Teachers' private theories and their design of technology-based learning

Daniel Churchill

Address for correspondence: Daniel Churchill is Assistant Professor at Faculty of Education, The University of Hong Kong, Pokfulam Road, Hong Kong. Tel: +852 2859 1141; fax: +852 2517 7194; email: dchurch@hkucc.hku.hk

Abstract
This study explores the private theories of four vocational education teachers in Singapore who have engaged in the design of technology-based learning for their own classes. The understanding of teachers' private theories is important in the context of contemporary educational reforms, which emphasise the shift towards student-centred practices and technology integration. As teachers learn to change strategies and utilise technology, they might also need to transform aspects of their private theories that could impede effective technology integration and lead them to continue with outdated educational practice. This study aims to understand and explicate areas of private theories that impede the effective design of student-centred technology-based learning. The final outcome of the study was a set of propositions for readers to examine for the possible application in their own environments.

Teachers' private theories
Teachers develop private theories that influence how they make decisions and take actions (Senge, 1990). These private theories are developed from observations, interactions, instruction or inferences (Johnson-Laird, 1983; Staggers & Norcio, 1993). A variety of issues has been addressed in literature: eg, planning and teacher thinking when linking a curriculum to instruction (Clark & Peterson, 1984); teacher reflections (Lloyd, 1999); teacher pedagogical content knowledge (Wilson, Shulman & Richert, 1987); teacher schemata and decision making (Borko & Shavelson, 1990); teacher epistemology (Howard, McGee, Schwartz & Pursel, 2000); teacher beliefs, social dynamics and institutional culture (Windschitl & Sahl, 2002); expert teacher thinking and teaching and instructional design models and principles (Moallem, 1998). Literature generally suggests that teachers hold cognitive constructs, beliefs, guiding principles, theories or preconceptions, which determine their instructional decisions and technology integration.

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Researchers have only recently begun to explore teachers' use of technology and influences that shape their thinking and decisions (see Windschitl & Sahl, 2002). The literature suggests four major areas of teachers' private theories that impact instructional decision making and technology integration: learning, students, teacher and technology (Borko & Shavelson, 1990; Howard et al, 2000; Lovat & Smith, 1990; Moallem, 1998; Pierson, 1999; Schömmer, 1990; Windschitl & Sahl, 2002; Yinger, 1978). Also, according to the literature, institutional influences impact the overall instructional decision making and technology integration (Borko & Shavelson, 1990; Clark & Peterson, 1984; Duffy, 1977; Lovat & Smith, 1990; Yero, 2002). In addition, the literature suggests that the knowledge of curriculum and pedagogical content is a factor that affects instructional planning and technology integration (Moallem, 1998; Wilson et al, 1987). It often appears that one of the areas of private theories is emphasised as a predominantly influential area upon teachers' decisions. For example, Borko and Shavelson, Lovat and Smith and Yinger suggest that the most important area of private theories in teacher instructional planning concerns students, notably, issues such as students' ability, gender, class participation, self-concept, social competence, independence, classroom behavior and work habits. The most important student characteristics for teacher planning appear to be learning ability. Others (eg, Hashweh, 1996; Howard et al; Schömmer, 1990) suggest that epistemology is the most important area of private theory in teacher instructional planning. According to Schömmer, this area includes five dimensions: the structure, certainty and source of knowledge and the control and speed of knowledge acquisition. However, it appears unlikely that exactly the same area of private theory would be predominant for all teachers. An area of highest significance for teachers is likely to dominate their decisions in instructional planning and technology integration. If teachers are to change or modify their private theories, they must engage in a self-examination of these theories and explore alternatives. Reflection might enable teachers to engage in self-examination of their private theories (see Senge, 1990). However, such reflection must be facilitated by an appropriate intervention strategy. This strategy must be based on understanding teachers' theories in general and the influences of these theories on instructional planning and technology integration.

Methodology
In this qualitative multicase study, I have explored the private theories of four teachers from a large technical education institute in Singapore who engaged in the design of technology-based learning for their own classes. In the study, I have attempted to explicate issues that limited the effective design of technology-based learning of the participants. The institute comprised 10 campuses with about 1500 teaching staff delivering over 30 courses to thousands of students. At the time of the study, the institute was undergoing major reform with the aim of establishing student-centred practices and promoting the use of technology as a means of developing intellectual capital for the country. Considerable financial resources were allocated to support technology integration across the 10 campuses of the institute.

At that time, my role at the institute was to provide leadership and support to this teaching community in the area of pedagogy and educational technology. Although my background in engineering, education, instructional design and multimedia, along with years of teaching experience in secondary school, technical institutes and teacher training institutes, was very useful, my only partial understanding of teachers' private theories in this particular environment was a limitation. Teachers in the institute were largely deploying technology for the delivery of automated instruction, quizzes, lecture material, notes and presentations. Accordingly, the teachers understood technology as a platform that supported their existing teacher-directed practices.

An effective strategy for preparing individuals for the contemporary world requires a shift away from direct instruction towards student-centred pedagogical practices. In direct instruction, it is the job of teachers to guide their students to think in particular ways and to arrive at 'correct' answers (Carter, 1997). In contrast, students in a student-centred practice use technology as a tool for accessing, analysing and transforming data and information, organising knowledge and creating representations of what they know (Jonassen & Rohrer-Murphy, 1999). Administrators at the institute recognised that their teachers needed to be prepared for effective technology integration in learning, as their existing preparation has focused only on classroom strategies. However, it was not envisaged that as teachers learn to change strategies and utilise technology, they must also transform the existing private theories that guide their instructional decision making and lead them to integrate technology to support outdated models. Intervention might be essential in supporting teachers to transform their private theories. To understand this intervention, teachers' private theories and their decision making for technology integration must be explored, explicated and synthesised in keeping with an appropriate strategy. A single study with a small group of teachers is certainly not sufficient to synthesise this strategy for wide application beyond this particular institute. However, this study might provide an important milestone towards understanding an appropriate strategy for supporting teachers in moving towards more effective technology integration.

**Participants**

The participants were engaged in the Education Technology Champions programme organised by their institute. They were identified and selected for the programme by their management as exemplary technology-using teachers. During the six-month-long programme, these teachers were relieved of their teaching duties to allow them time to engage in the design of technology-based learning activities and develop competencies for effective technology integration in learning. After this period, these teachers were expected to act as change agents promoting technology integration and providing some consultation to other teachers in their sections. They were provided with development tools and technical support throughout the programme. I conducted an initial meeting with six teachers selected for the programme. We met in the institute's headquarters. During the meeting, the teachers were informed about the research and were asked if they were prepared to participate. I provided them with an 'Agreement to Participate' form and a short brief about the protection of their identities.
Table 1: Profile of the participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age at the time of the study</th>
<th>Teaching area</th>
<th>Length of teaching experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tom</td>
<td>Late 40s</td>
<td>Precision Engineering</td>
<td>22 years</td>
</tr>
<tr>
<td>Nicole</td>
<td>Early 40s</td>
<td>Electronics Engineering</td>
<td>20 years</td>
</tr>
<tr>
<td>Jane</td>
<td>Late 30s</td>
<td>Mechanical Maintenance</td>
<td>15 years</td>
</tr>
<tr>
<td>Eleanor</td>
<td>Late 30s</td>
<td>Business Studies</td>
<td>15 years</td>
</tr>
</tbody>
</table>

*Pseudonyms are used to protect the participants’ identities.

their roles and entitlement to pull out of the study at any time. Four out of these six teachers accepted the invitation to participate. Their profiles are presented in Table 1.

Study questions
Two questions guided the data collection and analysis of this study:

• What interlinked areas of private theories mediate the participating teachers’ design of technology-based learning?
• How do the participating teachers’ private theories change through reflection during the design of technology-based learning?

Procedure
Qualitative data collection occurred over the period of six months. The data collection for each of the participants included:

• two interviews and a collection of field notes in the initial stage of the study to identify a participant’s private theories;
• a collection of written reflections to explore changes in private theories;
• a collection of artifacts produced to understand whether private theories lead to the design of direct instruction or student-centred learning;
• a final meeting at the end of the study to discuss changes in private theories.

The first interview was conducted within the first few days of the study. This semistructured, 60-minute-long interview was conducted with each of the participants individually. The interview questions focused on the areas of each teacher’s private theories identified in the literature review. The participant was informed of the focus areas of discussion a few days before the actual interview to allow time for thinking about relevant issues. The interview was recorded using a microcassette recorder and transcribed. The transcript was read and validated by the participant.

The second interview was conducted a few weeks later after the participant had produced a prototype of technology-based learning. This 60-minute-long interview focused on the prototype. The issues identified from the literature were, once again, points of discussion; however, this time, the focus was more specifically directed towards
the designed learning experience encapsulated by the prototype. The interview was recorded and transcribed, and the participant validated its content.

I conducted a content analysis of the interview transcripts to identify single units of private theories. A unit of a private theory comprises relevant statements made by a participant in an interview. I used a word processor to highlight and copy these statements in a separate document, which was then printed out on cardboard. During this time, I visited the participants on many occasions; we had coffees together and engaged in casual discussions. During these experiences, I took field notes with a view to identify any emerging theories. These emerging theories were also added to the list of private theories identified in the interviews. The cardboard was sliced into cards with a single unit of the participant's private theory per card. The participants were given their sets of cards and asked to go through them, challenge the validity of the statements and remove any card with a private theory that they did not hold as valid. The participants and I collaboratively sorted the remaining cards into stacks, representing areas of private theories. The participants were then asked to indicate which of the stacks of cards was most relevant to their decision in relation to developing a prototype. The orientation of the prototypes and final designs provide clues about links between the participant's theories and design decisions.

I collected all the prototypes created by the participants. The prototypes were developed using presentation software to simulate the final technology-based learning. At this time, I engaged two advisors to help in determining whether the prototypes were aligned towards teacher-directed instruction or student-centred learning. These advisors were experienced teachers and instructional designers who had previously designed exemplary student-centred technology-based activities. They were not associated with the institute at which the study was conducted. The final technology-based learning designs were collected at the end of the six months. Two advisors and I evaluated them to determine whether there was a shift towards student-centred practice.

After the prototypes had been submitted, I invited the two advisors to visit the institute and deliver a short seminar–demonstration of student-centred technology-based learning. I held an hour-long discussion with the participants to discuss the seminar. The intention of this event was to initiate the participants' reflections and related changes in their own theories and subsequent decisions. After the seminar, the participants began converting their prototypes into final products. This process lasted for almost five months, after which the participants returned to their normal duties. During this period, the participants were asked to record their reflections every two weeks by completing an open-ended reflective journal entry. I conducted a content analysis to identify units of private theories in these reflections. With each respective participant, I sorted the units into areas of private theories. I counted the total number of cards for each of the areas of private theories noted in the reflections and used this simple information as a basis for gaining an understanding of which areas of private theories appeared to dominate reflections.
At the end of the six months, I met with each of the participants to discuss the changes in their respective private theories. The participants were given their sets of cards outlining their theories as identified in the initial stage of the study. Then the participants removed the cards with theories that they did not hold as valid any longer. The participants then informed me about any change of the dominant area. Changes in the participants' private theories that had come about as a result of reflections and design experience were examined in three contexts: (1) based on the changes of the prototype as noted by the two advisors and me, (2) based on change in the dominant focus area as identified by the participant and (3) based on a participant's rejection of initial private theories as collected at the beginning of the study. In this context, I attempted to identify private theories, which did not change and which continued to impede student-centred technology integration.

Results: private theories of the four cases in the study

Participant one: Tom

Tom informed that his design decisions at the beginning of the study were dominated by private theories on technology. Here are some such theories held by Tom (located in interviews and validated by him):

- Computers are becoming an important tool to impart knowledge.
- Technology can give you immediate access to content and schedule.
- Technology enables students to repeat a lesson.
- With technology, the role of a teacher might be taken away, as a computer can teach.
- With technology, I can force students to go through questions without allowing them to quit.
- Technology can provide questions and answers that can be checked immediately.
- Computers with multimedia assist students to remember new information.
- Computers and multimedia elements help students to concentrate.
- Computers enable students to easily move from one page to another.
- Computers can provide fantastic screens that can improve learning.

These theories led Tom to design direct instruction as demonstrated by the prototype that he produced. The two advisors and I evaluated Tom's prototype and agreed that it reflects traditional thinking about learning as direct instruction. Tom approached his design of a prototype by thinking about how technology could be useful for learning. He saw technology as useful primarily as a mechanism for direct instruction and drill and practice. He also saw it as effective for reinforcement of learning through delivery of content any time, anywhere and as many times as needed. Two screens from Tom's prototype are shown in Figure 1. Tom also demonstrated a strong tendency towards direct instruction because of his theories about students. Tom perceived his students as reluctant to collaborate because of their belonging to a culture that, from his viewpoint, does not welcome open discussions. This tendency was further reinforced in his theories about the roles of a teacher. He understood that a teacher was responsible for covering content and checking that students met minimum requirements before an examination takes place.
In the final discussion, Tom indicated that his dominant area had shifted focus from technology to learning. Here are some of Tom’s theories about learning that he continued to hold at the end of the study after the rejection of some of the theories from the initial stage:

- Learning is an internal process.
- Theory is merged with application.
- Setting real-life problems is important for students’ learning.
- Giving the students a chance to come up with their points of view will help teachers to understand them better.
- In a workshop situation, there must be parameters left for students to explore and share findings that might be different from group to group.
- The ability to analyse problems is helpful to students.

Although these theories could potentially lead to a student-centred prototype, the initially strong influence on Tom of theories about technology led him in the opposite direction. Some more interesting theories about learning emerged from Tom’s reflections:

- Learning is a process that includes activities such as thinking and problem solving.
- Learning with technology enhances transfer of learning, visualisation and reasoning.
- Engaging students with questioning will enhance learning.
- Learning should give students freedom to make mistakes.
- Learning should allow students to choose their own methods of solving problems.
- Learning should allow students to think for themselves.
• Learning must give students freedom to choose and select the information they seek.
• Learning must help students to understand applications in real life.

A shift in the dominant focus area appeared to allow private theories about learning (rather than about technology) to lead Tom’s design decisions. In his reflections, he wrote that ‘it was wrong to consider students or technology early in my initial design, as that limited my planning of learning’. He stated that he approached his redesign by focusing on how he wanted learning to happen. Then, after he had an idea about the learning process, he began searching for the ways in which technology could make this possible. Last, he considered the students and how to support their progress through the learning process. Tom had previously made a claim that ‘knowledge had to be validated by a teacher’. Later in his reflections, he wrote that ‘any knowledge should be put in application so that students could witness transfer of theory into practice for themselves’. For Tom, there was no real proof now of someone knowing something until they were asked to complete an application task rather than doing a quiz as he had understood earlier. In this context, it was important to set real-life problems for students. Application should lead to sharing, and for Tom, giving students a chance to come up with their points of view could help him to understand them better. With theories about learning as the emerging dominant area, Tom’s attention moved away from technology. This focus on learning prompted a sharp shift towards student-centred practice in technology integration as it was understood from the evaluation of his final

Figure 2: Interactive digital resources from Tom’s final design

design by the two advisors and me. His new design contained learning activities set as a collaborative problem-solving task and interactive digital resources (see Figure 2 for an example). These resources allowed students to change various parameters, observe phenomena and collect data needed for an inquiry that informed their problem solving. He planned that students would work in small groups to create a proposal for a client for the production of a certain metal piece. He provided a template that directed students to give attention to certain essential parameters and to approach the task as a professional engineer would do. At the same time, he provided some space for learners to explore additional parameters by examining interactive learning objects, engaging in dialogue and agreeing on the final details of the proposal. At the same time, he planned for learners to collect data from various catalogues available at the websites of the major manufacturers of engineering tools.

Participant two: Eleanor
Unlike Tom, Eleanor’s private theories focused mostly on the area of learning from the beginning of the study. Her theories enabled her to aim for student-centred technology integration. She held that learning was more effective when another person was involved, and thus it should be collaborative. She understood that if students were engaged in learning, a teacher should adopt the role of a facilitator. Her initial plan is reflected in the following statements from the second interview:

I plan for student involvement with technology continuously through the semester. However, they would not be totally lost as I will be there to facilitate their learning. The class will be divided into five groups with six members per group. Each group will be required to set up a web site to document a learning outcome in the form of digital portfolios. Their web site should have a feedback mechanism, such as a guest-book, to collect feedback from a course facilitator or peers. They will also be provided with a discussion board to allow for private discussions.

For Eleanor, the teacher should set up projects for collaborative learning and follow up on the learning processes to ensure that learning was happening. However, Eleanor was concerned as to whether her plan was going to work with her current students and whether her management and colleagues would appreciate this approach:

I have many concerns: ‘What will I do if students are not able to complete activities?’; ‘Will they [colleagues] see the value of investing effort in this work?’; ‘Will this meet their [colleagues’] expectations?’; ‘How about students’ expectation to be spoon-fed?’ And, I have to give many explanations to the management as to why I am doing things this way.

Initially, Eleanor designed two versions of her prototype: one version is student-centred, and the other is direct instruction as a back-up to be deployed if her critics disapproved of her student-centred approach.

Eleanor’s final design was a product of her continuous reflections in pursuit of the effective implementation of her theories on learning. This was an exemplary design of student-centred technology integration. Her plan was to engage students to work in small groups and examine the organisational and accounting practices of a ‘virtual
factory'. The factory was an interactive digital representation of an imaginary place developed by Eleanor (see Figure 3). The students were able to explore different departments, access data about employees, equipment, costs incurred, etc and to collect this data in separate documents for subsequent analysis. The data that the students obtained was randomised: eg, power consumption of a certain machine or salary rates of employees. This enabled different groups of students to collect different data, which in turn informed their analysis differently, exposing them to a spectrum of possibilities.

She continued to emphasise learning as a collaborative process and designed activities that would involve students in this process. Through the experience, she managed to put aside her concerns over whether her plan would work with her students and whether her management and colleagues would appreciate her design. In particular, Eleanor appeared to develop more trust in her students' abilities to learn. Eleanor's focus appeared to shift away from the perception of students as academically less able, lacking confidence and dependent on a teacher and therefore incapable of learning independently. Rather, she began considering ways in which she could provide support for the students given their characteristics. One of the key teacher roles, as underlined by Eleanor in her reflections, was to help students build their self-confidence by allowing them to make mistakes, share and be appreciated as contributors. She also emphasised a need for a facilitator to ensure that students were making correct use of communication tools to increase their independence level.

Throughout the study, Eleanor remained concerned about whether her approach would be accepted by her management and colleagues. However, in the later part of the study, she appeared more willing to take risks because of her reinforced belief that 'in a
dynamic society we must change approaches to teaching and learning towards student-centred practices'.

**Participant three: Nicole**

Nicole was persistent in her conviction that technology was best used as a means of helping her maintain what had worked well for her for the last 20 years—teacher-directed instruction. She stated that she was led by her theories about students. Nicole believed that her students were not able to link theory and practice and to apply knowledge without her guidance. For her, students were dependent, lacked confidence and constantly needed to be reassured that what they knew was correct. Nicole emphasised that her students were not fully prepared to learn from each other because of cultural barriers that prevented them from accepting multiple perspectives and sharing. For Nicole, there was a danger that technology could distance students even further from each other. For her, one of a teacher’s basic roles was to monitor the students’ progress to ensure that learning was happening to prepare them for an examination. Technology could not duplicate such a role, she believed. She saw the benefits of technology as being the delivery of multimedia-based content, which enabled students to move through the content at their own pace. They could also access this content as many times as they needed. The content could be enhanced by drill-and-practice items with instant feedback. There was little shift in Nicole’s theories throughout the study. Some changes in the prototype, in relation to quality of content presentation, were just indications of Nicole’s willingness to try out new tools. She maintained her initial theories about students. These theories resulted in her continuing to incorporate direct instruction as the primary element of learning design.

**Participant four: Jane**

Jane’s initial design was informed by her private theories on the roles of a teacher. These theories led her to incorporate direct instruction in her design. She perceived technology as a supplement to teachers in the contexts of delivery of content and motivation of students. She explained that it was difficult for her to motivate her students, and technology could provide media-enhanced content that could do this. She considered that this content could help to bring theory and practice closer through visuals that would otherwise be accessible only in a workshop. Another benefit of technology for Jane was that it could ‘monitor if students were accessing content and if 100% participation was achieved’. However, she argued that technology could only monitor access to the content, not provide evidence of what students had learnt. For her, this is where a teacher supplemented technology. Therefore, in her view, learning should take place in a classroom where students could first access content in a computer, then once that content is absorbed independently, they should engage in discussions led by a teacher whose focus is to check that learning has occurred. As the study progressed, she began to explore whether technology could help her students to become more independent. However, she remained firm in her belief that technology could not provide students with the initiative to learn, this being the task of the teacher in a classroom environment. This understanding underpinned her persisting private theories about the roles of a teacher, which in turn informed her decisions in designing technology-based learn-
ing. Technology was to provide content, while a teacher's roles were to ensure that learning occurred. Accordingly, Jane planned for the delivery of content in a classroom environment where she could keep an eye on her students. Her final product remained essentially as direct instruction.

**Discussion of results and recommendations**

**Areas of the participants' private theories**

In this study, the participants' private theories that informed their decisions for technology integration fall into six focus areas. Four of these areas were identified in the literature review before the data collection: learning, students, teacher and technology (Borko & Shavelson, 1990; Howard *et al.*, 2000; Lovat & Smith, 1990; Moallem, 1998; Pierson, 1999; Schömmer, 1990; Windschitl & Sahl, 2002; Yinger, 1978). Two additional focus areas emerged from the data: design and educational changes. The six focus areas articulated in the study are presented in Table 2.

The literature also noted content and pedagogical content knowledge as other areas that affect instructional planning and technology integration (see Moallem, 1998; Pierson, 1999; Windschitl & Sahl, 2002). In this study, I observed traces of pedagogical content knowledge within the private theories on learning. However, although I noted that content knowledge is important for the effective design of resources, in the study, I did not find it to be a homogenous area that mediated the design of technology-based learning. Perhaps further studies might focus on exploring the manner in which knowledge of content mediates design of technology-based learning. Institutional influences that I initially understood from literature as independent areas of private theory (see Dwyer, Ringstaff & Sandholtz, 1985–98; Lovat & Smith, 1990; Moallem, 1998) did not appear as homogenous and independent areas in this study. Rather, theories related to institutional influences were observed within other areas of private theories. This obser-

<table>
<thead>
<tr>
<th>Area of private theories</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Students</td>
<td>How the institute's students learn, their limitations, their ability to use technology for learning and collaboration</td>
</tr>
<tr>
<td>2. Learning</td>
<td>Knowledge and how it is acquired, useful teaching and learning strategies, ways learning can be evaluated</td>
</tr>
<tr>
<td>3. Teacher</td>
<td>Teachers' roles in learning in a classroom and in a technology-based environment</td>
</tr>
<tr>
<td>4. Technology</td>
<td>Use of technology in a class before this study, ways in which technology-based learning differs from classroom learning, limitations and benefits of technology for learning</td>
</tr>
<tr>
<td>5. Design</td>
<td>Selection criteria for topics determining suitability for technology-based learning, planning and design of technology-based learning</td>
</tr>
<tr>
<td>6. Educational changes</td>
<td>Changes in society and their implications in education, ways in which such changes impact teachers and students</td>
</tr>
</tbody>
</table>

Table 3: Results for the four participating teachers

<table>
<thead>
<tr>
<th>Participant</th>
<th>Initial dominant area*</th>
<th>Prototype approach</th>
<th>Final dominant area</th>
<th>Final design approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tom</td>
<td>Technology</td>
<td>Direct instruction</td>
<td>Learning</td>
<td>Student-centred learning</td>
</tr>
<tr>
<td>Nicole</td>
<td>Students</td>
<td>Direct instruction</td>
<td>Students</td>
<td>Direct instruction</td>
</tr>
<tr>
<td>Jane</td>
<td>Teacher</td>
<td>Direct instruction</td>
<td>Teacher</td>
<td>Direct instruction</td>
</tr>
<tr>
<td>Eleanor</td>
<td>Learning</td>
<td>Student-centred learning</td>
<td>Learning</td>
<td>Student-centred learning</td>
</tr>
</tbody>
</table>

*Area that dominated a participant’s design decisions.

The literature often claims that one of the areas of teachers’ theories is predominant in their instructional planning (Borko & Shavelson, 1990; Howard et al., 2000; Lovat & Smith, 1990; Schönmer, 1990; Yinger, 1978). Other literature appears to assume that all areas of teachers’ theories are of equal importance for their instructional planning and technology integration (Moallem, 1998; Windschitl & Sahl, 2002). In this study, I noted that different areas dominated the design decisions of different teachers. Four out of the six areas of private theories were found to dominate the participants’ design decisions either at the beginning or at the end of the study. Table 3 indicates dominant areas for each of the participants at the initial and final stages of the study (as informed by the participants). These dominant focus areas were associated with previewed learning designs to establish a link between each of the dominant areas and the participants’ inclination towards student-centred or direct instruction practice.

Three of the prototypes (Tom’s, Nicole’s and Jane’s) at the beginning of the study were in the form of direct instruction. I observed that this understanding, although contradictory to the institute’s reform agenda, was in various ways encouraged by the management at the institute. During one of my discussions with the management, I noted beliefs that technology would save institutional resources by cutting the time that teachers spent teaching. Some managers believed that such products could consist of multimedia with audio, video, graphics, texts and animations, and the quality of media was often perceived as the most important indicator of a good technology-based learning model. The management also believed that technology would help to prepare students for examinations. One might argue, perhaps, that from an education technology practitioner’s perspective, the institution’s management should move beyond rhetoric when promoting student-centred practices and technology integration. A better chan-
for communication of initiatives could provide a solution to this problem of a perceived conflict between management policy and practice.

The participants also demonstrated some intentions to prepare students for examinations through the use of technology. Private theories related to assessment appeared to present potential limitations to the shifting of teacher thinking and practice in a student-centred direction. The participants appeared disposed towards perceiving evaluation as something prescribed by the institute rather than as a formative process leading to improved learning outcomes. Only one prototype, provided by Eleanor, contained student-centred activities and intentions for formative evaluation; however, she expressed concerns as to whether her students were capable of learning in this way and whether her colleagues and management would appreciate her approach.

There was a shift towards student-centred practice as observed from the participants' final designs. This observation supports claims by Dwyer et al. (1985–98) and Becker and Ravitz (1999, in Windschitl & Sahl, 2002) that teachers tend to become more constructivist as a product of technology integration experience. Tom 'transformed' through the experience and designed a student-centred learning model. For Eleanor, the shift was an extension of her belief in student-centred practice, increasing trust in her students and decreasing concern over whether colleagues and management would approve of her approach. For Nicole and Jane, this shift did not lead to a complete change; rather, their dominant focus areas of theories on students and the roles of a teacher led them to continue with direct instruction designs.

From the study, I have developed the understanding that when private theories about learning dominate the participants' design, their products tend to incorporate student-centred technology-based learning. When the other three areas of theory dominated design, it appeared to lead to a direct instruction model. This indicated that in the context of the institute's reforms, which emphasise a shift towards student-centred practice, the decisions of participating teachers should be dominated by their private theories about learning rather than by theories about students, technology or teacher.

Based on understandings gleaned from this study and my own experience as an education technology practitioner, I believe that an appropriate design framework could provide an effective intervention tool. This framework should be sensitive to the teachers' private theories and should initiate reflections that would lead them to focus on theories on learning. To maintain focus on learning, teachers should plan a learning task before any content resource is considered. Students should be considered in terms of their ability to successfully complete a learning task so that appropriate support can be planned. The design process should be sensitive to teachers' concerns about their technical skills, and teachers must be freed from institutional expectations to develop resources on their own. In addition, teachers should be offered training in the facilitation of technology-based learning.
Reflections

Units of private theories were extracted from the participants' reflections and written out on individual cards. The cards were sorted with the aid of the participants into the six areas of private theories. The fact that all the units of private theories derived from the participants' reflections fall into the six areas of private theories is an indication that these areas are valid in the context of the study. Theories about learning, technology and design appeared most frequently in the reflections. Considering that theories about learning appeared linked to student-centred designs, this observation indicates that reflection after exposure to exemplary technology integration practices was important in the context of the changes made by the participating teachers in line with the educational reforms at the institute. The reflection activity prompted the participants to consider their theories about learning, and if this area became predominant, the teachers' designs were likely to become student-centred.

Frequent reflections about design were expected considering the nature of the participants' involvement; that is, they were engaged in a design experience that virtually demanded such reflection. Similarly, frequent thinking about technology was expected through the study as the participants awoke to the wider possibilities of technology through the experience. Most of these reflections addressed concerns about the technical skills and limitations of available software and hardware at the institute.

Theories about teacher and educational changes appeared with moderate frequency in the reflections. The participants appeared to begin to explore the changing nature of their involvement in student-centred practices, and it seemed likely that this prompted some of their reflections. The final designs confirmed this observation, as there were increased attempts by the participants to plan for teacher involvements in support of the students' learning in an online environment. In their reflections on educational changes, the participants noted that changes were imminent, expressed the belief that they should happen and that the teachers themselves should go along with the changes. However, one participant reflected that many people were reluctant to accept changes; she suggested that in addition to personal resistance, this might be attributable to the ways in which these changes have been communicated and implemented by the management.

It is interesting that theories on students did not appear frequently in the reflections. Further to this observation, I might suggest that the reflection activity possibly reduced the participants' concerns about students, which limited student-centred design in the initial stage of the study. Some concerns about collaboration and the communication skills of the students appeared in the reflections. The participants noted that in Asian culture, people were not much open to discussion and were usually emotionally reactive to differences in opinion. In addition, there was a concern with English language skills. This thinking could lead to limited online collaboration, much of which necessarily involves language. The final designs triangulated this observation, as two participants did not plan for any online communication in their designs. The remaining two participants planned to use online communication; how-
ever, they expressed some doubts as to whether it was going to work with their current students.

*Emerging area of constraints to student-centred design practice*

The reflection activity appeared to lead the participants towards the examination of their theories about learning and away from concerns about students. However, although the reflection activity in this context was an important and positive strategy, this intervention did not necessarily result in coherent teacher change and student-centred designs. Certain constraints created negative influences on private theories on learning and led some of the participants to confine themselves to direct instruction design. These constraints could be identified, and an appropriate intervention should successfully address them. From the study, I understand that the challenges for intervention with teachers are (1) how to initiate their reflection and inquiry into their own theories about learning and (2) how to enable teacher thinking to remain dominated by private theories on learning throughout their design experience. An intervention must account for the issues that are likely to divert teachers' attention and result in direct instruction designs. Four emerging issues appeared to be contributing to a resistance to change and continued to drive the participants towards direct instruction: students, assessment, technology and management. These general constraining issues were noted in the reflections and within the private theories that the participants were seen to have maintained at the end of the study. These issues appear to emerge from two directions. On one hand, there are private theories about students (eg, learning abilities and confidence), assessment (eg, purpose of assessment) and technical skills (eg, confidence in one's own technical skills). Tugging in another direction are theories that largely came about as a result of intuitional influences. These included assessment (eg, frequency and mode of assessment), technology (eg, hardware and software provided) and management (eg, expectations and communication of initiatives).

I recognise that because the participants were not in classroom contact with their students over this period, they were unable to test their preliminary designs of technology-based learning with the students. Changes in teachers' private theories could potentially be extended through 'reflection in action' (Moallem, 1998). Further research should attempt to explore this proposition.

*Summary and recommendations for further studies*

Teachers' private theories mediate their design of technology-based learning. In this study, the participating teachers held theories in six broad areas: learning, students, teacher, technology, design and educational changes. In the case of each participant, one of these areas dominated the technology-based learning design. Four of these six areas were found to be dominant: learning, students, technology and teacher. The participants were generally inclined towards direct instruction. Technology-based learning tended to be understood as a product comprising explicit subject matter and electronic quizzes rather than as a process of knowledge construction. The dominant focus areas of the participants were: technology, students or teacher. Learning was found to be the only dominant area related to the design of student-centred learning.
This suggests that any intervention for the design of student-centred learning should ensure that theories on learning become and remain dominant. Reflection was an important activity that enabled the participants to closely scrutinise their theories on learning. Questioning their own theories on learning, however, did not necessarily lead the participants to student-centred practice. The constraints that prevented student-centred design arose from the participants' theories on students, assessment and technology and the impact of institutional influences on private theories in relation to assessment, technology and management. These four issues, essentially pulling in opposite directions, are the areas that interventions must address to structure changes to student-centred practice.

This study aims to add its outcomes to the existing knowledge concerning the design of technology-based learning and to teacher thinking in that context. The final outcome of the study provides insight into a particular group of teachers' private theories within the experience of technology-based learning design. The results of the study could help teachers to reflect on and more clearly articulate to themselves their private theories. If teachers could identify the theories that mediate their design, they are more likely to make better decisions regarding the means of implementing any desired changes. The understanding of teachers' theories is important in the context of educational reforms that emphasise technology and changes in teaching and learning towards student-centred practices. Administrators might find the study useful for planning change-management strategies for technology integration in their institutions. The study might also be useful for researchers. Further research might attempt to identify additional areas of teachers' theories which mediate their design decisions, explore the manner in which content knowledge mediates the design of technology-based learning, explore possible links between other areas of private theories and student-centred design practice, explore links between teacher reflection and intervention change agency and determine if specific intervention can be paired with specific areas of private theories and explore the relationship between the constraints and potential links between constraining theories.

References


