Teacher Inquiry into Student Learning:

The TISL Heart Model and Method for use in Teachers' Professional Development

Cecilie J. Hansen
Researcher, Technology for Practice, Uni Research Health, Norway.
E-mail: cecilie.hansen@uni.no

Barbara Wasson
Professor, Centre for the Science of Learning and Technology (SLATE) & Department of Information Science and Media Studies, University of Bergen, Norway.
E-mail: barbara.wasson@uib.no

PEER REVIEWED ARTICLE

ABSTRACT

Researchers have recently been calling for new models of teacher education and professional development for the 21st century. Teacher inquiry, where the teacher's own practice is under investigation, can be seen both as a way to improve day-to-day teaching in the classroom and as professional development for teachers. As such, it should also have a role in teacher education. In this article, we present the iterative development of the TISL Heart, a theory-practice model and method of teacher inquiry into student learning, which has a particular emphasis on the use of student results generated in the information and technology-rich classroom. This article proposes that this practice-near model is particularly relevant for teacher education, as it draws upon existing practices in using student data at a progressive school that focuses on the use of technology to enhance student learning. The article concludes by discussing the implications for its role in teacher education, particularly related to data literacy and its use in teaching.

Keywords

Teacher Inquiry, Teacher Inquiry into Student Learning, Teacher Education, Educational Professional Development

INTRODUCTION

Recently, researchers have been calling for new models of teacher education and professional development for the 21st century (e.g. Krumsvik, 2012; Wastiau, 2014). The OECD (2009) defines professional development as 'activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher' (OECD, 2009, p. 49). Professional development is often associated with an activity that is carried out separate from the practice of teaching itself (Clark, Luckin & Jewitt, 2011), and traditionally, this has taken place through courses and further education. In Norway, for example, there is currently pressure for teachers to develop their practice through more courses (Barth-Heyerdahl, 2013). This model of professional development demands

resources, such as time for teachers to be away from their classrooms to take courses and to prepare and deliver assignments, which means funding is required to pay for substitute teachers.

Freebody et al. (2008) suggest that teachers need to be innovators, researchers and knowledge builders, and as such, need to contribute to new pedagogical practices themselves. Teachers can inquire into and assess innovative practices, and share their findings with their professional community. Thus, an alternative or complementary approach to external courses is to support teachers in developing and improving their *existing practice through teacher inquiry.* Rooted in notions of teaching as a professional activity that can continuously be improved, *teacher inquiry* is a form of teacher research where the teacher's own practice is under investigation. Developing and researching teacher practice for the adjustment of one's own teaching should be a continuous practice in any teacher's career, and thus, the competence to carry out teacher inquiry needs to be developed during initial teacher education.

Teaching researchers have pointed out the importance of future teachers developing research skills during their education (Menter, Hulme, Elliot & Lewin, 2010; Bakken & Sollid, 2014). For example, Norway government reports show that education students should gain more practical experience in research and development, referred to as *active student research*, during their studies, meaning that candidates should develop *change and development skills* as the basis for the future school (Bakken & Sollid, 2014). Furthermore, the 2013 Norwegian curriculum for teacher training states that candidates should be able to contribute to innovation processes and conduct professionally-oriented scientific development projects with a high degree of autonomy to further develop their skills and contribute to both colleagues' and the school's academic and organizational development (Bakken & Sollid, 2014). For Butler, Schnellert and McNeil (2015), this can be achieved through *collaborative teacher inquiry focused on improving student learning.*

Wastiau (2014) refers to how teacher-training models for the 21st century need to be updated in both a quantitative as well as a qualitative manner. She calls for a paradigm shift for both initial teachers' training as well as professional development, although it is probably 'difficult to achieve through existing teacher education and training models' (p. 4). Agreeing with Darling-Hammond (2006), Wastiau argues for the need for new teacher training models that are based on the 21st century professional: a professional who *continuously* learns from his or her teaching, within a lifelong and life-wide context. The need for a new approach is also rooted in the change of tools and environment, as:

> …the role of the teacher in contemporary education systems requires reflective and multi-skilled professionals, able to design efficient and differentiated learning environments offering ubiquitous technology for better learning, with a high capacity for contextual judgment on which to act (Wastiau, 2014, p. 4).

Such demands require teachers to have the competence to carry out teaching inquiry in 21st century classrooms, and this competence must be addressed during initial teacher education. Furthermore, while 21st century technology and information-rich classrooms (Reimann et al., 2016) enable new pedagogy and new ways of learning, and generate new types of data that can be used for improving teaching and learning, they also provide new opportunities for teacher inquiry into student learning (Wasson & Hansen, 2016). These information and technology-rich classrooms generate a plethora of new types of student data that can be gleaned and utilised for improving teaching, assessment, feedback and feedforward. Teacher inquiry into how these data can improve these practices should be part of a teacher's own professional development. This also exacts new demands for data literacy and use (Wasson & Hansen, 2016).

In the European NEXT-TELL project (http://www.next-tell.eu/), one focus is on providing methods and tools to support teacher inquiry into student learning, with a focus on using student data generated in the information and technology-rich classrooms (Clark et al., 2011; Hansen & Wasson, 2013; Reimann et al., 2016; Luckin et al., 2016). In our research on teacher inquiry, we have developed the TISL Heart, a theory-practice model of teacher inquiry into student learning and a method for supporting its use by teachers. We propose that this practice-near model is particularly relevant for teacher education, as it draws upon existing practices in using student data at a progressive school that focuses on the use of technology to enhance student learning. Furthermore, our research on data literacy and use for teaching (Wasson & Hansen, 2016) identifies teacher inquiry using student data as a skill that teachers must develop in order to teach in the information and technology-rich classroom; thus, this needs to be addressed in teacher education. Understanding the relationship between teaching and student learning is important, not only for teachers, but also for student teachers, and emphasising this relationship during teacher education could lead to a more systematic approach in developing teachers' practice.

In this article, we present the development of the TISL Heart Model and Method of teacher inquiry into student learning, which supports evidence and data-based decisions based on student learning, and we argue for its use in teacher education. The article begins with a brief overview of literature related to teacher inquiry. Then the TISL Heart Model and Method, which are anchored both in theory and current teacher practice, are presented. The article concludes with a reflection on the importance of introducing teacher inquiry in teacher education.

Related Research

Developing teacher practice and the adjustment of teaching should be continuous practices in any teacher's career, and should begin during teacher training. Teachers in general reflect on the impact of their teaching plan on students, and they make adjustments based on their experience (Cierniak et al., 2012). This reflection over one's own teaching practice is part of professional development (Larrivee, 2000).

idunn.no
Nordiske tidsskrifter på nett

Research on how teachers could improve practice by conducting research on their own practice is not new (Clark, Luckin & Jewitt, 2011). Research traditions such as action research, teacher research, classroom research, practitioner inquiry and teacher inquiry, which emerged in the 1970s and 1980s, were not the first instances of an *insider focus*. Dewey, as early as in 1933, was expounding on the benefits of teachers' reflective practice (Lytle & Cochran-Smith, 1994; Cochran-Smith & Lytle, 1999; Ritchie, 2006; Dana & Yendol-Hoppey, 2009; Rich & Hannafin, 2008; Rust, 2009). While having different roots, each of these research traditions 'highlight the role classroom teachers play as knowledge generators' (Dana & Yendol-Hoppey, 2009, p. 3).

Teacher inquiry, which emerged in the late 1980s (Cochran-Smith & Lytle, 1999), is one form of professional development. The teacher inquiry process has been described as the *systematic, intentional, self-critical, planned investigations* into one's own teaching practice (Clark et al., 2011; Cochran-Smith & Lytle, 1993; Dana, Gimbert & Silva, 1999; Dana & Yendol-Hoppey, 2009), as 'focused on providing insight into a teacher's classroom practice in an effort to make change' (Dana & Yendol-Hoppey, 2009, p. 2), and as 'a bridge connecting research, practice, and education policy and as an important and practical way to engage teachers as consumers of research' (Rust, 2009, p. 1882). In their extensive survey of the literature, Clark et al. (2011) found that 'key characteristics that may contribute to a broadly conceptualised definition of teacher inquiry include the notion that it is: systematic, intentional, contextual, self-critical, practical, action oriented, planned, evidence-based, evaluative, and shared' (p. 8), and the main challenge lies in transforming a teacher's *personal* skills, knowledge and expertise into *professional* skills, knowledge and expertise.

Still, what is new in this area is how technology brings a new dimension to the ability to investigate and improve one's own practice, both in *supporting* the teacher inquiry process and in the *collection* of evidence in the form of student data. Some researchers have focused on the role of student data in teacher inquiry, although not on student data generated by the use of technology tools and applications. One of the major works on teacher inquiry and student data is that of Timperley, Wilson, Barrar & Fung (2007). Their '*Teacher Inquiry and Knowledge-Building Cycle*' (See Figure 1) was developed based on a literature survey of ninety-seven studies. While they found that assessment was never an isolated component of professional development, they found that approximately fifty per cent of the core studies made specific reference to teachers developing their understanding and use of assessment *as a part of their professional development* focusing on the skills of *interpreting and using data*. In all these studies, assessment was used to provide an analysis of the teaching–learning relationship for the purpose of improving teaching. Student learning was seen to be a function of teaching, and assessment provided the information to improve and refine teachers' understanding of that relationship. Assessment information was used in various ways to identify the next steps for teaching at individual, class and programmatic levels, as well as for providing the motivation for teachers to engage in professional learning.
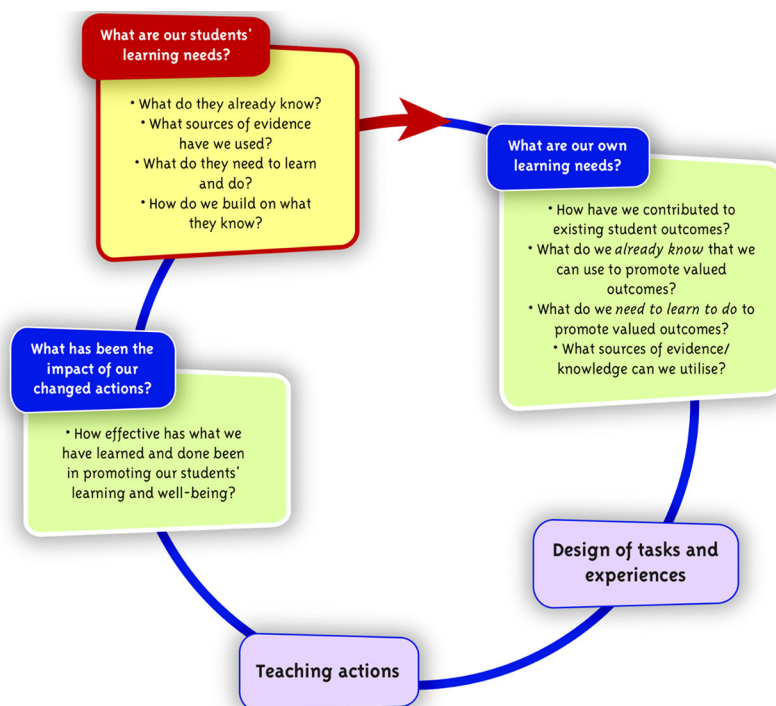
Figure 1

Assessment was also used as a tool for reflecting on the effectiveness of teaching practice with particular students so practice could be either confirmed or revised for the next group. Timperley et al. (2007) also found that such interpretations and uses of assessment information were often addressed in the core studies. Good assessment information allows for targeted teaching, but can only serve this purpose if teachers are focused on the teaching-learning relationship and how to improve it. Without this focus, they found that assessment instead would become a tool for labelling students.

Others, though, have taken the perspective regarding tools that have been used to implement teacher inquiry. For example, Daly et al. (2009) in their study of teacher CPD (continuing professional development) with ICT (information and communication technology), argue from a technology perspective and suggest '...teachers need to use social software such as blogging and podcasting to support inquiry into their practice and ... need to learn how to work with Web 2.0 and integrate technologies into their everyday lives' (p. 37). In their extensive overview, Clark et al. (2011) identified a number of tools in use to support teacher inquiry, including data capture and analysis tools (Dawson, 2007), discussion forums, video tools, chat, teacher e-portfolios (Barab, MaKinster & Scheckler, 2003), learner portfolios (Penman, 2010), video analysis tools (Rich & Hannafin, 2008), Web 2.0 tools such as Flickr, blogs and Skype (Smith, Underwood, Walker, Fitzpatrick, Luckin, Benford, Good & Rowland, 2007), and data visualisation tools (Lee & Bull, 2008). The growing use of technology in teacher practice opens for a shift from researcher-centred studies to teacher-centred approaches to inquiry, and it requires inquiry meth-

ods that will *support and guide teachers* and enable them to participate in evidence-centred and evidence-based decision-making (Clark et al., 2011). It is this turn towards evidence-centred methods and teaching design that teacher inquiry into student learning (TISL) aims to support. This will require technology that can support practitioners in the teacher inquiry process and in the use of student data for evidence-based decision-making. To date, however, there are no dedicated methods or little such technology to support practitioners in the use of student data in the inquiry process. Furthermore, although there is an increasing amount of data that can be used for evidence-based decision-making, as Wayman (2005) explains, practitioners do not have the competence to 'view their craft and their students' learning through the information lens' (p. 301). This links specifically to the needs for teachers to build their data literacy and use for student learning (Wasson & Hansen, 2016).

In the NEXT-TELL project (Reimann et al., 2016), we address these issues through the development of the TISL Heart, a model and method to support teacher inquiry into student learning. In addition, we have developed a number of formative assessment tools, such as RGFA (Vatrapu, 2016) and PRONIFA (Kickmeier-Rust et al., 2014; Kickmeier-Rust & Albert, 2016), which enable teachers to use real-time learning and visual analytics (Vatrapu, Teplovs, Fujita & Bull, 2011) for visualising student learning information that can inform formative feedback and pedagogical intervention. The tools can also aggregate and store the learning results in an Open Learner Model tool (Bull et al., 2012; Bull et al., 2016) that visualises student competence development. This article focuses on the iterative development of the TISL Heart.

TISL in NEXT-TELL

Teacher Inquiry into Student Learning (TISL), our approach to teacher inquiry in NEXT-TELL, sees the classroom as a learner-centric, technology-rich ecology of resources (Luckin, 2010; Luckin et al., 2016), where there is a plethora of student data available. At the core of TISL is an extension to the principles of teacher design research (Bannan-Ritland, 2008) to include a teacher's focus on the use of student data for innovation and change, as explained by Clark, Luckin & Jewitt (2011):

> TISL does not focus on the assessment design of students' learning – rather it aims to engage teachers in developing a deeper understanding of the role, purpose and value of student data at both strategic and classroom level, i.e. in relation to their own professional growth as teacher practitioners and in the alignment of their professional development activity with schools' strategic planning goals as a tool for sustained innovation and change (p. 11).

One key to using student learning for developing one's own practice is the ability to find research questions driven by one's own interests, which imparts the ownership of questions and findings. This may encourage change that is derived from one's own inquiry (Clark, Luckin & Jewitt 2011). Thus, the chal-

lenge is to support and scaffold the process of making personal inquiry into professional practice change.

Scaffolding the process of 'making the personal into the professional' by using technology and student data further distinguishes *teacher inquiry* from *teacher inquiry into student learning* (TISL). Clark, Luckin and Jewitt (2011) explain:

> TISL is a systematic, intentional, design-oriented approach to teacher's technology-supported inquiry into students' learning. It focuses on the development and use of formative e-assessment methods using advanced learning technologies (digital tools) to capture, analyse, interpret, share and evaluate student data. In so doing, it aims to contribute to the development of teacher professionalism and school improvement through a focus on teacher-centred, practice-based, evidence-oriented research activity (p. 13).

Teaching practice involves both teaching and assessment, and a key aspect of TISL is how to use assessment data to change teaching. Assessment can be a summative assessment of learning or a formative assessment for learning. As Black and Wiliam (2004) point out, a formative assessment for learning must also adjust teaching – not just learning. This is the essence of our approach to TISL: the focus is on using student data to inform teaching practice. Furthermore, as today's classrooms become populated with digital tools, more and varied student data are accessible; this student data can be harnessed and interpreted by teachers and by automated processes (Bull et al., 2012; Bull et al., in press; Johnson & Bull, 2016), and used as evidence to inform teaching practice.

The first TISL model (See Figure 2), developed by the London Knowledge Lab (Clark, Luckin & Jewitt 2011), was a theoretical, seven-step model based on Timperley et al.'s (2007) model (Cf. Figure 1). Each step was meant to guide the teacher to investigate one's own students' learning in order to improve and change practice.
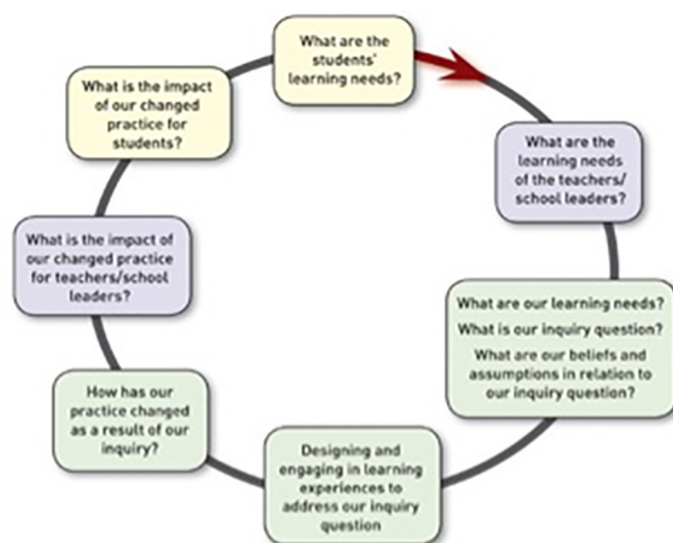

Figure 2

REFINING THE TISL MODEL AND METHOD

In our discussions with teachers about teacher inquiry, we had the impression that they already carried out aspects of TISL, but that the concept was too theoretical. Thus, in order to ground the theoretical model in practice, we carried out a series of studies as part of an iterative design process. We were interested in finding out if there were already aspects of TISL in current practice and if the teachers collect, analyse, use and share student data. The two iterations, described below, illustrate how current teacher practice informed a refined TISL Model and Method.

Iteration 1: From TISL to the TISL Heart

In order to investigate *how teachers currently use student learning* in order to develop and change their teaching, we invited teachers from our collaborating high school to a workshop that was arranged as three focus group interviews. These interviews centred on a series of questions related to Clark et al.'s (2012) TISL Model and Method, and they culminated in the teachers drawing a model of how they currently use student data to improve their teaching. Through analysis of the data, we developed the TISL Heart Model and Method. As the TISL Heart builds on the theoretical version of the TISL Model and Method as well as on the practice models developed by the teachers, we refer to this as a theory-practice model.

Goals

A focus group study of current teaching practice was carried out with ten teachers at a technology-rich and information-rich school with these goals:

1   To investigate how teachers understand how they currently use student data to improve their teaching.

2   To develop the TISL Model and Method.

A focus group method was used to carry out the research. Focus groups are a good method for gaining insight and an overview of common experiences, attitudes and aspects in environments where people interact and provide rich data (Malterud, 2012), with much interaction between the participants (Halkier, 2002).

Data Sources and Collection

The research fieldwork was carried out at Nordahl Grieg, an upper secondary school in Bergen, Norway, which since its conception in 2006 and opening in 2011 has had a focus on the use of technology to enhance students' learning experiences. Nordahl Grieg is a public school comprising three grades (VG1, VG2 and VG3) and students from ages sixteen to nineteen. The ten teachers participating in this study were natural science (STEM) and English (TESL) teachers, male and female, and teachers with long and short experience. Table 1 gives an overview of the participants.

TABLE 1 OVERVIEW OF STUDY PARTICIPANTS

Group	Teaching subject	Teaching Experience	Students Age	Gender
S-1	STEM (Mathematics, natural science, Gymnastics)	1 year	16	Male
S-1	STEM (Natural science, Biology, Chemistry, Economy)	16 years	15–19	Male
S-1	STEM (Mathematics, natural science)	½ year	15–19	Male
S-2	STEM (Mathematics, natural science, Gymnastics)	29 years	15–19	Female
S-2	STEM (Mathematics, natural science)	4 years	15–19	Female
S-2	STEM (Geography, natural science)	23 years	15–19	Female
E-1	TESL (English, Norwegian)	15 years	15–17	Female
E-1	TESL (English)	Unknown	15–18	Female
E-1	TESL (English)	Unknown	15–18	Female
E-1	TESL (English, Norwegian)	½ year	15–18	Female

The teachers were asked to divide themselves into three focus groups; the only criterion was to have English (TESL) teachers in one group. The STEM teachers organised themselves into two groups, resulting in one group of female and one group of male teachers. Thus, the groups comprised four TESL teachers (E-1), three male STEM teachers (S-1), and three female STEM teachers (S-2).

The session began with a plenary presentation introducing the idea of how teachers can conduct research on their own teaching practice, followed by an introduction to the first TISL model with an emphasis on the ideas of collecting, analysing and sharing data and further developing teaching and assessment based on these data.

After the introduction, the teachers were presented with a series of eight questions. Each question was individually projected on a whiteboard, and they were asked to discuss each question within their group for five minutes before being presented with the next question. The questions were:

1   Do you collect data on student learning? Why (not), and how?

2   Do you analyse data on student learning? Why (not), and how?

3   Do you share data on student learning? Why (not), and how?

4   What do you do with collected, analysed and shared data? Why (not), and how?

5   How do you further develop teaching based on collected, analysed and shared data? Why (not), and how?

6   How do you document the collected, analysed and shared data? Why (not), and how?

7   Is technology used to document, analyse and share data? Why (not), and how?

8   Is modelling used to plan teaching? Why (not), and how?

9   After the last question, the teachers were asked to draw a model of their own teaching inquiry practice.

The discussions were lively and focussed. The moderator (a researcher) mingled among the groups to make sure the questions were understood, and helped out on other issues that arose. The secretary (the other researcher) took field notes about the process, moving between the groups. The atmosphere was very good, and the discussions had a good flow in all the groups. The experience showed that this was a fruitful way of doing the focus groups, but also showed that teachers needed somewhere between five and ten minutes to discuss each question. If they were not ready to move on to a new question, they were given a few more minutes to finish their discussion. The short time, however, made the discussion very effective, and there seemed to be an expected 'causality/flow' in the questions.

During the focus groups, the following data were collected:

–   Audio recordings of three groups' discussions of the eight questions

–   Audio recordings of the three group discussions while they drew their model

–   Three drawings of models of how each group uses student data to improve student learning

The digital sound recordings comprise 91.45 minutes (S-1), 64.25 minutes (S-2) and 94.32 minutes (E-1). S-2 did not manage to turn on the recorder during the final modelling activity, so these data are missing.

Data Analysis

The audio recordings were transcribed in full. The data were analysed according to the goals of the study.

The interviews were analysed by two researchers to identify themes relating to how teachers currently use student data to improve their teaching. The coding began with each researcher interpreting the data and identifying units of analysis in relation to the teachers' perspectives. New themes emerged during this process, and they were constantly compared following the process of open

coding (Strauss & Corbin, 1990). The two researchers negotiated their identified themes, resulting in a set of twenty-two initial themes. Next, further analysis explored connections between the initial themes, resulting in their integration into eight higher-level themes:

1 Documentation

2 Collecting

3 Systematising

4 Analysing

5 Use of technology

6 Sharing

7 Use of student data

8 Change of practice

For example, the higher-level theme 'analysis' is analysed further into the sub-categories 'analyse data to improve my own teaching', 'how to analyse the data' and 'analyse data to know what feedback to give to students'. The coded data, grouped according to the higher-level themes, were examined for instances related to the teachers' understanding of their use of the student data.

The drawings developed by the teachers and their discussions of the TISL model were analysed iteratively. First, commonalities were identified among the teachers' models. Then the original TISL model was further developed to take into account the current practices. The data related to the discussions as they drew their diagrams were used for clarification and further understanding of their current practice.

Results and Discussion

Goal 1: Teacher understanding of current practice

The focus group discussions revealed that while teachers do carry out some form of teacher inquiry, they do not do so in a unified, systematic or structured way. The teachers collect and share data in order to develop their teaching practices, and they exchange experiences in order to help students develop. All the groups explained that they collect student data in different ways; there is not a unified way of collecting student data:

> 'Collecting data on student learning is something we do in different ways. We do this all the time. Continuously!' (S-2)

'We collect data when they have had tests, group work and projects, anything' (S-2).

'Something is collected on paper there and then, and we maybe write down that this worked' (E-1).

'I keep a little too much in my head, I think. Yes, you know that in a busy school day this is often reality that one does this, but I'm trying to record things' (S-2).

'It could have been more systematic; perhaps it would have had a positive impact on student learning, that is possible' (E1).

Furthermore, there does not seem to be a shared understanding or a common method for collecting, sharing and using data on student learning for further professional development of the teacher. Student data and observations are used to change practice for the group of students, and in this way, they are further developing their own teaching. For example, they explained:

'I must admit that I do this a little unstructured. Something collected on paper, something collected there, and then noting down that this worked' (E-1).

'In connection with tests or other assignments, you evaluate, or at least I do, so that you can use it the next time or make changes so you get a better plan the next time' (S-1).

'...and then we see if there's anything we can use, or change it a bit or make different so that it fits exactly the group we have. There and then. Is that not what we're doing'? (S-2)

The sharing of teaching practice and methods happens though teams, but this kind of sharing is not unified in structure. It was clear in the discussions, however, that even when they collected data and tied them to their practice, they remained unsure of why ideas worked or did not work.

We also found that the teachers had difficulty with some of the research language in the original TISL models; thus, we were interested in developing a model that was closer to their practice and used a language that was meaningful to them.

Goal 2: To develop the TISL Model and Method

The following factors further informed the development of the TISL Heart Model and Method: the teacher discussions about 1) how they collect, analyse, share, document and use data on student learning, 2) how they further develop teaching based on this data, and 3) how technology supports these processes, together with 4) their drawings of their current practice, and 5) the discussions regarding these drawings.

The teacher drawings
The teacher models (See Figure 3) were examined for similarities and differences, and the transcribed discussions of them planning, discussing and drawing them were used to clarify and further understand the models.
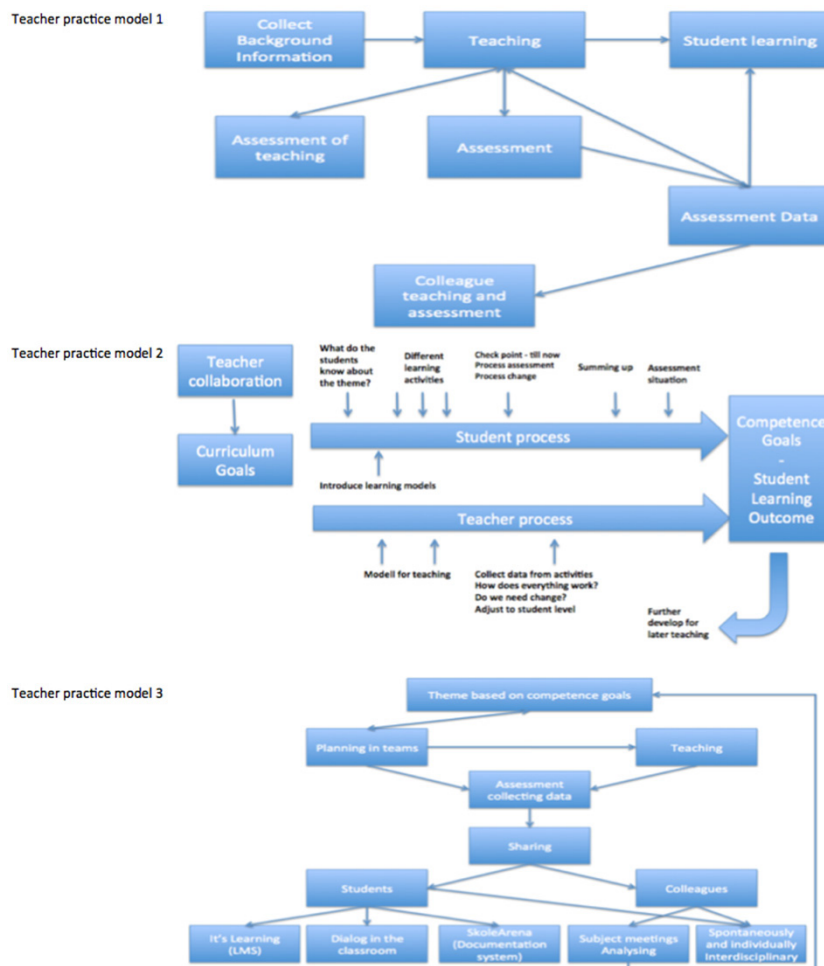

Figure 3

This initial analysis revealed similarities, including:

– The study of curricular plans and competence goals

– Designing activities (including assessments) to collect information about students' levels of competence

– Teaching based on competence goals

– Assessment of students' knowledge and skills related to the level of achievement

– Sharing of results and experience with colleagues and students

– Replanning and further development of teaching

The teachers were not at all used to modelling or visualising their practices, and while they found the modelling difficult, having them conduct discussions while drawing seemed to be most fruitful for scaffolding the process. For example, they explained:

> '...And then we have the second sharing with your colleagues [pointing to the model being drawn] either spontaneously or individually or across disciplines. Should we draw it? Otherwise, it happens at these technical meetings where we share experiences about what we felt the teacher got out of it, and how we felt it went' (T).

'But here [pointing to the model being drawn], you have a change in teaching, and then you see the results of the assessment afterwards. You can then see it in the students' grades later, and if there has been an increase in their results, you can then show your colleague...' (S-1).

The resulting models (See Figure 3) gave us a very good picture of their current practice. Although the models did not show a unified way of practicing inquiry and changing practice, it showed that they still had common elements in their practice, and elements of TISL.

The Joint Teacher-Practice Model
The analysed teacher models were merged into one Joint Teacher-Practice Model highlighting commonalities in their practices; see Figure 4. There were no major differences in their drawings, showing that all groups had very much the same perception of their practice. Planning learning activities was a very vital part of their practice, and it led to teaching, assessment and further learning outcomes for both teachers and students. One other crucial element that emerged in the models of their practices was the idea of sharing results with both colleagues and their students.
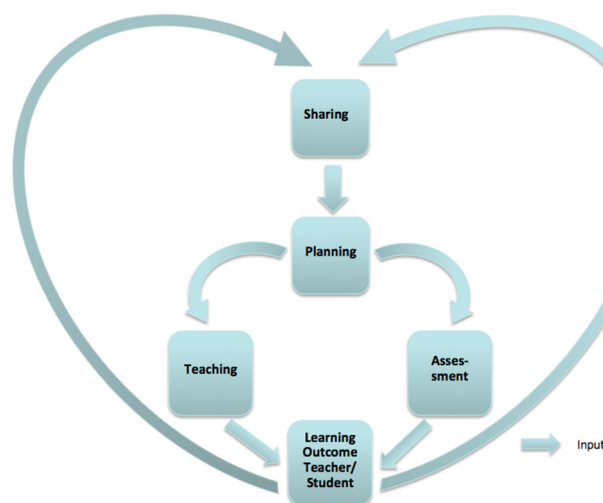

Figure 4

A comparison of Clark's initial Theoretical TISL Model (Cf. Figure 2) and the Joint Teacher-Practice Model revealed that elements were lacking in both models. The Joint Teacher-Practice Model captures the planning; teaching and assessment; and sharing, but the TISL Model's components of collecting and analysing student data for the concrete goal of developing practice were missing. It is this missing 'intention' of changing their practice through the use of student data that we have tried to capture in a theory-practice model. Thus, the Joint Teacher-Practice Model and the Theoretical TISL Model were merged into the *TISL Joint Teacher-Practice Model* (See Figure 5), which shows that planning leads to changes in the practice of teaching and assessment (the green arrows). Furthermore, the new model also captures other basic elements vital for improving practice: the movement of student data (blue arrows) and the analysing and systematising of new input to a current practice (purple arrows), in addition to the change of practice (green arrows).
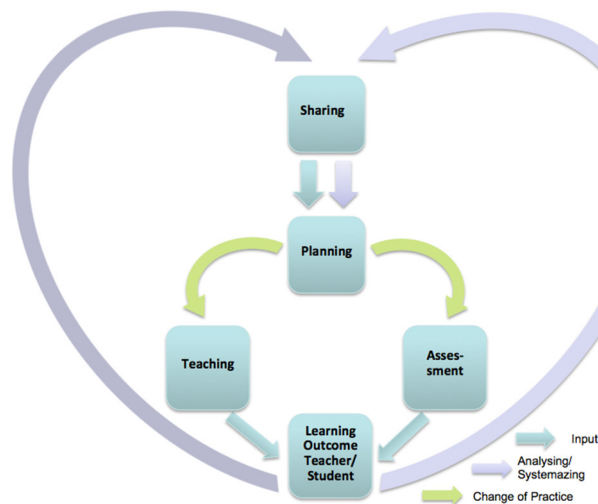

Figure 5

This theory-practice model is useful for researchers and for explaining the theoretical ideas behind teacher inquiry to practitioners, but we wanted a useable model that will guide the teachers through the inquiry process. Furthermore, a theory-practice model will support Cochran-Smith and Lytle's observation that 'a unique feature of the questions that prompt practitioners' inquiry is that they emanate from neither theory nor practice alone but from critical reflection on the intersections of the two' (Cochran & Lytle, 2009, p. 4). Thus, the next step was a final transformation to operationalise the model into a teacher inquiry model that is generalisable and useful for teachers interested in intentionally improving their practice. The result is the TISL Heart; see Figure 6.
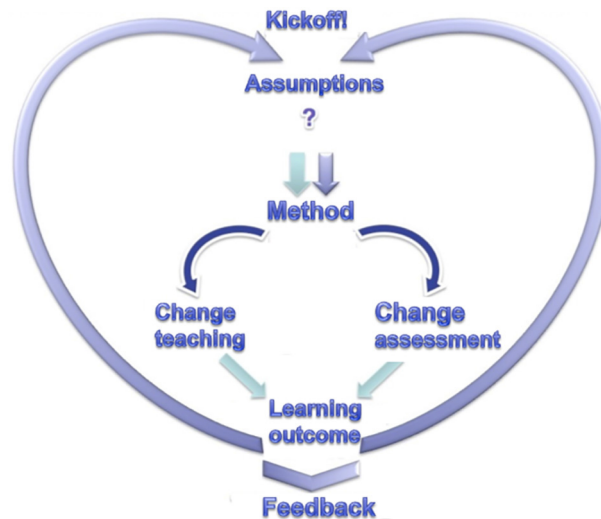
Figure 6

Literature within the field suggests that the formulation of a question is key to the teacher inquiry process, and that the question is rooted in practice (Rust, 2009; Butler, Schneller & MacNeil, 2015), and focused on student learning. For example, Butler et al. (2015) found that 'while the vast majority of teachers reported learning through collaborative inquiry, their commitment seemed strongest when they focused, not directly on themselves as learners, but on achieving improved outcomes for students' (p. 5). In order to capture this, the TISL Heart begins with the *Kick-off*, which is when a teacher first identifies the issues related to student learning in which s/he is interested. Related to these issues are *Assumptions* and beliefs that flavour the teacher's understanding of the issues. Aware of the issues and assumptions, a manageable *Research question* (shown as a question mark) needs to be formed – see also Luckin et al. (2016) for empirical work related to the identification of a narrow enough question to investigate. The research question ('?') feeds into the heart of the TISL Heart, the *Method*, which expounds how to collect student data to answer the *research question*. Student data are collected during teaching and assessment, and are fed into a *Learning outcome*, the analysis of which feeds into *Feedback* (for students), which is shared (with other teachers) and is used for reflection. This leads to new assumptions, new practice (teaching and assessment) and, thus, further change.

The TISL Heart is both a theory-practice model and a method for teachers to use student learning, activity and assessment data for professional development and better student learning. As a model, it captures the original Theoretical TISL Model and the essence of current practice, as synthesised from the group discussions and the drawings of current practice. In order to support teachers in the TISL Heart approach to teacher inquiry, the TISL Heart Method (See Table 2) was developed. Each of the seven steps provides trigger questions to lead the teachers through the method.

TABLE 2 THE TISL HEART METHOD.

The TISL Heart Model	The TISL Heart Method
Kick-off	Is there something you would like to know? E.g. What are the students´ learning needs?
Assumptions	State your assumptions! Formulate and explain your first thoughts from the Kick-Off!
Research question	Develop a research question! Formulate and reformulate!
Method	Find a method! How will you find/collect the answers?
Changing teaching and assessment	Change! Collect data from teaching and assessment!
Learning outcome	Analyse! What is the result of changed practice?
Feedback and sharing	Change based on evidence! Report!

Iteration 2: The TISL Heart in Use

In order to investigate whether the teachers understood the TISL Heart in use and to determine if it needs further refinement, we invited teachers from Nordahl Grieg to a workshop where they could plan a teacher inquiry project related to their own practice.

Goals

A workshop where teachers were introduced to the TISL Heart and led through the TISL Heart method was carried out with seven teachers at Nordahl Grieg upper secondary school (only two of the teachers had participated in the previous workshop) with the goal:

1   To investigate how teachers understood and used the TISL Heart method

2   To identify the requirements for a tool that would scaffold the TISL Heart method

Data sources and collection

Teachers at Nordahl Grieg were invited to a workshop on teacher inquiry. Of the seven participating teachers, three were STEM teachers, and four were language teachers (French, Spanish and two teachers of Norwegian to hearing-impaired students). Several teachers wanted to work together to plan a TISL project, so we ended up with three groups of two and one 'group' of one.

After an initial introduction to the TISL Heart, the teachers were asked to progress through the seven steps of the TISL Heart method. Differently coloured Bristol board posters, spread around the room, were used to represent the different steps with the questions from the method written on each corresponding poster. Each group was given a unique colour of Post-it notes that represented their unique project.

To create their TISL inquiry project, they started at step one, continued to step two, then three, and so on, at their own pace, discussing and answering the questions posed at each step on the corresponding poster. They had to be as concrete as possible and then write the decisions on Post-it notes that they then placed on the relevant poster (See Figure 7). In addition, they were given a voice recorder with which to record their discussions during the process and as we went through their Post-it notes with them after they were done.

During the workshop, the following data were collected:

– The posters with the Post-it notes for each group

– Audio recordings of the group discussions

– Audio recordings of the researcher discussion with each group

– Observation notes

Figure 7

Data Analysis

The teacher Post-it notes were transcribed into digital form and grouped first according to each step in the method and second according to each group, representing a plan for a TISL Heart inquiry project (See Figure 8 for the pink group's notes). The audio discussions were transcribed in full. The Post-it notes and transcribed discussions were analysed by two researchers, according to the goals of the study. Reading through the Post-it notes together with the transcribed discussions, we identified instances in the data that provided insight into the steps of the TISL Heart method and a desire for a technology tool to support the method.

Pink Group

---

1. Kick-off

Is there something you would like to know? E.g. what are the students' learning needs? What are your learning needs?

What do they (the students) know from before?

What should they know after a certain period, regarding the (national) curricula plans? What goals do the students have?

2. Assumptions

State your assumptions! Formulate and explain your first thoughts from the Kick-Off! Assess students' results. Think about how the students could be able to better show what they know or how to learn more.

3. Research question

Develop a research question! Formulate and reformulate!

How much can students improve their oral skills during one semester?

4. Method

Find a method! How will you find/collect the answers?

What do the student know now? How have we/they been working until now? – What do the teacher/student want the student to know? – Need a measurement method. Before and after period.

5. Changing teaching and assessment

Change! Collect data from teaching and assessment!

Assessment results and assessment method-

Teaching -> results -> teaching method

6. Learning outcome

Analyse! What is the result of changed practice?

Teacher assesses students' skills after learning situations. Can also have own reports from students (self-assessment) about own learning outcome.

The students have: *Increased / More skills or Same skills or Less strong (weak) skills*

It is just statistically that the method can be validated and for each single student many different factors play a role.

7. Feedback and sharing

Change based on evidence! Report!

Describe data and reflections and the choice of a new method.

Present findings, discuss and conclude.

Figure 8 TISL Heart Method post-it notes for pink group (translated to English)

Results and Discussion

Goal 1: To investigate how teachers understood the TISL Heart method

The Post-it notes and discussions revealed that they had some problems with the TISL method. It showed that some of the steps were difficult to understand, and in particular, the notion of '*assumption*' was difficult. In addition, as they were only planning their inquiry project and not carrying it out, the input to the last three steps was speculative. Accordingly, these steps will have to be examined more closely in a later study.

Their assumptions tended not to be assumptions, but rather questions or tasks for a method – even before they formed a clear question. The assumptions from four of the groups included:

– Assess students' results. Think about how the students could better show what they know or how to learn more.

– Are there competence goals where the whole class is weak? Teaching is not sufficient. What can be done better?

– Do the teaching methods work? Why or why not? Feedback from students. Look at yourself. Formative assessment. Student conversations.

– Use collected assessments/conversations (document) 'all info' to see if the changes have been leading to different learning outcomes.

After reviewing the Post-it notes together with the teachers, the discussions revealed that they tend to 'jump' to the research question when explaining their assumptions. The idea of the assumption step was to get the teachers to think about their kick-off issue and identify the beliefs they have about this issue. We discussed reversing method steps 2 and 3 so the teachers would make the kick-off concrete in step 2 with a research question, and then have them identify their assumptions in step 3. We decided, however, that the TISL Heart method, while influenced by practice, should be as closely related to a research method as possible. Being true to this, the steps were left alone, and rather, the step description was reformulated with helping questions and examples. The updated TISL Heart method is shown in Table 3, with the new text in bold.

In addition, step 6, Learning Outcome, with the description 'Analyse! What is the result of changed practice?' was difficult as they were not sure how they would analyse the data they collect. This was not surprising, and it highlights the fact that they will need more support with data analysis. This is part of a larger issue tied to data literacy related to an inquiry process (see Conclusions).

TABLE 3 REVISED TISL HEART METHOD BASED ON WORKSHOP FINDINGS (CHANGES IN BOLD).

Steps	Description
Kick-off	Identify something you would like to know about student learning? Something you wonder about? E.g., Why are some of the students not learning the material? What do the students think about my new learning materials?
Assumptions	Identify what you think are the reasons or explanations for the issue you identified in the Kick-off (step 1)? E.g., You think some of the students hold certain misconceptions! You believe that the students did not seem to like the new digital materials you used!
Research question	Develop a research question! Formulate and reformulate!
Method	Find a method! How will you find/collect the answers?
Changing teaching and assessment	Change! Collect data from teaching and assessment!
Learning outcome	Analyse! What is the result of changed practice?
Feedback and sharing	Change based on evidence! Report!

Goal 2: To identify the requirements for a tool that would scaffold the TISL Heart method

The discussions with teachers during the TISL workshop revealed that they would like a tool to support them in the inquiry process. These ideas from the discussions were talked about further with tool developers and resulted in a prioritised list of high-level requirements for such a tool:

1   First, it had to support professional development.

2   Visually, it had to look like the TISL Heart model and outline the steps of the TISL Heart method.

3   The scaffolding and leading questions following each step had to be easily viewed.

4   It had to be a quick and easy tool to use, preferably for tablets.

5   It had to be easy to connect steps in the process to student learning data, just one click away.

6   It had to be easy to share findings.

7   It had to be easy to generate a report for management and school leaders.

These priorities clearly identify that the teachers meant for the tool to be easy to use and support the TISL Heart method, with which they had already worked. A tool to support the TISL Heart is being developed by NEXT-TELL Polish partner BOC Information Technologies Consulting.

Conclusions

In the introduction of this article, we reviewed literature that argues for teacher education to build student teacher capacity in teacher inquiry (Freebody et al., 2008; Menter et al., 2010; Bakken & Sollid, 2014) and calls for new teacher-training models that are based on the 21st century teaching professional, who has to design learning environments that offer technology for better learning and who continuously learns from their teaching (Wastiau, 2014). Then we introduced the NEXT-TELL approach to teacher inquiry (Clark et al., 2011), where the focus is on the use of student data generated in technology-rich and information-rich classrooms. Motivated by observations that these classrooms produce a plethora of student data that can be used to improve student learning (see other publications from the NEXT-TELL project related to the students' use of data for reflection on their own learning, such as Bull et al., 2016; Johnson et al., 2016; and Kickmeir-Rust & Albert, 2016), we carried out a study on teacher inquiry at a progressive school in Bergen that focuses on the use of technology to enhance student learning. This article described the resulting iterative development of a theory-practice model to support *teacher inquiry into student learning*, which places student data at the centre of the inquiry process. The resulting TISL Heart Model and Method blend a theoretical model of teacher inquiry with teachers' own models of their current practices with investigating student data. A relevant question is whether the TISL Heart Model and Method are relevant for use in teacher education and by student teachers.

Using the TISL Heart requires not only the competence to carry out teacher inquiry, but it also requires data literacy. In related work, we explored the knowledge, skills and abilities required to make effective use of the new kinds of data and information available for teaching, assessment and diagnosing learning in the technology-rich and information-rich classroom. We developed a framework of data literacy and use for teaching and argued that digital competence needs to encompass data literacy (Wasson & Hansen, 2016). Due to the increased prevalence of technology in all aspects of the teaching practice, teachers are confronted with an enormous amount of data and information about their students; these data-rich work environments require new knowledge, skills and abilities to leverage the possibilities in and beyond these classrooms, and teacher inquiry into student learning is one way to do so. Furthermore, data literacy and use are highly relevant for both student teachers and practicing teachers in order to keep up with an increasing focus on formative e-assessment that uses educational data mining and learning analytics methods (e.g. Knight, Buckingham Shum & Littleton, 2014; Kickmeir-Rust et al., 2014; Vatrapu, Reimann, Hussain & Pantazos 2016).

Extending digital competence for teachers to encompass *data literacy and use for teaching* and *teacher inquiry using student data* is a necessity, but also a challenge. Much work on teachers' digital competence, as well as digital competence and teacher education (e.g. see the special issue in the *Nordic Journal of Digital Literacy*, volume 4, 2014, <http://www.idunn.no/dk/2014/04>), has

shown that teachers' digital competence is low and its place in teacher education is weak. For example, Krumsvik (2012) found that the digital competence of teacher educators was too low, while Tømte, Kårstein and Olsen (2013) found that 'the development of professional digital competence all over is weakly instituted at the management level of teacher education programmes, and that most programmes lack a comprehensive approach to the development of such skills' (pp. 243–244). Still, we support those who argue that it is necessary for the 21st century teaching professional to be able to handle student data and to use these data for professional development and to improve student learning (e.g. Butler, Schneller & MacNeil, 2015). We believe the TISL Heart offers a model and method that can be used to introduce these ideas during teacher education, in particular because it is more than a theoretical model and incorporates current practice in the use of student data.

Testing the model with student teachers will be an important next step. Open questions address the integration of teacher inquiry methods into teacher education. How should such a model be introduced, and when? (Perhaps for students in their last year, as some experience with teaching is necessary.) What challenges will student teachers have when implementing the method in their studies, and what competences will they need?

In conclusion, the ability to develop practice through the *inquiry of one's own practice* should be of interest for educational institutions, their student teachers and future workplaces, as well as for teachers, school leaders and policy makers. Understanding the relationship between teaching and student learning is important, not only for teachers, but also for student teachers. Emphasising this relationship during teacher education could lead to a more systematic approach in developing teachers' practice.

Acknowledgements

REFERENCES

Avramides, K., Hunter, J., Clark, W., Hansen, C., Wasson, B., Kossowski, M. & Hilemann, E. (2013). Methods and Specifications for TISL Components V3. European Commission IST-285114, NEXT-TELL Research Report D5.5, p. 44.

Bakken, J., & Sollid, H. (2014). *Forskende lærerstudenter*. Akademika forlag. ISBN 978-82-321-04215.s 12–18.

Bannan-Ritland, B. (2008). Teacher design research. An emerging paradigm for teachers' professional development. In A.E. Kelly, R. A. Lesh & J.Y. Baek (Eds.), *Handbook of design research methods in education* (pp. 246–262). New York: Routledge.

Barab, S.A., MaKinster, J.G. & Scheckler, R. (2003). Designing system dualities: Characterizing a web-supported professional development community. *Information Society,* 1 *9*(3), 237–256. DOI: 10.1080/01972240309466

Barth-Heyerdahl, L. (2012). Nå skal svake elever få bedre oppfølging, og lærerne skal få etterutdanning. TV2. Accessed 1/9/13: http://www.tv2.no/nyheter/politisk/stoltenberg-med-milliardloefte-til-skolene-4106602.html

Black, P.J., & Atkin, J.M. (1996). *Changing the subject: Innovations in science, mathematics and technology education,* London: Routledge.

Black, P., & Wiliam, D. (2004). Working inside the black box: Assessment for learning in the classroom, *Phi Delta Kappan,* Bloomington, Indiana, United States. Accessed 10/2/13: https://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/Synopsis_assessment.pdf

Bull, S., Wasson, B., Kickmeier-Rust, M., Johnson, M.D., Moe, E., Hansen, C., Meissl-Egghart, G. & Hammermüller, K. (2012). *Assessing English as a Second Language: From Classroom Data to a Competence-Based Open Learner Model*, ICCE 2012, November, Singapore.

Bull, S., Johnson, M.D., Masci, D. & Biel, C. (2016). Integrating and visualising diagnostic information for the benefit of learning. In P. Reimann, S. Bull, M. Kickmeir-Rust, R. Vatrapu & B. Wasson (Eds.). *Measuring and visualising competence development in the information?rich classroom.* London: Routledge, pp. 167–180.

Butler, D.L., Schneller, L. & MacNeil, K. (2015). Collaborative inquiry and distributed agency in educational change: A case study of a multi-level community of inquiry. *Journal of Educational Change*, *16*(1), 1–26. DOI: 10.1007/s10833-014-9227-z

Cierniak, G., Biel, C., Hesse, F., Craft, B., Hansen, C., Wasson, B., Hillemann, E., Meissl-Egghard, G., Hammermüller, K., Vatrapu, R. & Reimann, R. (2012). Report on RDS 2. European Commission IST-285114, NEXT-TELL Research Report D6.4, p. 90.

Clark, W., Luckin, R. & Jewitt, C. (2011). Methods and Specifications for TISL Components V1. NEXT-TELL. Next Generation Teaching Education and Learning for Life. European Commission IST-285114, NEXT-TELL Research Report D5.1, p. 92.

Cochran-Smith, M., & Lytle, S. (1999). The teacher research movement: A decade later. *Educational Researcher, 28,* 15–25. DOI: 10.3102/0013189x028007015

Cochran-Smith, M., & Lytle. S.L. (1993). *Inside/outside teacher research and knowledge*. New York, New York: Teachers College Press.

Cochran-Smith, M., & Lytle, S. (2009). *Inquiry as stance: Practitioner research for the next generation*. New York, New York: Teachers College Press.

Daly, C., Pachler, N. & Pelletier, C. (2009). *Continuing professional development in ICT for teachers: A literature review.* Coventry: WLE Centre, Institute of Education.

Dana, N.F., & Yendol-Hoppey, D. (2009). *The reflective educator's guide to classroom research: Learning to teach and teaching to learn through practitioner inquiry.* Thousand Oaks, CA: Corwin Press.

Dana, N.F., Gimbert, B.G. & Silva, D.Y. (1999). Teacher inquiry: Staff development for the 21st century. *Pennsylvania Educational Leadership*, *18*(2), 6–12.

Darling-Hammond, L. (2012). Policy frameworks for new assessments. In P. Griffin, B. McGaw & E. Care (Eds.) *Assessment and Teaching of 21st Century Skills,* 301–339. Springer Netherlands.

Dawson, K. (2007). The role of teacher inquiry in helping prospective teachers untangle the complexities of technology use in classrooms. *Journal of Computing in Teacher Education, 24*, 5–12.

Ellis, C., & Castle, K. (2010). Teacher research as continuous process improvement. *Quality Assurance in Education, 18,* 271–285.

Freebody, P., Reimann, P. & Tiu, A. (2008) *Alignment of perceptions about the uses of ICT in Australian and New Zealand schools*, Centre for Research on Computer Supported Learning and Cognition, Faculty of Education and Social Work, University of Sydney.

Hansen, C., Emin, V., Wasson, B., Mor, Y., Rodriguez-Triana, M.J., Dascalu, M., Ferguson, R. & Pernin, J.-P. (2013). Towards an integrated model of teacher inquiry into student

learning, learning design and learning analytics. In Hernández-Leo, D., Ley, T., Klamma, R. & Harrer, A. (Eds.) *Scaling up Learning for Sustained Impact. Lecture Notes in Computer Science*, Vol. 8095 (pp. 606–607). London: Springer (8th European Conference on Technology Enhanced Learning, 3, September 17–21, 2013. Paphos, Cyprus).

Hansen, C., & Wasson, B. (2012). Teachers' inquiry into students' learning: Studying and supporting teachers' professional development. In Cierniak, G., Biel, C., Hesse, F., Craft, B., Hansen, C., Wasson, B., Hillemann, E., Meissl-Egghard, G., Hammermüller, K., Vatrapu, R. & Reimann, R. (2012). Report on RDS 2, Chapter 6. European Commission IST-285114, NEXT-TELL Research Report D6.4.

Hattie, J., & Timerperly, H. (2007). The power of feedback. *Review of Educational Research, 77*, 81–112. Accessed October 2013. Available at: http://rer.aera.net. DOI: 10.3102/003465430298487

Johnson, M.D., & Bull, S. (2016). Designing for visualisation of formative information on learning. In P. Reimann, S. Bull, M. Kickmeir-Rust, R. Vatrapu & B. Wasson (Eds.). *Measuring and Visualising Competence Development in the Information?rich Classroom.* London: Routledge, pp. 221–234.

Kickmeier-Rust, M., Bull, S. & Meissl-Egghart, G. (2014). Collaborative language learning in immersive virtual worlds: Competence-based formative feedback and open learner modelling. *International Journal of Serious Games, I*(II), 67–74.

Kickmeier-Rust, M., & Albert, D. (2016). Competence-based knowledge space theory: Options for the 21st century classroom. In P. Reimann, S. Bull, M. Kickmeir-Rust, R. Vatrapu & B. Wasson (Eds.) *Measuring and Visualising Competence Development in the Information?rich Classroom.* London: Routledge, pp. 109–120.

Knight, S., Buckingham Shum, S. and Littleton, K. (2014) Epistemology, assessment, pedagogy: where learning meets analytics in the middle space, *Journal of Learning Analytics*, , 1(2) pp. 23–47. DOI: 10.1145/2460296.2460312

Krumsvik, R. (2012). Teacher educators' digital competence. *Scandinavian Journal of Educational Research*, *58*(3), 269–280. DOI:10.1080/00313831.2012.726273

Larrivee, B. (2000). Transforming teaching practice: Becoming the critically reflective teacher. *Reflective Practice, 1*(3), 293. doi:10.1080/713693162.

Luckin, R. (2010). *Re-designing learning contexts: Technology-rich, learner-centred ecologies*, London: Routledge, pp. 74–91.

Luckin, R., Hansen, C., Wasson, B., Avramides, K., Hunter, J. & Oliver, M. (2016). Teacher inquiry into students' learning: Research pedagogical innovations. In P. Reimann, S. Bull, M. Kickmeir-Rust, R. Vatrapu & B. Wasson (Eds.). *Measuring and visualising competence development in the information?rich classroom.* London: Routledge.

Lytle, S.L., & Cochran-Smith, M. (1994). Inquiry, knowledge, and practice. In S. Hollingsworth & H. Sockett (Eds.), *Teacher research and educational reform: Ninety-third yearbook of the National Society for the Study of Education* (pp. 22–51). Chicago: University of Chicago Press.

Mandinach, E.B., Honey, M. & Light, D. (2006). A Theoretical Framework for Data-Driven Decision Making. AERA, San Francisco.

Mislevy, R.J., Almond, R.G. & Lukas, J.F. (2003). A Brief Introduction to Evidence-centered Design. College Park, Maryland: College of Education at the University of Maryland. http://www.education.umd.edu/EDMS/mislevy/papers/BriefIntroECD.pdf

OECD (2009). Creating Effective Teaching and Learning Environments: First Results from TALIS. p. 306 – ISBN 978-92-64-05605-3

Penman, A. (2010). Enhancing Learning through Innovative ICT, Reforming Assessment Conference, Oct. 2010, London, UK.

Reimann, P., Bull, S., Kickmeir-Rust, M., Vatrapu, R. & Wasson, B. (Eds.) (2016). Measuring and visualising competence development in the information?rich classroom. London: Routledge.

Rich, P., & Hannafin, M. (2008). Capturing and assessing evidence of student teacher inquiry: A case study. *Teaching and Teacher Education, 24*(6), 1426–1440. DOI: 10.1207/s15327671espr1003_5

Rust, F. (2009). Teacher research and the problem of practice. *The Teachers College Record,* 111, 1882–1893.

Smith, H., Ng, KH., Walker, K., Underwood, J., Heldt, S., Fitzpatrick, G., Luckin, R., Good, G., Wyeth, P. & Benford, S. (2007) Reconstructing mobile learning experiences with multiple data streams. In *Proceedings of the Workshop on Research Methods in Informal and Mobile learning (MIL-RM*), Institute of Education, London, Dec. 2007.

Timperley, H., Wilson, A., Barrar, H. & I. Fung (2007). Teacher Professional Learning and Development: Best Evidence Synthesis Iteration. Wellington, New Zealand: Ministry of Education.

Utdanningsdirektoratet (2010). Vurdering på ungdomstrinnet og i videregående opplæring, Oslo. Accessed 1/6/14: http://www.udir.no/PageFiles/Vurdering%20for%20laring/ Dokumenter/Hva%20er%20vurdering%20for%20laering/ Vurdering%20for%20l%C3%A6ring%20i%20forskriften/2/ Ny%20vurderingsforskrift_8-10_nett.pdf

Vatrapu, R., Reimann, P., Hussain, A. & Pantazos, K. (2016). Repertory grids for formative assessment: Concept, method, tool, and findings. In P. Reimann, S. Bull, M. Kickmeir-Rust, R. Vatrapu & B. Wasson (Eds.). *Measuring and visualising competence development in the information?rich classroom.* London: Routledge, pp. 121–136.

Vatrapu, R., Teplovs, C., Fujita, N. & Bull, S. (2011). Towards Visual Analytics for Teachers' Dynamic Diagnostic Pedagogical Decision-Making, In Proceedings of the 1st International Conference on Learning Analytics and Knowledge (LAK '11), 93–98. ACM, New York, NY, DOI=10.1145/2090116.2090129 http://doi.acm.org/10.1145/ 2090116.2090129

Vygotsky, L. (1978). *Mind in society: Development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wasson, B., & Hansen, C. (2016). Data literacy and use for teaching. In P. Reimann, S. Bull, M. Kickmeir-Rust, R. Vatrapu & B. Wasson (Eds.). *Measuring and visualising competence development in the information?rich classroom.* London: Routledge, pp. 56–73.

Wastiau, P. (2014). From face to face to online teacher professional development – Paving the way for new teacher training models? *Nordic Journal of Digital Literacy*, *9*(1), 4–5.

Wayman, J. C. (2005). Involving teachers in data-driven decision making: Using computer data systems to support teacher inquiry and reflection. *Journal of Education for Students Placed at Risk*, *10*(3), 295–308.