in my questionnaire cannot be established. Mitchell (1997) questions the legitimacy of educational researchers assigning scores to "*variables like an attitude, opinion or even knowledge"* (Mitchell, 1997, p. 49). According to Mitchell the lack of a sound mathematical basis for generating such 'quantitative' data from qualitative data would render meaningless any statistical analysis conducted on data which has been generated by this method. Using *t*-tests was therefore not a 'legitimate' option.

In addition to the ordinal nature of my data, a further potential problem with *t*-tests also made them unsuitable to use. Because they use group means, *t*-tests do not make use of all the data in a set and could suggest that the data for two samples (e.g. before and after an intervention) are similar, when they may not be (as pointed out by McElduff et al., 2010). Clason and Dormody (1994) illustrate this potential problem with *t*-tests using the example of two sample groups that have the following frequency responses to the same Likert-type item.

	Never	*Seldom*	*Sometimes*	*Frequently*	*Always*
Group 1	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*
Group 2	*0.5*	*0.0*	*0.0*	*0.0*	*0.5*

Group 1 and Group 2 both yield a mean frequency of 0.2, and using a *t*-test produces a non-significant difference of p = 1.0. Thus using *t*-tests suggests no significant differences between the groups, although an examination of the data shows that there are notable frequency differences for the categories selected by the two groups. These are not be revealed by the *t*-test. In the case of the data from the questionnaire on how teachers' computer use changed, the *t*-test could have masked differences in teachers' choice patterns across the individual items (different computer tasks).

I then considered using the chi-square test for independence to analyse whether the increases or decreases in teachers' use of different computer-based tasks were statistically significant. The chi-square test for independence is used when each member of the sample "*falls into exactly one category*" (Watkins et al., 2008, p. 711) and one wants to know if there is some association between the proportion of respondents falling into each ordinal category in different situations or whether the proportions are independent of each other. The null hypothesis for the chi-square test in my study would have been that there was no significant difference between the number of teachers carrying out a particular type of computer task before the innovation was introduced, and the number of teachers carrying out that task after the innovation was introduced. Accepting the null hypothesis would mean that any differences observed between two groups is due to chance alone, while rejecting the null hypothesis would mean that the difference between the 'before' and 'after' frequencies cannot be attributed to chance alone and is therefore statistically significant. However, the chi-square test requires expected numbers of five or greater in each category in order to work reliably:

> *Like the normal approximation to the binomial distribution, the χ^2 distribution is a continuous distribution that can be used to approximate a discrete distribution. The larger the expected frequencies, the closer the distribution of possible values of χ^2 is to a continuous distribution. In order to have a reasonable approximation, the expected frequency in each category should be five or greater.* (Watkins et al., 2008, p. 684)

An examination of my data showed several of the cells in the contingency table for various tasks did not meet this requirement, which meant that the chi-square test was not a suitable option for analysing my data.

Based on the advice of a statistician, the nonparametric sign test, which is used "*to test the median difference of independent paired observations*" (Fong, Kwan, Lam, & Lam, 2003, p. 237) was finally chosen to test for the significance of differences between teachers' usage of different computer-based tasks before the innovation ('before' group) and after the innovation ('after' group). 'Median' refers to the "*middle value*" of a set of data (Corder & Foreman, 2009, p. 14). The 'median difference' thus refers to the difference between the middle values for two groups (e.g. my 'before' and 'after' groups). The median or middle value is obtained by comparing the number of positive and negative changes between the two groups. The null hypothesis for the sign test is that the median difference between the two groups is zero (i.e. there are an equal number of positive and negative changes), which means that there is no difference between the two groups. The alternative hypothesis for the sign test is that the median difference between the paired samples is not equal to zero, which suggests that there is a difference between the two groups. The binomial distribution is used to test for significance of the difference between the groups. This distribution is used when there is a discrete number of independent events and only two possible outcomes of each event (Watkins et al., 2008). In my case, I was comparing the number of increases in teacher's usage of a type of computer-based task with the number of negative changes (decreases in usage of that task). If a task shows more teachers with an increase in usage than a decrease in usage (i.e. more positive differences than negative differences) or *vice versa*, then the null hypothesis is rejected and the change observed cannot be attributed to chance alone. The two-sided sign test was used to check for significant changes in both directions, i.e. increased or decreased teacher usage of a particular computer-based task. The steps used in the sign test are shown below using the example of *creating basic PowerPoints:*

- Calculate the differences between the 'before' and 'after' frequency for each teacher and assign a '+' for an increase in usage and a '**-**' for a decrease in usage. The differences and signs for teachers frequency of *creating basic PowerPoints* is shown below and on the next page:

Teacher	**Before *DigiDays***	**After *DigiDays***	**Difference (Before - After)**	**Sign**
2	2	3	1	**+**
3	3	3	0	
7	2	2	0	
14	2	2	0	
15	2	2	0	
16	2	3	1	**+**
17	3	4	1	**+**
18	2	4	2	**+**
19	1	2	1	**+**
20	2	2	0	
21	0	3	3	**+**
22	0	2	2	**+**
23	1	1	0	
24	4	4	0	
25	1	3	2	**+**
27	3	3	0	
28	4	4	0	
29	2	3	1	**+**
30	1	3	2	**+**
31	4	4	0	
32	3	3	0	
33	4	4	0	
34	1	2	1	**+**
35	0	1	1	**+**
36	3	3	0	

37	1	1	0	
38	1	2	1	**+**
39	4	4	0	
40	3	3	0	

- Total the number of positive and the number of negative signs (shown below for example of *creating basic PowerPoints).*

Number of increases in usage (+)	13
Number of decreases in usage (-)	0
Number of zeroes	16

- Where zero differences (also referred to in the literature as 'ties') occur "*the sign test must be modified to account for the ties*" (Coakley & Heise, 1996, p. 1243). Discarding the ties contributes to errors by suggesting that results are significant, when they are not (Fong et al., 2003). One of the approaches suggested in the literature for handling zero differences between paired samples "*is to equally likely assign ties as positive or negative*" (Fong et al., 2003, p. 237). In my example, this would mean dividing the 16 ties equally between the number of increases and decreases, as shown below:

Number of increases in usage (+)	21
Number of decreases in usage (-)	8

- Calculate the *p*-value for the changes. Since I was interested in either an increase or decrease in the number of teachers using a particular task, the two-sided sign test was appropriate (i.e. the probability of obtaining as many, or more than, the observed number of increases and decreases in usage). The binomial distribution formula (see below) is used to calculate the probability of obtaining a given difference for a sample n, with the probability (p) of obtaining either a positive or negative decrease is equal to 1 in 2, or 0.5 (Spiegel, 1988).

$$\text{probability of difference } x = \frac{n!}{x!(n-x)!} p^x (1-p)^{n-x}$$

where:
x = a given difference (e.g. -1, 0, 1, 2, etc) between the before and after score
n = sample size
! = factorial (the product of all the whole numbers, except zero, that are less than or equal to that number)
p = probability of obtaining a positive or negative decrease = 0.5

- For my data, using the sign test required that the individual probabilities of obtaining differences for x = 1 to x = 29 (since n= 29) be calculated using the formula shown above (see Appendix AU, which shows the individual probabilities calculated for differences ranging from 1 to 29). Calculations were done in *Microsoft® Office Excel 2007*. Since the null hypothesis states that the number of positive changes equals the number of negative changes, the more extreme the values are from the observed number of positive and negative changes, the more likely the chance that there is a significant difference between the before and after groups. In the case of the changes in teachers' usage of the example task *creating basic PowerPoints* 21 positive changes and 8 negative changes were observed. Therefore the total probability of obtaining these results for the task *creating basic PowerPoints*, or more extreme results, is the sum of the individual probabilities for each possible combination of positive and negative counts greater than or equal to 21 positive changes. Expressed mathematically, this is the probability of obtaining 21 positive changes or greater, or 8 or less, in 29 trials. Adding the probability values (using the individual probabilities calculated in Appendix AU) for $x \leq 8$ and $x \geq 21$ gives:

$$\textit{probability} = p(0) + p(1) + p(2) + p(3) + p(4) + p(5) + p(6) + p(7) + p(8) + p(21) + p(22) + p(23) + p(24) + p(25) + p(26) + p(27) + p(28) + p(29)$$

$$= (1.86 \times 10^{-9}) + (5.40 \times 10^{-8}) + (7.56 \times 10^{-7}) + (6.81 \times 10^{-6}) + (4.42 \times 10^{-5}) + (2.21 \times 10^{-4}) + (8.85 \times 10^{-4}) + (2.91 \times 10^{-3}) + (0.008 \times 10^{-3}) + (0.008 \times 10^{-3}) + (2.91 \times 10^{-3}) + (8.85 \times 10^{-4}) + (2.21 \times 10^{-4}) + (4.42 \times 10^{-5}) + (6.81 \times 10^{-6}) + (7.56 \times 10^{-7}) + (5.40 \times 10^{-8}) + (1.86 \times 10^{-9})$$

$$= 0.0241$$

The sign test calculations for the changes in teachers' use of the 19 tasks are shown in Appendix AU. When reporting the statistical significance of the differences in teachers' use of computers, before and after the innovation, as determined by the sign test results, I have reported actual *p*-values, as advocated by several researchers and authors (e.g. Creswell, 2012; Mitchell, 1997; Neie, 1974), rather than stating that a fixed significance level (e.g. 0.01 or 0.05) has been reached. In the words of Neie (1974, p. 377) "*the accepted values for significance are typically p = 0.05 or less, but there is certainly nothing sacred about these figures"*. The difference between a significant p value of 0.04 (considered significant at the 95% level) and a *p*-value of 0.06 (considered non-significant) is that the former suggests there is only a 4/100 chance that the difference between two samples is due to chance, while the negligibly larger latter *p*-value suggests that there is a 6/100 likelihood of the difference between two samples being due to chance. The question is why, when considering values that are so close together, one would be considered significant and the other not. Neie goes on to point out that a non-significant result does not mean that no difference exists. Rather, it suggests that there is insufficient evidence to accept that the difference is due to "*anything other than chance*" (Neie, 1974, p. 377). Creswell claims

> *It is best to report the specific p level for each statistical test because the conventions for rejecting the null hypothesis are general rules of thumb. Individual researchers and consumers, depending on the circumstances, may differ with respect to what constitutes a statistically significant difference.* (Creswell, 2012. p. 299)

By not using a specific significance level and reporting actual *p*-values readers can decide for themselves whether the *p*-value is small enough to allow for something other than chance to have caused the difference.

Analysis by teacher

When analysing the data by teacher, I wanted to compare the changes in individual teacher's usage of computer-based tasks before and after the innovation, and possibly test whether these changes were statistically significant, or could be attributed to chance alone. Comparing the changes in each teacher's **total usage** would involve adding the response data for each of the 19 tasks to give a total 'before' and 'after' usage for each teacher (measured in usage units). Mitchell (1997) regards it as inappropriate to add the values for very different items to obtain total scores for inferential analyses. In my case because the 19 computer tasks are very different (e.g. some are teacher-tasks and others learner-tasks), it was not possible to use the total usage values for inferential analysis. However, it was still possible to **compare the extent of change in computer usage for each teacher** without using these values for inferential analysis. To calculate total usage for each teacher I expressed the nominal categorical responses as meaningful values (number of days per year), as shown on the next page:

Category	Number of days per year
never	0
couple of times a year	2
about once a month	12
about once a week	52
about once a day	365

A possible criticism of expressing the category responses as 'number of days per year' is that school holidays (when tasks would probably not be done) are not taken into account. However, the holidays taken by the 29 teachers from the same school are likely to be similar and could thus be regarded as a constant error which is unlikely to affect comparisons of the size of change across the teachers.
Despite not being able to conduct inferential analyses on an individual teacher's change in total usage from before to after the innovation, it was possible to use the sign test (which is based on medians) to test for statistical significance of the changes in individual teacher's usage of the 19 tasks. In this case I would be comparing the number of tasks which showed an increase or decrease, for a particular teacher, and testing whether the changes could be attributed to chance alone.

Analysing the data for individual teachers thus involved firstly, comparing, the extent of change in total usage after the innovation (measured in usage units) for each teacher and, secondly, analysing the number of increases and decreases of each teacher's usage of the 19 computer-based tasks (see Appendix AV for sign test calculations for the changes in number of tasks, for individual teachers).

6.3.4 Ranking *DigiDay* tasks

In Chapter 1 I pointed out that if technology is to improve education it must be used in ways that contribute to meaningful learning. When looking at the changes in teachers' use of computers after the innovation, I thought that it would be useful to examine the types of computer-based tasks teachers were setting for *DigiDays.* Doing so could provide me with valuable insights into whether the tasks teachers set promoted meaningful learning. I had descriptions from my interviews with teachers or hard copies teachers had provided me with, of 33 *DigiDay* tasks which had been set for learners over the first 18 months after the innovation. I had also observed learners carrying out some tasks in the school computer laboratories when I visited the school on two *DigiDays*.

I searched the literature to find a suitable tool or suitable criteria for scoring the *DigiDay* tasks. Although I came across various tools for assessing digital learning materials (e.g. Albion, 1999; Nokelainen, 2006; Squires & Preece, 1996), none of them was suitable for ranking computer-based tasks based on potential to promote meaningful learning. However, two sources from the literature proved useful. The first source was an article by Hew and Cheung (2013) in which they reviewed 27 articles which examined the impact of Web 2.0 technologies (e.g. podcasts and wikis) on learning. These researchers summed up the important aspects of evaluating computer-based tasks as "*how the technologies are used, and how one conceptualizes learning*" (Hew & Cheung, 2013, p.47). The idea put forward by Hew and Brush about 'how the technologies are used' suggested that a tool for ranking the *DigiDay* tasks should include a criterion based on the value of technology usage for the task, so this became my first criterion (see row 1 of Table 33 on page 231). The 'conceptualisation of learning' referred to by Hew and Cheung (2013) suggested another possible criterion – the philosophy of instruction which underpins the task. Squires and McDougall (1994) state that the learning theory underpinning software may be explicitly stated or implicit in the design (as is discussed in Chapter 5, with reference to the software evaluation aspect of my study). Based on this reasoning, which could also apply to computer-based tasks, I looked at the pedagogical design underlying the *DigiDays* tasks, which eventually became my third criterion (see row 3 of Table 33 on page 231).

The second useful source I came across in my literature search supported the idea of a criterion based on how technology is used, but also provided a further idea. This source was *The Scoring Guide for Lesson Plans That Use Technology Resources,* developed by the North Central Regional Technology in Education Consortium[19]. It is a tool designed to score lesson plans incorporating ICT. Although the tool was not suitable for scoring learner computer-based tasks based on their potential to promote meaningful learning, two criteria from the scoring guide seemed relevant for my purposes. The first criterion is the idea of focusing on how technology is used for the task, which I had already come across in the Hew and Brush paper. A second criterion from the scoring guide, "*Cognitive Tasks*", suggested a criterion based on the cognitive level of the task. I used this as the second criterion in my tool (see row 2 of Table 31) but because the wording of descriptors used in the Scoring Guide was vague I refocused the categories using Bloom's cognitive levels, as discussed later.

Initially I considered including a fourth criterion in the rubric relating to **the level of computer skill required to execute a task.** I wanted to differentiate between tasks which required only basic computer skills (e.g. designing tables in *Word,* entering data in *Excel*, conducting basic Internet searches) and those requiring more complex computer-based skills (e.g. drawing graphs and using formulae in *Excel*, and creating a multimedia *PowerPoint* presentation). However, I decided to omit this criterion as I found that it placed an undue emphasis on the technical skills associated with using computers, rather than the potential of the task to deepen understanding of subject-related content and concepts.

The tool I developed consists of three criteria, with three levels of scoring for each:

- The effect of using technology when carrying out tasks. I distinguished between three different levels of effect of technology use when carrying out educational tasks:
    - ***Using technology has minimal effect on how the task is carried out.*** This would apply to tasks which could just as well have been done off computer. Examples of such tasks would be completing a crossword puzzle or answering a comprehension exercise. In each of these examples, the effect of using technology would mainly be to produce a typed document, with little additional benefit for learning over a paper-based task.
    - ***Using technology allows the task to be carried out more efficiently*.** This generally refers to technology usage which reduces the time needed to complete a task, or which simply produces more professional-looking documents, e.g. summarising information in tables in *Microsoft Word*; producing graphs in *Microsoft Excel*, or conducting Internet

[19] The North Central Regional Technology in Education Consortium has not been in operation since 30 September 2005. The *Scoring Guide for Lesson Plans That Use Technology Resources* was accessed on 12 July 2010. The scoring guide is no longer available online but has been included as Appendix AW.

searches. Each of these examples could be done without a computer, but using technology expedites carrying out the task.

- ***Using technology improves the effectiveness of the task in promoting meaningful learning.*** Some technological applications could enhance learning by creating opportunities for learners to experience things not possible without using computers. For example, appropriately designed multimedia software could provide learners with individualised, timely, and informative feedback which learners could use, for example, to correct misconceptions they hold. Another example would be the use of software which requires learners to apply their knowledge to solve problems using, for example, simulations or educational gaming software. Rennie and Morrison point out that while "simulations are not new to education", using computers for simulations has given them a "*different character*" (Rennie & Morrison, 2013, p. 81). These authors ascribe the educational benefits of carrying out simulations using a computer largely to their inherent interactivity and the manner in which this interactivity creates a dynamic environment within which learners can explore a simplified system by controlling one or a few criteria at a time. Learners are likely to be actively engaged in constructing their own knowledge when they have to decide on a course of action, whether it be changing parameters in a simulation and examining the consequences to develop an understanding, or trying to reach the next level in an educationally meaningful game.

- **The cognitive level of the task.** Karagiorgi and Symeou (2005) believe that the potential for ICT use to promote meaningful learning appears to be greatest when learners are using ICT for cognitively demanding tasks. According to Bloom's taxonomy, there are six cognitive levels. The lowest cognitive level involves tasks which simply promote the acquisition of ***knowledge***. The next level involves tasks which promote ***understanding***. Tasks at the four higher cognitive levels involve learners in manipulating their knowledge through ***application*** (using a concept in a new situation), ***analysis*** (separating concepts into component parts so that different structures which comprise the concept can be understood), ***synthesis*** (combining diverse elements together in a new meaningful structure) and ***evaluation*** (making judgments about the value of ideas and materials) (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). For the purposes of creating a tool to evaluate the digital tasks, I combined the four highest cognitive levels (application, analysis, synthesis and evaluation) into a single group labelled 'higher cognitive skills', as is done by many authors using Bloom's taxonomy (e.g. Anderson et al., 2001; Hew & Cheung, 2013; Krathwohl, 2002). This gave me three cognitive levels: *acquiring knowledge*, *developing understanding*, and *using the higher-order cognitive levels* when learners are required to transfer or manipulate their knowledge.

- **Pedagogical design implied in the task.** According to Ausubel, Novak, and Hanesian (1978) for meaningful learning to occur learners must link material to the mental schemata which comprise their existing cognitive structure. In his theory of learning Ausubel (1968) described the learning process as a continuum ranging from rote-learning (e.g. the content is learned off by heart and is not linked with existing schemata) to meaningful learning (material is assimilated into existing schemata, which may need to be modified to accommodate the new ideas). Rote learning is associated with the retention of information (Mayer, 2002). Mayer defines 'retention' as follows:

> *Retention is the ability to remember material at some later time in much the same way it was presented during instruction.* (Mayer, 2002, p. 227)

Mayer emphasises the difference between rote learning and meaningful learning as being the extent to which learners attend to or engage with material, which consequently influences their ability to transfer their knowledge in new situations. He further points out that

> *meaningful learning is consistent with the view of learning as knowledge construction in which students seek to make sense of their experiences.* (Mayer, 2002, p. 227)

Tasks with an implied design which makes it unlikely that learning will go beyond reception learning are likely to involve cognitive processes associated with the acquisition of knowledge. Mayer also points out that "*when the goal of instruction is to promote transfer, the focus shifts to the other five cognitive process categories, Understand through Create*" Mayer (2002, p. 228). McClelland (1982) lists three conditions for meaningful learning arising from Ausubel's theory of learning. Firstly, the material to be learnt must be meaningful, which means it must be relevant to the learner. Secondly, the learner must have some existing knowledge into which the new material can be incorporated. Thirdly, the learner must be motivated to engage with the material to be learned. While the last of these conditions depends on the learner, the first two conditions have implications for how teachers design tasks, i.e. the extent to which the task design mentally engages learners and promotes knowledge construction. I have distinguished between three types of tasks based on the extent to which the pedagogical design implied in the task promotes knowledge construction:

- ***Tasks for which learning does not go beyond reception learning.*** Based on the description by Mayer (2002) of rote learning involving learners handing material in much the same way it was delivered during instruction, I will refer to tasks which require learners to attend to material but which do not foster deep cognitive thinking as tasks for which learning **does not go beyond reception learning**. Examples of such tasks would be learners accessing or acquiring information from an external source such as their teacher, or a book or computer, without deep mental processing. Other types of tasks would be those in which learners are provided with a set of instructions which they have to follow like a recipe, or in which they are required to apply their knowledge to a **familiar** situation. These tasks are characterised by the minimal level of mental processing required by learners. Terms which could be used as indicators that a task does not go beyond reception learning include: *recall, retrieve, access* or *find information, complete, provide, list,* and *identify.*
- ***Tasks in which some learner-dependent constructivism may occur.*** The wording of these tasks is such that it does not ensure that constructivist learning will occur but, depending on the individual learner and how they engage with the material, there is a possibility that meaningful cognitive engagement might happen which allows the construction of knowledge – hence the term "learner-dependent constructivism'.
- ***Tasks which promote construction of knowledge.*** Tasks which require learners to cognitively engage with new information are more likely to promote deep and meaningful learning. Deep learning is believed to be fostered *"where the learner actively participates in the construction of knowledge*" (Lai, 2008, p. 216). Jonassen (2009, p. 222) suggests that learners have to mentally *"manipulate their environment*" to be engaged in their own learning. Such manipulation could involve learners making conscious choices about their learning situation, e.g. deciding what information they need to gather evaluating the

usefulness of information they have gathered setting parameters in a simulation or solving problems in game-based learning. Terms which suggest active mental engagement and could thus be used as identifiers for this type of task include *analyse, synthesise*, and *evaluate.*

The original scoring tool for ranking the technology-based tasks for their potential to promote meaningful learning, shown in Table 33, thus considered the effect of using technology for the task, the cognitive level of the task, and the pedagogical design implied in the task. However, when using this tool to rank the 33 *DigiDay* tasks I found that the tasks were ending up with similar scores for cognitive level of the task and the pedagogical design implied in the task. Only one task was assigned different scores for cognitive level and pedagogical design. Because of the high correlation in the scores for the cognitive level and the pedagogical design, it made no sense to include both criteria in the ranking tool as they gave identical scores. I decided to use the pedagogical design implied in the task because it focused on the construction of knowledge, which is essential for meaningful learning. Mayer (2002) points out that there is a correlation between the pedagogical design implied in the task and the cognitive level of that task. The final tool used to rank the 33 *DigiDay* tasks thus only uses the first and third criteria highlighted in yellow in the table. The ranking of the 33 *DigiDay* tasks is reported in the next chapter.

Table 33. Criteria for scoring technology-based tasks

Criterion	1	2	3
Effect of using technology	Technology use has **little effect on the task**. Task can be done just as efficiently off computer.	Technology use **improves the efficiency** with which a task is carried out.	Technology use increases the **effectiveness of the task to promote meaningful learning.**
Cognitive level of task	Involves learner acquiring **knowledge**.	Promotes learner **understanding**, for example, through learners applying their knowledge in familiar situations.	Requires **higher-order cognitive skills** involving the manipulation of knowledge (applying knowledge in new situations, analysing, evaluating, synthesising).
Pedagogical design implied in the task	Task **does not go beyond reception learning** as it does not require learners to link information to their existing schema.	**Learner-dependent constructivism** may occur during the task, depending on the level of motivation of the learner	Task promotes **constructivist learning** as it involves learners linking information to their existing schemata.

6.4 CHECKING VALIDITY FOR THIS PART OF THE STUDY

Attempts to improve the validity and rigour of the study were discussed in Chapter 3 (see pages 87-92). I have already pointed out that all instruments used in the study were face validated by my supervisor, a researcher with many years of experience in developing and administering instruments (see page 89 in Chapter 3). The scoring tool for ranking the *DigiDay* tasks was also checked by my supervisor. All statistical calculations were checked by a statistician, who had advised me on the appropriateness of the statistical tests used to analyse my data.

6.5 CONCLUDING REMARKS

This chapter provided readers with some background information on the *DigiSchool Project* and dealt with methodological matters relating to analysing whether the changes in teachers' use of technology for instruction, after the innovation, were due to chance alone or whether they could be attributed to other factors. The results of these analyses are presented in Chapter 7, together with a discussion of the factors impacting on teachers' use of technology at the case study school.