Lesson Planning and Students' Performance Feedback Data Use

by

Tesfaye Getinet Kibret

A Dissertation Submitted to Faculty of Psychology in Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

University of Koblenz-Landau, Campus Landau

April, 2016

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Declaration

I, the undersigned, declare that this dissertation is my original work and has not been presented for a degree in any other universities, that all sources of material used for the dissertation has been duly acknowledged.

Name of the candidate Tesfaye Getinet Kibret

Signature TesfayeG.Kibret

Date 5 April, 2016

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Dissertation Committee:

Professor Dr. Ingmar Hosenfeld, Supervisor ________________________

Head of the Institute of Center for Educational

Research, Campus Landau

Professor Dr. Alexander Kauertz, Co- Supervisor ________________________

Head of the Department of Physics Didactics,

Campus Landau

Professor Dr. Manfred Schmitt ___________________________

Chairman of the dissertation committee

Vice Dean of the Faculty of Psychology

Abstract

This study had two main aims. The first one was to investigate the quality of lesson plans. Two important features of lesson plans were used as a basis to determine the quality of lesson plans. These are adaptability to preconditions and cognitive activation of students. The former refers to how the planning teacher considers the diversity of students pre-existing knowledge and skills. The latter refers to how the planning teacher sequences deep learning tasks and laboratory activities to promote the cognitive activation of students. The second aim of the study was to explore teachers thinking about and explanation of externally generated feedback data on their students' performance. The emphasis here was to understand how the teachers anticipate planning differentiated lessons to accommodate the variations in students learning outcomes revealed by the feedback data. The study followed a qualitative approach with multiple sources of data. Concept maps, questionnaires, an online lesson planning tool, standardized tests, and semi-structured interviews were the main data collection instruments used in the study. Participants of this study were four physics teachers teaching different grade levels. For the purpose of generating feedback for the participant teachers, a test was administered to 215 students. Teachers were asked to plan five lessons for their ongoing practices. The analysis showed that the planned lessons were not adapted to the diversity in students pre-existing knowledge and skills. The analysis also indicated that the lessons planned had limitations with regard to cognitive activation of students. The analysis of the interview data also revealed that the participant teachers do not normally consider differentiating lessons to accommodate the differences in students learning, and place less emphasis on the cognitive activation of students. The analysis of the planned lessons showed a variation in teachers approach in integrating laboratory activities in the sequence of the lessons ranging from a complete absence through a demonstrative to an investigative approach. Moreover, the findings from the interviews indicated differences between the participant teachers espoused theory (i.e. what they said during interview) and their theory- in –use (i.e. what is evident from the planned lessons). The analysis of the interview data demonstrated that teachers did not interpret the data, identify learning needs, draw meaningful information from the data for adapting (or differentiating) instruction. They attributed their students' poor performance to task difficulty, students' ability, students' motivation and interest. The teachers attempted to use the item level and subscale data only to compare the relative position of their class with the reference group. However, they did not read beyond the data, like identifying students learning needs and planning for differentiated instruction based on individual student's performance.

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ACKNOWLEDGMENTS

I am grateful to my supervisors, Professor Dr. Ingmar Hosenfeld and Professor Dr. Alexander Kauertz, for the personal and academic qualities they shared with me on my dissertation. I would like to thank Professor Ingmar Hosenfeld, who has helped me through academic and personal obstacles that I have met during my study. His oral and written comments were educative, helpful, and appropriate. I want to thank him especially for his detailed comments and suggestions on this study, and many thought-provoking conversations that we had concerning feedback data use. Professor Ingmar has established a stress-free advisor-advisee relationship. His openness to new ways of seeing, his appreciation of the difference in human thoughts about how they view the world, his confidence in my ability, and his insightful feedbacks powered me to keep progressing despite the challenging situations I was in during my doctoral study. I am immensely grateful for his insightful comments, helpful suggestions, challenging questions, and constructive feedbacks. I would especially like to thank him for his good heart, friendly face, encouraging words, and positive attitude. More than all, I appreciate for the space he had in his heart for me which enabled me to realize the completion of my dissertation. I would also like to thank my co-supervisor, Professor Dr. Alexander Kauertz, who has spent his energy and valuable time during the course of my study. He helped me in establishing link with other scholars working at other universities in a similar area. This helped me a lot in getting available data collection instruments like the online lesson planning tool we used. Professor Alexander also helped me a lot particularly in finding physics test items as well as in validating the test items I constructed that I used for the purpose of generating feedback data. His way of thinking made me stronger, to pay more commitment on my dissertation. The experience from him was a big lesson in my career, and would shape my way of seeing things. I owe special thanks to Moritz Kessel who helped me in translations, contacting participant teachers, rating lesson plans, and conducting interviews. I would like also to thank Laura Elisabeth who helped me in translations, and conducting interviews. My doctoral experience has been full of challenges. I owe special gratitude to those people who helped me during my distress time. I am thankful to all members of Graduate School of Teaching and Learning Processes, UpGrade, for all support they rendered me. I would like to thank the University of Koblenz-Landau, and The German Foundation of Sciences (DFG) for sponsoring and financing me for the first 21 months of my study time. My sincere thanks go to my sisters Mulunesh and Warkinesh, and my brother Berihanu. Thank you Berihanu for your endless encouragement and long distance phone calls. Last but not least, special thanks for my daughter Soreti Tesfaye, and my Sons Robsan Tesfaye, and Fraol Tesfaye for giving me permission to go away from you. My kids, you had a hard time during my absence for the study period, thank you for the sacrifice.

1 Introduction

Lesson planning is a complex process that involves analyzing students learning needs, delineating learning objectives, designing sequence of activities and tasks to promote cognitive development of learners, and planning for evaluating and reflecting on the outcomes of learning and teaching (Jalongo, Rieg, & Helterbran, 2007; Oser & Baeriswyl, 2001; Panasuk & Todd, 2005; Todd, 2005). A high quality lesson plan takes into account the cognitive activation of students and is adapted to preconditions. A lesson plan that takes into account the cognitive activation of students is characterized by the presence of deep learning tasks that are cognitively challenging and enabling students in constructing and applying knowledge (Baumert et al., 2010; Fullan & Langworthy, 2014; Neubrand, Jordan, Krauss, Blum, & Löwen, 2013; Oser & Baeriswyl, 2001). A lesson plan adapted to preconditions is characterized by differentiation of the lesson to accommodate the diversity of students' pre-existing knowledge and skills (Corno, 2008; Haynes, 2007; Liyanage & Bartlett, 2010; Panasuk & Todd, 2005; Stender, 2014; Vogt & Rogalla, 2009). It involves taking into account the different abilities, experiences, preferences, and interests of learners when planning and implementing a lesson. A lesson plan adapted to preconditions provides a range of alternative learning environments to accommodate the wide range of student needs. This depends, firstly on the ability of the teacher to identify students learning needs on the basis of an in-depth analysis of students learning data, and secondly on the creativity and ability of the teacher in applying and integrating learning and instructional theories, best practices outlined by research, and their lived experience.

To plan lessons customized to individual students learning needs, a teacher must base instructional decisions on students' performance data. One method of basing instructional decision on students' data is using externally generated feedback data on students' performance. Feedback from external assessments of student achievement provides teachers with information about the extent to which learners have achieved learning goals and educational standards. There are ample research reports that indicate the positive effects of feedback on students' performance (Black & Wiliam, 1998; Hattie, 1987; Hattie & Timperley, 2007; Irons, 2008; Kluger & DeNisi, 1996; Office of Economic Co-operation and Development [OCED], 2005; Pelligrino, Chudowsky, & Glaser, 2001; Protheroe, 2001). Motivated by the positive effects of feedback on students learning, policymakers and researchers urge educators to base instructional decision on students' performance data. For instance, policymakers argue that the only way to increase student achievement levels is to base instructional decisions on students data (Schildkamp & Kuiper, 2010); The Standing Conference of the Ministers of Education and Cultural Affairs of Germany(KMK, 2006) urges the use of feedback data for educational monitoring, quality assurance and development of school education; the Dutch school performance feedback system arise out of a belief in the power of feedback to learn and to produce change (Visscher, 2009). The No Child Left Behind (NCLB) in United States urged states to adopt test-based accountability systems to improve student performance (Marsh, Pane, & Hamilton, 2006). In addition to these, research reports reveal the importance of using assessment results to make informed instructional decisions (Schildkamp & Kuiper, 2010), and planning of lessons on the basis of an in-depth data analysis on student learning (Knapp, Swinnerton, Copland, & Monpas-Huber, 2006).

The reports on the positive effects of feedback on students' performance are primarily the case where teachers provide feedback and students receive it. In general, however, feedback can also be applied to contexts in which teachers are the recipients of externally generated feedback data on their students' performance. The effect of such externally generated feedback data on teachers lesson planning is not known. An evidence-based instructional development by teachers using information from external feedback on performance of students helps to close the gap between students' learning and the desired educational goals and standards. Teachers' use of feedback data on their students' performance for adaptation of lessons demands teachers to understand and interpret the feedback data, ask questions, anticipate the causes for underperformance, and develop adaptive lesson (Ben-Zvi & Garfield, 2004; Chun, 2010; U.S. Department of Education, 2011). Addressing diverse learning needs of students revealed by data interpretation demands adaptive planning and teaching. Adaptive planning and teaching requires an integration of subject knowledge, mandated standards and curricula, diagnosis of students' preconditions and learning processes, instructional strategies and classroom management (Carpinelli et al., 2008; Eylon & Bagno, 2006; Magnusson, Krajcik, & Borko, 1999; Oser & Baeriswyl, 2001; Shulman, 1986; Vogt & Rogalla, 2009).

Data on students learning are only useful if teachers bring concepts, criteria, theories of action, and interpretive frames of reference to ask questions about their students' learning, to formulate questions and hypotheses about students learning, and to develop an intervention strategies (Knapp et al., 2006; Schildkamp & Kuiper, 2010; Vanhoof, Verhaeghe, Verhaeghe, Valcke, & Van Petegem, 2011; Visscher, 2009). In evidence driven instructional planning, knowing the exact cause of underperformance is difficult (Visscher, 2009). However, teachers can ascribe (or attribute) reasons for their students' performance. On the other hand, teachers' attributions to students' academic success and academic failure influences the expectancies that teachers hold for students' future academic success which in turn influences teachers actions towards the failing students in their everyday teaching (Cooper & Burger, 1980; Georgiou, Christou, Stavrinides, & Panaoura, 2002; Guskey, 1982; Hall, Villeme, & Burley, 1989; Weiner,1985). Teacher related variables like teacher data literacy, teacher pedagogical content knowledge, teacher belief including their academic attributions influence teachers use of external feedback data on their students' performance in adaptively planning lessons.

In this study, the contents are organized into five chapters. The first chapter shortly introduces the contents and the organization of the study. The second chapter presents the review of related literature. This chapter consists of reviews on lesson planning, adaptive planning and teaching, integrating motivational principles into the sequence of instruction, quality of lesson plans, concept mapping as a lesson planning tool, assessment and feedback within the classroom context, feedback data use for instructional decision, data literacy, pedagogical content knowledge, and academic attribution. The review on lesson planning first presents an introductory idea on conceptualization of lesson planning, and the purposes of lesson plans. Second a bird eye view of approaches to lesson planning, and the categories of extant research on lesson planning were discussed. The third part discusses research based lesson planning which of course consists of three main stages. These stages are defining learning objectives based on content analysis and diagnosis of students' prior knowledge, designing research based lessons, and conducting a kind of action research to test the designed lesson and to refine it. The fourth part of the review on lesson planning explains standards based lesson planning. A model of standards based lesson planning and a protocol for developing standards based lesson plan were discussed. The fifth section discusses four stages of lesson planning that include developing cognitive objectives, designing homework, planning the developmental activities, and constructing mental activities. The sixth section presents a Metacognitive Strategy Framework for lesson planning. This section details how the metacognitive strategies of advance organization, self-management, organizational planning, directed attention, selective attention, self-monitoring, and self-evaluation can be used in planning the content of the lesson, planning for the implementation of that content, and planning for the evaluation of both teaching and learning outcomes.

The review of literature on adaptive planning and teaching presents on how teachers account students' cognitive learning differences both individually and in a socio-cultural context of the classroom. Following this, techniques of integrating motivational principles into the sequence of instruction were discussed. This part details some motivational principles and models that have been in use to incorporate motivational strategies when designing lessons. One of the main focuses of this study was to understand how teachers accommodate the diversity in students pre-existing knowledge and skills, and how they thoroughly sequence deep learning tasks to account for the cognitive activation of students. These two important features are discussed in detail under the section quality of lesson plans. Afterwards, concept mapping as a lesson planning tool was elaborated.

The most important focus of this study was to investigate how teachers use externally generated student performance feedback data to customize and adapt lessons to students learning needs. Accordingly, literatures on assessment and feedback data were reviewed. In the seventh section of the review of related literature, assessment and feedback within classroom context is presented. Following this, feedback data use for instructional decisions was discussed. This part details data use framework to improve instruction, and factors that influence the effectiveness feedback data use. The ninth section of the review of literature discusses about data literacy and research on teachers data literacy. Finally, pedagogical content knowledge, and academic attributions were discussed.

The third chapter discusses the research questions that guided the study. The fourth chapter deals with the research design and participants, data sources and instrument of data collection, the research procedure, and method of data analyses. The fifth chapter presents result and discussion of the findings, conclusion, and limitations of the study.

2 Review of Related Literature

2.1 Lesson Planning

2.1.1 Introduction.

Lesson planning is the most important part of teaching, and of improving students learning. This is because it provides teachers with opportunities to plan instructional activities to more effectively meet students' learning needs and/or to differentiate instruction to enable all students to benefit from instruction. Through planning, the teacher organizes and structures instructional activities to stimulate the cognitive activation of students (Oser & Baeriswyl, 2001). Oser and Baeriswyl (2001) also argued that through planning teachers are expected to create both the visible structure of a lesson (concrete activities of students) and the deep structure of learning (the cognitive operations of students). However, the authors claimed that most teachers organize only the conditions for the concrete activities of students over the inner mental activities of learners. The processes of lesson planning is a complex activity that demand the planning teachers (1) to design lessons for activating learning by taking into account both learners prior knowledge and learners motivation; (2) to anticipate the kind of mental activities to take place when students learn the planned lesson, (3) to plan different kinds and levels of supporting individual students in their learning, and (4) to plan how to assess the outcomes of implemented instructional plans (Oser & Baeriswyl, 2001). Oser and Baeriswyl proposed four level scheme (model) of planning for teaching-learning. Firstly, the teachers anticipate the desired learning outcome and plan appropriate learning activities to achieve the desired learning. A teacher at this level creates a mental models focusing on what content to be taught and a step-by-step learning strategy. Secondly, the teacher plans the sequences of teaching (the visible structure of teaching). Thirdly, the teacher plans for sequences of learning (internal learning process) focusing on mental processes of the learner. Fourthly, the teacher anticipates both the cognitive and emotional learning product, and the teacher plan to measure the attainment of learning products (Oser & Baeriswyl, 2001, p.1034). In summary, the teacher plans for teaching activities, deep learning activities, and evaluation of learning products.

Lesson planning is a systematic development of instructional requirements, arrangements, conditions, and materials and activities, as well as testing and evaluation of teaching and learning. It involves teachers' purposeful efforts in analyzing the learning needs and developing a coherent system of activities that facilitates the evolution of students' cognitive structures (Panasuk & Todd, 2005). Lesson planning is an essential part of teaching and learning where the teacher integrates their experience of students learning, learning theories, theories of instructional design, and best practices outlined by research to satisfy students learning needs. When viewed from these points, the planning teacher integrates theory, research, and practice to plan a meaningful learning experience for students (Jalongo, Rieg, & Helterbran, 2007).

There is a normative idea that effective planning is an essential element of good teaching and of promoting student learning and achievement. The planning process helps the teacher to select goals; to develop learning activities, and to design appropriate assessments to evaluate and reflect on the outcomes of teaching and learning. Quoting Jacobsen, Eggen, and Kauchak (2006), Jalongo et al. (2007, pp. 44-45) explain four primary purposes for lesson planning: conceptual, organizational, emotional, and reflective. Lesson planning for conceptual purpose involves the planning teacher in answering the following questions: What knowledge, skills, or attitudes do teachers want students to learn? What conceptual decisions about student learning need and learning objectives to be considered? What sequence of activities would best serve meeting learning objectives? What types of assessments reflect the learnings achieved? Planning for conceptual purpose enables the planning teacher in making informed pedagogical choices by carefully attending to these questions. Planning for the organizational purpose involves taking into account available time, available materials, physical factors, and the needs of the students. Considering and planning for such organizational elements are very important for the implementation of the planned lesson.

Lesson planning for emotional purpose is concerned with the following questions: What confidence level exists when a teacher has done his or her "homework"? What level of anxiety exists when teachers know that they are underprepared? Planning for the purpose of reflection involves teachers to consider the following questions: What can be learned from experience? What does or does not work? What can be done to strengthen one's teaching? Engaging in these processes affords teachers an on-the-spot opportunity to adjust the lessons. Teachers need to proactively answer the above questions to plan a meaningful learning experience for students by making informed decisions on learning objectives as well as teaching objectives, sequences of activities, methods of teaching and learning, the kind of social structure, the what and the how of assessing students learning to evaluate, reflect and act on for further improvements. Ideally, teachers consider these elements to plan lessons by adapting to students pre-existing conditions such as the abilities and skills of their students, possible misconceptions, students' difficulties in understanding and materials or facilities required to gauge the instruction.

2.1.2 Approaches to lesson planning.

The first approach to lesson planning was the Tyler's (1949) framework, which explicates a linear sequence of events from statement of aims for a lesson, through selection and organization of learning activities, to evaluation of its delivery and outcomes (Jalongo et al., 2007; Liyanage & Bartlett, 2008). Tyler's linear model consists of a sequence of four steps: "(a) specify objectives, (b) select learning activities, (c) organize learning activities, and (d) specify evaluation procedures" (Clark & Peterson, 1984, p.28). Such approach of lesson planning consider teaching as a linear sequence of events directed by the teacher and linked to pre-defined objectives(Jalongo et al., 2007). The second approach, which is rooted in critical pedagogy, views lesson planning as "a way of challenging the status quo and empowering learners" (Jalongo et al., 2007, p.20). This approach emphasizes students' involvement in decision-making processes. Proponents of this group claim that "the linear progression of lesson plans to be an impediment to the professional progress of teachers" (Jalongo et al., 2007, p.14). Jalongo et al. (2007) reported that proponents of this group criticize teacher-directed sequence of events in the presence of a diverse group of learners and dynamic classroom situations.

The third approach is moderators which lie between the two extremes. Moderates argued that "lesson planning is one way of getting close to the normative idea of what was expected to take place in the class" (Jalongo et al., 2007, p.14). Proponents of this approach view planning as an important part of teaching where "the planning teacher pre-actively decides on sequence of activities through diagnosis of individual students learning needs to provide meaningful learning experience for all students" (ibid., p.14). Moderators place importance on planning to reflect on practice.

They argue that lesson planning is influenced by the teacher's prior classroom experiences, and reflecting on practice is essential to adaptively plan lessons to meet the learning needs. They favor some latitude in the format of plans and argue for increased functionality (Kagan & Tippins, 1992). Moderators argue that through planning

> teachers must find ways to make the content important and meaningful to students. They cannot simply tell students what they have figured out for themselves. Even when teachers work with prepared materials, they still have to clarify what they want students to learn, anticipate how students are likely to respond, and adapt teaching suggestions to fit their own situation. (Dorph, 1997, p. 470)

Moderators like Dorph (1997) raised some important questions that teachers need to consider when planning in particular how to integrate their subject matter knowledge and pedagogy to create learning opportunities for students, how to design, adapt, and implement lesson plans. These questions raised by Dorph (1997) were:

> How do teachers learn to consider content from the standpoint of their students? How do they make a shift from thinking about what they know and care about to thinking about what students need to learn and what they are likely to find interesting, puzzling, or significant? How do they learn to frame questions that invite multiple possibilities rather than one right answer and to build discussions around students' ideas? How do they develop the habit and skills to monitor their practice and its impact on students? (p. 470)

Jalongo et al. (2007) pointed out that "all the proponents of the three approaches seek to provide a much-needed scaffold for student learning and teacher effectiveness and desire to support teachers in achieving their full potential as educators, thereby promoting the learning of all students" (p.21). Despite the existence of these three approaches, there is no empirical evidence that indicates the relative effectiveness of each approach in the classroom. In line with this, Kagan & Tippins (1992) argued that everyday lesson plan qualifies as a myth in education because there is no empirically derived lesson plan format that captures what exemplary teachers do in the classroom. The authors noted that "although a variety of lesson plan formats are recommended for use by pre-service teachers, none of the formats are derived empirically" (Kagan & Tippins, 1992, p. 477). Clark and Peterson (1984) categorize research about lesson planning into two basic types. The first category is that

> researchers have thought of planning as a set of basic psychological processes in which a person visualizes the future, inventories the means and ends, and constructs a framework to guide his/her future action. This conception of planning draws heavily on the theories and methods of cognitive psychology. (p.18)

The second category is that researchers have defined planning as "things that teachers do when they say they are planning….a descriptive approach to research on teacher planning in which the teacher takes an important role as informant or even as research collaborator" (Clark & Peterson,1984, p.18).

As an educator and researcher, my philosophy of teaching and learning puts me in the domain of the moderators. Influenced by this, only researches on lesson planning which fall within this domain are reviewed for this study. The research on lesson planning reviewed for the purpose of this study includes research based lesson planning, standards- based lesson planning, the four stages of lesson planning strategy, and meta-cognitive strategy framework for lesson planning.

2.1.3 Research based lesson planning.

In an attempt to develop teachers knowledge of products of Physics Education Research (PER), Eylon and Bagno (2006) developed a research based professional development model for high-school physics teachers in designing lessons. Experienced high-school physics teachers participated in a long workshop program where they developed several lessons in teams using the model. The authors selected and offered appropriate topics which were relevant to the teachers' ongoing practices and identified as problematic in the physics education research literature to the participating teachers. Their model consists of ten consecutive steps organized into three stages. These steps and stages are summarized and presented in figure 1.

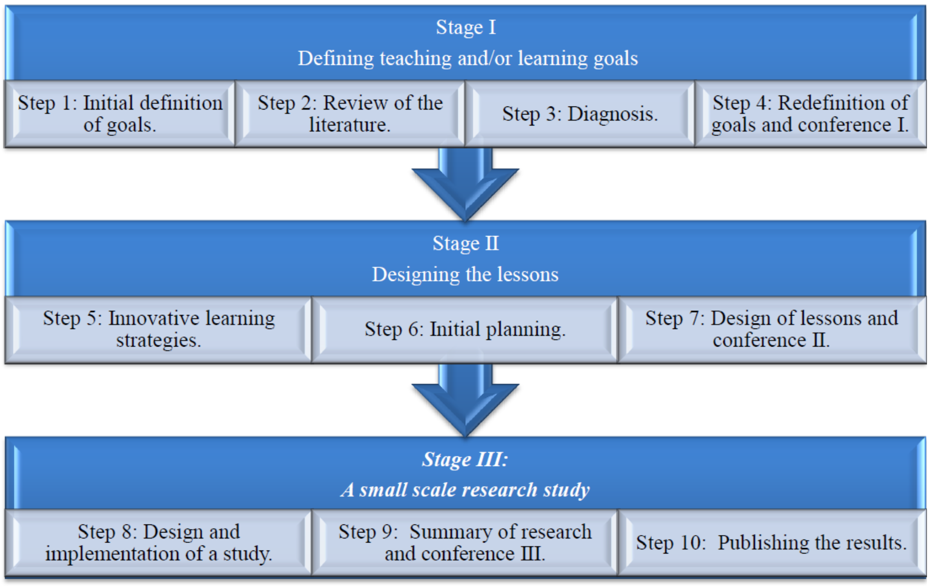

Figure 1. Research based lesson planning model.

The first stage in Eylon and Bagno's (2006) lesson planning model is "defining teaching and/or learning goals based on content analysis and diagnosis of students' prior knowledge" (p.3). The first step in this stage is the initial definition of learning and/or teaching goals for a particular concept or content. In this step, teachers individually construct a concept map describing the concepts and principles involved in their planned lesson, compare and discuss the maps with their peers ultimately coming up with group maps (Eylon & Bagno, 2006). In the second step, teachers review the literature on physics teaching as well as physics learning relevant to their topic. From the reviews teachers report the main learning difficulties and instructional strategies identified by physics education research. At the third step, teachers design, administer, and analyze a diagnostic questionnaire to examine students' level of understanding. At the fourth step, teachers redefine the initial goals on the basis of their findings emerging from the second and third steps. In the conference I, teachers discuss their initial concept maps; the review of the literature; the diagnostic tool developed to identify students' difficulties; the results of administering the diagnostic tool in the classrooms; and some preliminary thoughts for the planned lesson. The teachers summarize their work by incorporating the input of the conference participants. According to Eylon and Bagno (2006) stage I of the model enables teachers to identify problems encountered by them (as learners) and by their students (through diagnosis) and can motivate them to design lessons customized to their own needs.

The second stage is designing the lessons. In the first step of the second stage, teachers read about a research-based instructional strategy and discuss the challenges and the advantages of the strategy. In the second step of the second stage, teachers develop a preliminary plan using some of the strategies they identified in step 1 of this stage. The plan consists of a short description of the goals and the rationale for the means of achieving them using the innovative instructional strategies. In the third and last step of the second stage, teachers design lessons based on the information they compiled about students' learning difficulties indicating the techniques to overcome these difficulties. In conference II, teachers present and discuss the rationale of the lessons and the relevant learning materials, and refine the lesson plans using the input from the workshop.

The third and final stage involves conducting a small-scale research study. The first step of the third stage includes "formulating research questions, designing the structure of the study, designing research tools, implementing the planned lessons in their classes, conducting the relevant research, and checking the effectiveness of the innovative lessons on their students' learning" (Eylon & Bagno, 2006, p. 8). In the second step of the third stage, teachers analyze the results of the study and present them to their peers in the third conference. In this conference teachers report their findings and reflect on the whole process. The third step of third stage and last step in the processes is writing a paper summarizing the process and submitting it to the journal of Israeli physics teachers.

Eylon and Bagno's (2006) report from analysis of a case study showed that the model advanced teachers' awareness of deficiencies in their own knowledge of physics and pedagogy, and teachers' perceptions about their students' knowledge; teachers' knowledge of physics and physics pedagogy; a systematic research-based approach to the design of lessons; the formation of a community of practice; and acquaintance with central findings of physics education research. They also reported that the model led to several implementation difficulties as it required large investment from the teachers.

This research based lesson planning approach could help teachers to integrate learning theories and theories of instructional design, best practices from research, and their experience in designing lessons. The model encourages teachers to become researchers of their own practices. This could greatly develop teacher's profession in particular their pedagogical content knowledge and their ability to reflect on practice through action research. Such informed instructional decisions could potentially contribute to improvement of students learning. However, with the bulk nature of school curriculum, defined time schedule, with teachers teaching on average, say, 20 hours per week in a class consisting of twenty or more students when viewed with respect to the time teachers have; teachers would find the practical feasibility of the model questionable.

2.1.4 Standards-based lesson planning.

Standards are what students should know (content) and be able to do (process) (Carpinelli et al, 2008). Content standards define what is to be taught and what kind of performance is expected. Planning standards-based lesson requires the teacher to align student work expectations and classroom assessments to the standards and the learning objectives of the lesson, and to establish criteria to judge student attainment of the standard (Carpinelli et al, 2008). Learning objectives, aligned with standards, must be stated in terms of a measurable student behavior; and assessment must measure the student achievement of the skills and knowledge defined by the learning objectives and the standards (Carpinelli et al, 2008).

According to Carpinelli et al (2008), a model for creating and implementing standards-based lesson plans are: (i) identifying the concept that is to be taught, (ii) identifying and developing measurable learning objectives for the lesson, (iii) for each learning objective specifying the corresponding statement from the content standards, (iv) identifying a performance descriptor for each objective, (v) developing the assessment criterion from the performance descriptor for student mastery of the content of the lesson (e.g. level of acceptable competence), (vi) developing an activity to provide students the opportunity to acquire the skill and/or knowledge specified by the learning objective and the appropriate statement of the standards, and (vii) analyzing student behaviors and work products using the performance indicators to check if the student has acquired the skill and/or knowledge of the learning objective specified by the indicator(s) of the standard(s). The authors did argue that teachers can set higher expectations that meet the standards if they begin their lesson planning with expectations of the standards in mind. Alignment with standards must also include the assessment of student achievement of the skills and knowledge defined by the standards.

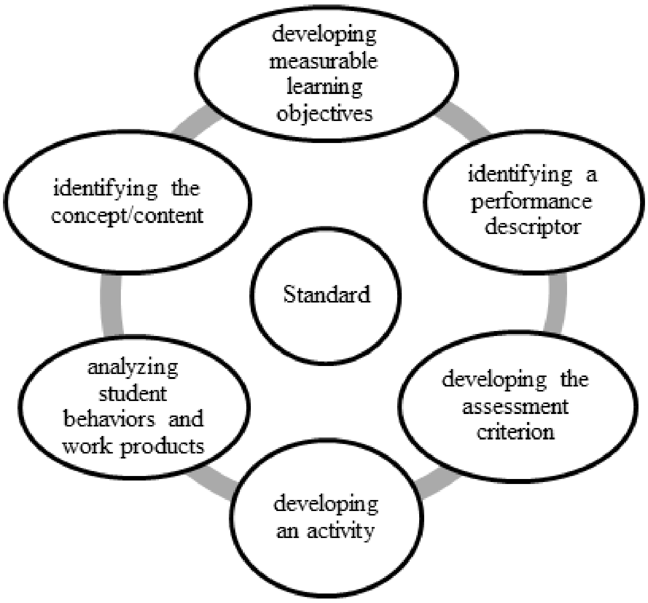

Figure 2. A model of designing standards based lesson plans.

The identification of the learning objective(s) for the lesson is considered as a key of the processes in standards based lesson planning. Learning objectives should be stated in terms of observable student behavior (skills and knowledge). Carpinelli et al. (2008) wrote that:

> Matching the learning objectives(s) to the appropriate skills and knowledge specified by the grade-appropriate indicator(s) of the standard(s) begins the

> process of aligning the lesson and the instruction with the standards. Performance descriptors are then derived from the learning objectives, which in turn determine the content of the lesson, so that appropriate opportunities are provided for the students to achieve the skills and knowledge defined by the indicators of the standards. The performance descriptors can guide the selection and enhancement of the instructional process, and activities can be selected or designed to elicit the behavior or products described in the learning objective. The performance descriptors also provide the criteria for assessing the student behavior/work product resulting from the lesson. Thus, learning objectives are used to evaluate student performance. (Standards-Based Lesson Planning, para. 3)

Carpinelli et al. (2008) reported that a program had been developed for mathematics and science teachers to help refine their instructional planning skills and provide them with an effective protocol for developing standards-based lesson plans. Figure 3 indicates the sequence of the protocol.

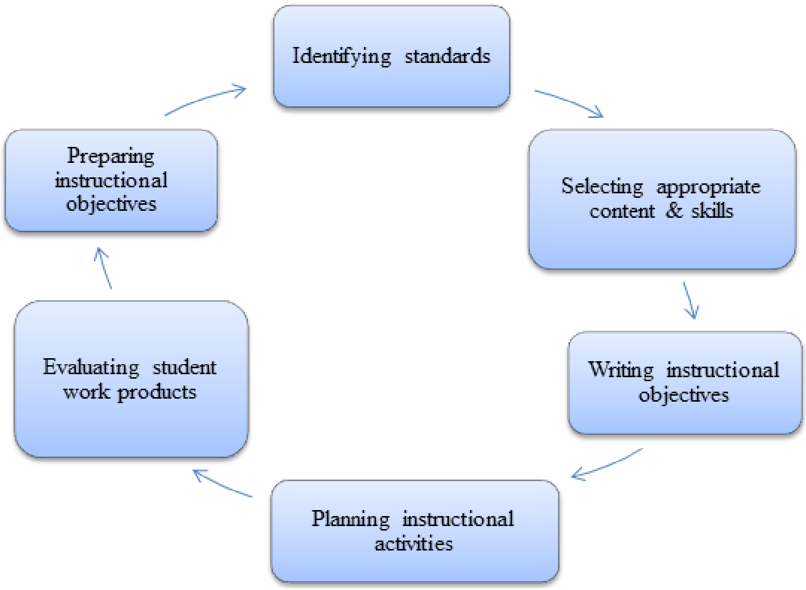

Figure 3. A protocol for developing standards based lesson plan.

Carpinelli et al. (2008) proposed the protocol for developing standards based lesson plan and it consisted of a series of steps which includes:

> (1) identifying a specific state or federal curriculum standard as the basis for planning a lesson; (2) selecting elements of the standard that would constitute appropriate content and skills to convey in a lesson; (3) writing instructional objectives that describe student outcomes demonstrating achievement of skills and content of the standard, (4) planning or selecting instructional activities that would elicit high quality student products or performances described in lesson objectives, (5) evaluating student work products by comparing them with expectations found in the instructional objectives, and (6) preparing instructional objectives that would result in student products or performances. (A Rubric for Assessing Standards-based Lesson Plans, para. 1)

2.1.5 The Four Stages of Lesson Planning (FSLP) strategy.

Quoting Panasuk (1999), Panasuk and Todd (2005) discussed the Four Stages of Lesson Planning (FSLP) strategy. These four stages are developing cognitive objectives, designing homework, planning the developmental activities, and constructing mental activities. The first stage of the four stage lesson planning strategy is developing cognitive objectives stating the level of cognitive engagement expected of students in terms of students' observable behavior. The cognitive objectives guide the lesson-planning process providing the basis for designing the instructional package and developing evaluation and assessment strategies (Panasuk & Todd, 2005). The second stage is designing homework that matches the cognitive objectives. Planning homework involves working through the problems to ensure the assignments incorporate the skills specified by the stated objectives, to create coherence from cognitive objectives to anticipated learning outcomes, to get insight into the nature and the details of the problems that the students are expected to work out, and to foresee students' possible difficulties.

The third stage of the four stage lesson planning strategy is planning the developmental activities that reflect the objectives and promotes meaningful learning and all levels of thinking. Planning developmental activities involves making informed pedagogical choices including instructional environment (such as inquiry-based instruction, expository/direct teaching, labs and projects), instructional approaches (problem solving, multiple representations, and connections) and class arrangements (individual, group work, pair work). The fourth and final stage of lesson planning is constructing mental activities based on and integrating all three previous stages. This involves designing and selecting problems that are basic elements of student prior knowledge as well as prerequisites of the new learning. The authors pointed out that the mental activities serve as an advance organizer to bridge the gap between what the learner already knows and what the learner needs to know.

According to Panasuk and Todd (2005), each stage involves concept and task analysis. Through concept and task analysis, teachers gain insight into the detailed nature of the concept/task to be learned and are better prepared to create a classroom environment that would facilitate students' meaningful learning. It also helps teachers in identifying students' prerequisite knowledge needed for learning new material. The concept and task analysis during lesson planning also provides teachers an opportunity to predict the kinds of misconceptions that students might have. Through planning examples that address misconceptions, teachers can establish conditions for students to rethink and consider their alternative conceptions. Panasuk and Todd (2005) used The

Four Stages of Lesson Planning (FSLP) strategy as an intervention to assist middle school teachers in the designing of their lesson plans. Their research showed that the lesson plans developed with the reference to the FSLP strategy revealed a higher degree of lesson coherence.

2.1.6 Meta- cognitive Strategy Framework (MSF) for lesson planning.

Liyanage and Bartlett (2010) developed a Metacognitive Strategy Framework (MSF) in an attempt to address the difficulty of trainees to develop a lesson maintaining alignment across aims, procedural steps, and evaluation. Liyanage and Bartlett's (2010) model considered the multidimensionality of knowledge involved when planning a lesson: declarative knowledge (the what we know or what we can declare of what we know), tacit or procedural knowledge (the how to do it or process level of knowledge), and conditional knowledge (where to apply known content and process, and in what sequence) as their theoretical framework for their model. Liyanage and Bartlett (2010) defined and explained how the metacognitive strategies (meta-view, advance organization, self-management, organizational planning, directed attention, selective attention, self-monitoring, and self-evaluation) can be used in lesson planning that involves three stages: planning the content of the lesson, planning for the implementation of that content, and planning for the evaluation of both teaching and learning outcomes (p.1364). The authors defined these metacognitive strategies as follows:

> Meta-view is defined as recognizing declarative, procedural, and conditional knowledge elements involved in the planning task. Advance organization is previewing students' needs, cultural backgrounds, learning preferences, proficiency levels, and available resources (time, infrastructure, texts), and

> delineating overall aim/s to achieve within these parameters. Self-management refers to understanding aspects such as my own preferred teaching style, strengths & weaknesses, knowledge of content covered within the planned lesson and arranging for the presence and/or understanding of these. Organizational planning is planning the parts (stages/steps within the lesson), delineating teaching (pedagogic) objectives for each stage/step, and choosing teaching and learning activities (TLAs) best conducive to achieving the pedagogic objectives and mainly to see how these help achieve the overall aim/s of the lesson. Directed attention is deciding in advance to attend to/spend more time on a particular step/TLA that is more relevant and crucial in attaining the overall aim/s, to weigh the relative importance of TLAs, and to ignore information that can be irrelevant and distracting. Selective attention is deciding in advance to attend to a specific concept, morpho-syntactic structure, or word its spelling or meaning within a step, and how such items are relevant and important in achieving the pedagogic objectives and, in turn, the overall aim/s. Self-monitoring is checking and placing-in measures such as observation or questioning to monitor whether the used TLAs are working as they were intended, and if and how students are engaged during the lesson. Self-evaluation is using appropriate measures to know-how efficiently (a) both pedagogic and overall aims have been achieved with a view to improving future planning and teaching, and (b) the learning objective/s, aim/s have been achieved. (Liyanage & Bartlett, 2010, p.1365)

The metacognitive strategy of meta-view is used throughout the three stages of planning a lesson to make decision on the content, process, and where and in what sequence to apply the content and processes. According to Liyanage and Bartlett (2010) the metacognitive strategies of advance organization, self-monitoring, and organizational planning provide metacognitive input when the teacher makes decision on what content to bring to the task, how to organize it, and where and in what sequence to apply known content and process.

> Advance organization provides a stimulus to anticipate content, processes, and conditions central to planning. Self-monitoring is a tracking strategy through which the planning teacher consciously register moves made and their level of acceptability. Organizational planning is a strategy that brings together the resources at hand to complete a task. For the planning teacher, this relates to his/her action or imagination in identifying the students to be taught; the assets to excite or sustain interest, to illustrate and illuminate key points, or to provide a culminating activity; the media of delivery and evaluation; and the wherewithal to keep the business of teaching and learning positive and confluent. (Liyanage & Bartlett, 2010, p.1365)

Liyanage and Bartlett (2010) argued that "planning for teaching involves making decisions regarding the relative importance and difficulty of pedagogic objectives, teaching and learning activities, and resources used" (p.1366). The authors explained how the metacognitive strategies of directed attention and selective attention are used when planning for implementation as follows:

> Metacognitive strategies of directed attention and selective attention are associated with a strategist bringing deliberate attention to a task; the former to define a field of engagement and minimize distraction, the latter to create specific focus within that field. Both focus a teacher's declarative, procedural, and conditional knowledge in planning strategically for implementation

> (teaching) of lesson content. Directed attention will help the teacher to identify and weight the relative importance of TLAs and their pedagogic objectives in relation to the overall aims of a lesson, to allocate time and resources accordingly, and to ignore irrelevant content. (p.1366)

The metacognitive strategies of self-monitoring and self-evaluation assist the teacher to plan for critical reflection on teaching and learning outcomes. By planning for ongoing evaluation, the teacher gets prepared on how to accommodate for unexpected contingencies within the overall aim/s of the lesson. Liyanage and Bartlett (2010) stress the importance of planning for evaluation as follows:

> Evaluation at the end of a lesson gives the teacher opportunities to gauge the success of teaching, TLAs and materials used, and student learning outcomes. It is a feedback loop through which the teacher's metacognitive knowledge systems are strengthened through incorporating critical reflective information about performances and their underpinning processes and planning with important forward-planning consequences. (p.1366)

According to Liyanage and Bartlett(2010), a lesson planned according to metacognitive strategy framework is characterized by the following features: clearly defined lesson aim/s and specific pedagogic objectives; a series of steps to attain the overall aim/s and specific pedagogic objectives; clearly described teaching and learning activities for each step; appropriate resources and materials to facilitate teaching and learning activities; techniques of monitoring and evaluating teaching and learning activities, and the learning outcomes. Liyanage and Bartlett (2010) applied their model to nine trainees. They reported that as the result of participating in their MSF, the nine trainees were able to more consciously attempt to integrate the declarative, procedural, and conditional aspects of their own knowledge about lesson planning into their action as lesson planners, implementers, and evaluators. The authors claimed that their strategy would provide significant additional perspective not only regarding lesson planning, but also regarding building trainees' views of themselves in the act of narrowing the gaps between their knowledge of, and confidence with, the declarative, procedural, and conditional elements of good practice. The effect of their model on students learning was not reported. The authors call for research community to test the effect of their model. However, one drawback I see in this model is that the model stresses on pedagogic objectives and neglected explicit account for cognitive objectives which is the central aim for the existence of planning a lesson. With this exception, the model looks feasible for use by school teachers.

The synthesis of the above approaches to lesson planning indicates that all authors implicitly or explicitly stressed the importance of identifying student leaning needs. Identifying students learning needs and adapting lessons to these needs is an essential aspect of lesson planning to customize and tailor lessons to individual students. In the next section reviews on adaptive planning and teaching is presented.

2.2 Adaptive Planning and Teaching

Wang (1980) viewed adaptive instruction as using alternative instructional strategies and resources to meet the learning needs of individual students. Adaptive instruction involves (1) taking into account different abilities, experiences, interests, and socio-economic backgrounds of children when planning and implementing a lesson, and (2) providing a range of alternative learning environments to accommodate the wide range of student needs (Wang, 1980). Wang pointed out that "adaptive instruction requires that alternate means of instruction are matched to students on the basis of knowledge about each individual's background, talents, interests, and past performance" (p.122). The author suggested that in adaptive planning and teaching, teacher assess individual student abilities and learning preferences, and uses information in selecting subsequent alternate learning opportunities. The author stressed that adaptive planning and teaching also attempt to bring students' abilities into a range of competence to help them benefit from the available instructional alternatives. "An adaptive teacher foresees individually diverse paths in learning, and possibly includes alternatives within the lesson planning" (Vogt & Rogalla, 2009). Vogt and Rogalla (2009) distinguished two types of teacher competencies regarding adaptive teaching: adaptive planning and adaptive implementation. The authors pointed out that "adaptive planning competency draws closely on teaching objective, subject knowledge and includes the anticipation of how the lessons will ideally develop" (p. 1052), and "adaptive implementation competency requires adjusting teaching methods or strategies of classroom management as well as the diagnosis of students' understanding and need of support" (p. 1052).

Corno (2008) distinguishes between adaptation at "macro" and "micro" levels. "Macro" adaptation is planning instruction for groups of similar students based on formal assessments of the intellectual ability of the learners (Corno, 2008). Micro adaptation is planning instruction to address individual students learning needs within the socio-cultural context through ongoing assessments (Corno, 2008). Corno argued that teachers make all the time the micro level adaptation in an ongoing course of instruction and in response to individual student learning need. Corno defines micro-adaptation as "continually assessing and learning as one teaches—thought and action intertwined" (p.163). Corno emphasized that "education occurs within a sociocultural context where tasks targeting individuals have a wider influence" (p.165). According to

Corno, "meeting expected learning goals will require adapting instruction to groups of individuals with like profiles…, or adapting instruction to individual students within the group context" (p.165).

In planning to teach micro-adaptively, the teacher focuses on what Corno (2008) calls the "middle teaching ground". Corno argued that within the social context of the classroom, "adaptive teachers aim to keep most of the students central within that teaching "middle ground" by adjusting teaching to learners and learners to teaching" (p.166). To emphasize the importance of adapting instruction to individual needs within the group context, Corno wrote:

> At some point down the road, the adaptive teacher wants as many students as possible to benefit from instruction provided to the whole group. So, one key hypothesis for new theory on adaptive teaching is that adaptive teaching is successful when students perform in ways that are more alike than different, as each student builds relative weaknesses into strengths. Notably, nowhere in this newer theory of adaptive teaching is the teacher adapting to *individual* students in a social vacuum. (p.165)

Corno explained that in the theories of individualized instruction and adaptive tutoring the individual student is the locus of instruction and adaptations are made relative to that student's own performance over time. In Corno's theory of adaptive teaching, the teacher adapts instruction to individual students in a social context where both advanced and weaker students had opportunities to be challenged and supported in the class. According to Corno's adaptive theory, "micro-adaptive teachers use approaches that capitalize on the strengths of other students in a class to bring more students into the teaching ground than were there at the start of an activity, project, or unit" (p.166).

The second approach to micro-adaptation proposed by Corno (2008) is developing students' self-regulated learning. In this approach,

> teachers target particular student skills and abilities…teach students how to self-motivate, or how to manage their homework…the ultimate goal for adaptive teaching is to increase the number of learners who are capable of working independently within the class group. (p.167)

According to Corno (2008), the dilemma of teaching individuals within heterogeneous classrooms can be addressed by micro-adaptation. However, the author pointed out that its effectiveness depends on teacher's ability to assess student strengths and weaknesses. While Corno emphasizes adapting instruction to create a middle teaching ground that benefits all students from similar instruction and treatment of individual needs within the sociocultural contexts, other researchers emphasize adapting instruction to individual learning needs on the basis of individuals performance. For example, Wang (1980) pointed out that to effectively adapt instruction to student differences, teachers must make informed instructional decisions based on the diagnosis and monitoring of individual student learning progress. The author suggested the use of criterion-referenced assessment indices to adapt instruction to the learning needs of individual students. Wang wrote that

> Criterion-referenced assessments designed to determine the presence or absence of certain specific competencies, provide teachers with the necessary information to determine skills and knowledge already possessed by students so that their appropriate entrance into the learning sequence can be insured. Such process oriented assessments for diagnosing and monitoring student learning are

likely to result in the optimization of instruction which adaptive instruction is designed to achieve. (p.123)

Corno and Snow (1986) also suggested adapting individual and group level instruction to students' level of performance for successful instruction. Other researchers also claimed that adapting lesson to the level of a student's academic performance contributes to their future academic performance (Connor et al., 2009; Curby, Rimm-Kaufman, & Cameron -Ponitz, 2009). Nurmi, Viljaranta, Tolvanen, and Aunola (2012) also found that teachers adapted their instruction according to the previous academic performance of a particular student. Corno's adaptive planning and teaching theory seems to have a practical feasibility than adapting instruction to individual student learning needs in a class with twenty or more different learning needs. In such classes, "teachers are forced to target on the class as a whole and work at the margins to adapt to individual differences" (Brophy, 2010, p.279). However, creating a middle teaching ground doesn't guarantee the treatment of individual differences. The model focusses on a whole class in a middle ground and teachers work to address individual differences marginally. Even though, it is a demanding task for teachers, to truly tailor lessons to individuals it important to plan lessons on the basis detailed analysis of individual students' performance.

The reviews presented above on adaptive planning and teaching focused more on students' cognitive learning differences. However, students' motivation to learn also influences students learning and performance. Similar to cognitive differences students have also motivational differences. Considering students motivational differences to learn is as important as considering cognitive differences while adapting lessons. In view of this, it is important to discuss how teachers can accommodate motivational differences when adapting lesson. For this purpose, models of motivation in education and some strategies of incorporating motivational principles into the sequence of instruction are reviewed and presented in the next section.

2.3 Integrating motivational principles into the sequence of instruction

In the following section, some motivational principles and models that have been in use to incorporate motivational strategies when designing instruction are discussed. These include Keller Model, Wlodkowski Time Continuum Model, strategies outlined by Brophy, the TARGET, and models of interest development.

2.3.1 Keller's Model.

Keller (1983) proposed four categories of motivational principles that can be incorporated when designing instruction. These four categories are: interest, relevance, expectancy, and satisfaction. Interest refers to the extent to which curiosity is aroused and sustained over time. Keller suggested five strategies for stimulating and maintaining interest: (1) "use novel, incongruous, conflictual, or paradoxical events, or arouse attention through an abrupt change in the status quo" (p. 401); (2) "use anecdotes and other devices to inject a personal, emotional element into otherwise purely intellectual or procedural material" (p. 402); (3) "give students opportunities to learn more about things they already know about and are interested in, but also give them moderate doses of the unfamiliar" (p. 402); (4) "use analogies to make the strange familiar and the familiar strange" (p. 403); and (5) "guide students into a process of question generation and inquiry" (p. 405).

Keller defined relevance as "the learner's perception of personal need satisfaction in relation to the instruction, or whether a highly desired goal is perceived to be related to the instructional activity" (Keller, 1983, p. 395). The author argued that motivation increases when students perceive that a learning activity will satisfy basic motives such as needs for achievement, power, or affiliation. Keller suggested three strategies to accommodate the relevance dimension of motivation. Strategies for increasing personal relevance call for (1) providing opportunities to achieve under conditions of moderate risk; (2) making instruction responsive by providing opportunities for choice, responsibility, and interpersonal influence; and (3) satisfying the need for affiliation by establishing trust and providing opportunities for no-risk, cooperative interaction (pp. 408-415).

Keller defined expectancy as "the perceived likelihood of success, and the extent to which success is under learner control" (p. 395). Keller suggested four strategies for increasing success expectancies: (1) provide consistent success experiences (on meaningful tasks), (2) use instructional design strategies that clearly indicate requirements for success, (3) use techniques that offer personal control over success, and (4) provide attributional feedback relating success to personal effort and ability (pp. 418- 421). Keller defined the last category satisfaction as "the combination of extrinsic reward and intrinsic motivation, and whether these are compatible with the learner's anticipations" (p. 395). The satisfaction of goal accomplishment effects the motivation for engaging in similar activities in the future. Keller suggested the following three strategies to attain the motivational category satisfaction: (1) use extrinsic rewards that come naturally from successful completion of the activity rather than using artificial extrinsic rewards, (2) use unexpected, non-contingent rewards over anticipated, salient, task-contingent rewards, and (3) use verbal praise and informative feedback rather than threats, surveillance, or external performance evaluation (pp. 421-427).

2.3.2 Wlodkowski's Model.

Raymond Wlodkowski (1984, 1985) suggested a time continuum model for building motivational strategies into instructional planning. Wlodkowski's model identifies three critical periods in a learning sequence in which particular motivational strategies will have the most impact: the beginning of the learning processes/activity (attitude and needs strategies), during learning processes/ activity (stimulation and affect strategies), and ending the learning processes/activity (competence and reinforcement strategies). To sequence motivational strategies into instructional planning, Wlodkowski suggested six basic questions to be considered by the teacher in the planning of any learning sequence. These basic questions were:

1. What can I do to establish a positive learner attitude for this learning sequence? (emphasis on beginning activities)
2. How do I best meet the needs of my learners through this learning sequence? (emphasis on beginning activities)
3. What about this learning sequence will continuously stimulate my learners? (emphasis on main activities)
4. How is the affective experience and emotional climate for this learning sequence positive for learners? (emphasis on main activities)
5. How does this learning sequence increase or affirm learner feelings of competence? (emphasis on ending activities)
6. What is the reinforcement that this learning sequence provides for my learners? (emphasis on ending activities). (Wlodkowski, 1984, p.23)

Attitude strategies address the question "What can I do to establish positive student attitudes toward the learning situation, as well as to establish the expectation that students will be able to meet its demands successfully?" They include sharing something of value with students (task-related anecdotes, humor, or personal experiences), communicating positive expectations and encouragement, and helping students to set realistic goals. Needs strategies address the question "How can I (the teacher) best meet the needs of the students?" They include making sure that students are physically comfortable and free from fear or anxiety, establishing a collaborative learning environment, structuring learning experiences and arranging for creation of products that support students' sense of identity and self-esteem, and including divergent thinking and exploration elements that appeal to students' needs for self-actualization. Stimulation strategies address the question "What about this learning activity will continuously stimulate students' attention and sustain their engagement in the activity?" This includes relating material to students' interests; using humor, examples, analogies, or stories to personalize the content; asking questions, especially questions that call for higher order thinking; and using spontaneity, unpredictability, or dissonance induction to periodically re-stimulate students' alertness and thoughtfulness.

Affective strategies address the question "How can I make the affective experience and emotional climate for this activity positive for students?" They include maintaining a positive group atmosphere, presenting content and asking questions that will engage students' emotions, and connecting the learning with things that are important in their lives outside of school. Competence strategies address the question "How will this learning activity increase or affirm students' feelings of competence?" They involve first making sure that students appreciate their progress by providing informative feedback and facilitating successful task completion, then encouraging students to take credit for these accomplishments by attributing them to sufficient ability plus reasonable effort. Reinforcement strategies address the question "What reinforcement will this learning activity provide for students?" They include calling students' attention to positive natural consequences of successful task completion, as well as providing them with praise or rewards. (Wlodkowski, 1984, pp. 24 - 32)

2.3.3 Brophy's techniques of integrating and adapting motivational principles.

Brophy (2010) argued that "learners are individuals and must be treated as such if we expect to optimize their motivation and learning" (p.278). The author suggested considering the cognitive style dimension of psychological differentiation for differentiating curriculum and instruction. "Cognitive styles are styles rather than abilities because they refer to how people process information and solve problems, not how well" (Brophy, 2010, p.280). Brophy explained two categories of a cognitive style dimension of psychological differentiation: field dependence versus field independence. The author detailed the difference as follows:

> People who are low in psychological differentiation (field dependent) have difficulty differentiating stimuli from the contexts in which they are embedded, so their perceptions are easily affected by manipulations of the surrounding context. In contrast, people who are high in psychological differentiation (field independent) perceive more analytically. They can separate stimuli from context, so their perceptions are less affected when changes in context are introduced. (p. 280)

Brophy (2010) discussed learner preferences in learning based on cognitive style dimension of psychological differentiation. The author argued that "field-dependent students prefer to learn in groups and to interact frequently with teachers, whereas field-independent students prefer more independent and individualized learning opportunities" (p. 280). Brophy suggested that teachers must consider both orientations and build on students' strengths but also work on their areas of weakness. Teachers might structure field-dependent students' learning experiences by providing frequent encouragement and praise, supporting when noting their mistakes, and allowing them to learn in collaboration with peers most of the time. Field-independent students can be supported by respecting their needs for privacy and allowing them frequent opportunities to operate autonomously.

Brophy (2010) provided set of questions to be considered and list of motivational strategies to be used when planning curriculum and instruction. Brophy recommended that teachers should consider the following questions when planning for any learning activity:

> (1) What are the learning goals? (2) Why will students be learning this content or skill? (3) When and how might they use it after they learn it? (4) Is there a way to use advance organizers to provide students with organizing concepts? (5) What elements of the activity could you (the teacher) focus on to create interest, identify practical applications, or induce curiosity, suspense, or dissonance? (6) Does the activity include interesting information or build skills that students are eager to develop? (7) Does it contain unusual or surprising information? (8) Can the content be related to events in the news or in students' lives? (9) Are there aspects that students are likely to find surprising or difficult to believe? (10) Are there ways to stimulate curiosity or create suspense by posing interesting questions? (pp. 316 & 319)

Brophy recommended the following strategies for stimulating students' motivation to learn:

> (1) communicating desirable expectations and attributions, and minimizing students' performance anxiety; (2) shape students' expectations about learning by being enthusiastic (regularly) and by being intense (when material is especially important and requires close attention); (3) stimulate situational motivation to learn by inducing curiosity or suspense; inducing dissonance or cognitive conflict; making abstract content more personal, concrete, or familiar; inducing task interest or appreciation; or inducing students to generate their own motivation to learn; (4) scaffold students' learning efforts by stating learning goals and providing advance organizers, planning questions and activities to help students develop and apply powerful ideas, modeling task related thinking and problem solving, inducing metacognitive awareness and control of learning strategies, teaching skills for self-regulated learning and studying, and teaching volitional control strategies; and (5) re-socialize the attitudes and behavior of apathetic students by developing and working in close relationships with them, discovering and building on their existing interests, helping them to develop and sustain more positive attitudes towards schoolwork, and socializing their motivation to learn. (p. 318)

2.3.4 Incorporating motivational principles into lesson planning using TARGET.

Ames (1990) identified six structures that teachers can work through to motivate their students to engage in learning activities: Task, Authority, Recognition, Grouping, Evaluation, and Time (TARGET). Brophy explained these structures as follows:

> Tasks are selected to provide an optimal level of challenge and to emphasize activities that students find interesting and engaging. Authority is shared with

> students and exercised with consideration of their needs and feelings. Recognition is provided to all students who make noteworthy progress, not just the highest achievers. Grouping is managed in ways that promote cooperative learning and minimize interpersonal competition and social comparison. Evaluation is accomplished using multiple criteria and methods, focusing on individualized assessment of progress rather than comparisons of individuals or groups. Finally, time is used in creative ways that ease the constraints of rigid scheduling and allow for more use of valuable learning activities that are hard to fit into 30-60 minute class periods. (p. 88).

Integrating motivational strategies in planning and sequencing lessons could provide an opportunity to arouse and stimulate student's interest in their learning. If student interest to learn is stimulated as well as sustained they can exert maximum effort in their learning, can shoulder responsibility for their own learning and can substantially engage in learning activities. How student interest develops?

2.3.5 Hidi and Renninger's model of interest development.

Hidi and Renninger (2006) define interest as a psychological state that is characterized by an affective component of positive emotion and a cognitive component of concentration. The level of student's interest influence their attention, goals, and levels of learning (Hidi & Renninger, 2006). Hidi and Renninger proposed a four phase model of interest development in learners. These are triggered situational interest, maintained situational interest, emerging individual interest, and a well-developed individual interest.

The first phase of the four-phase model of interest development in learners is a triggered situational interest. Triggered situational interest refers to a psychological state of interest that result from short-term changes in affective and cognitive processing. Providing learners opportunities to engage in a group work can trigger situational interest. If such instructional conditions sustain triggered situational interest, it evolves into the second phase of interest, maintained situational interest. Maintained situational interest "involves focused attention and persistence over an extended episode in time" (p.114). Such interest is held and sustained through meaningfulness of tasks and student involvement. Teacher can provide learners meaningful and personally involving activities to maintain their situational interest.

The third phase is emerging individual interest. "Emerging individual interest refers to a psychological state of interest as well as to the beginning phases of a relatively enduring predisposition to seek repeated reengagement with particular classes of content over time" (Hidi & Renninger, 2006, p.114). Such interest is characterized by positive feelings, stored knowledge and stored value, and the student values the opportunity to reengage tasks related to his or her emerging individual interest. Teacher can provide students an opportunity to engage on tasks related with student prior experience to enable the development of an emerging individual interest. The last phase is a well-developed individual interest. Hidi and Renninger (2006) defined well-developed individual interest as "the psychological state of interest as well as to a relatively enduring predisposition to reengage with particular classes of content over time" (p.115). A well-developed individual interest is characterized by positive feelings, and more stored knowledge and more stored value for particular content than for other activity including emerging individual interest. A teacher can facilitate the development and deepening of well-developed individual interest by providing instructional opportunities taking into account interaction and intellectual challenge that facilitate knowledge building.

2.4 Quality of Lesson Plans

The instructional and educational activities of teachers are complex and are often under the subject of pressure. This is because on one hand, teachers must adaptively plan lessons to accommodate the diversity in students pre-existing knowledge and skills, and on the other hand, teachers must anticipate how to appropriately adapt teaching to the spontaneous, random and dynamic conditions of classroom during instruction execution without abandoning the planned learning goals. They have to spontaneously and appropriately react to a variety of situations, for example unexpected student responses, or unexpected difficulties in understanding a task, in the everyday life of the classroom (Stender, 2014). Lesson planning involves a proactive anticipation how to handle these complexities.

Adaptive planning is a highly demanding activity for the teacher. The teacher should think about how to sequence and integrate the different parts of planning to provide a meaningful learning experience for students. Lesson planning activity involves the teacher in making decisions on (1) learning and teaching objectives, (2) the sequence of content, tasks and laboratory activities to provide students the opportunity to learn both the content and the science process skills, (3) methods of teaching and learning (or teaching learning activities), (4) classroom arrangements or social structure, (5) how to evaluate and reflect on the outcomes of teaching and learning, and (6) how to adaptively act on for further improvements of students learning. More importantly, the teacher is expected to make informed decisions on these elements of lesson planning by diagnosing and analysing students pre-existing conditions (knowledge and skills), and appropriately adapt lessons to students learning needs. To design a high quality lesson that potentially engage all learners in high level cognitive thinking and development, the teacher has to consciously, carefully, and adaptively make decisions on these parts of lesson planning before the actual implementation of the lessons.

The qualities of lesson plan could be determined from its features. Stender (2014) suggested that the functional features of lesson plan can be used to judge the quality of the lessons planned. The functional features of lesson plan are the adaptability of the lesson, the coherence of the lesson and its potentialities for cognitive activation of students. These functional features are discussed in more detail below.

2.4.1 Adaptability.

Adaptability of lesson plan refers to how the planned sequences of activities accommodate individual student pre-existing knowledge and skills and how the sequences of activities are tailored towards the learning needs and characteristics of individual learners. The planning teacher needs to take into account both outer preconditions and inner preconditions. The outer preconditions include among others the accessible material, laboratory facilities, and available time. The inner preconditions are related to attributes of students learning. These includes pre-requisites required for learning the material, the abilities and skills of students, the learning needs, and learning preferences of students. To prevent a planned lesson from changing during the instruction, it should be proactively adapted to such preconditions (Stender, 2014).

Other scholars also stress the importance of considering preconditions while planning and sequencing lessons. For instance, Panasuk and Todd (2005) explained that in the stage constructing mental activities in their four stage lesson planning strategy, the teacher plans and creates problems that are basic elements of student prior knowledge as well as prerequisites of the new learning. Such plan of action for mental activities help in bridging what the learner already knows and needs to know to successfully learn the material at hand. Identification of students' learning needs and development of a plan of action to fulfil those needs are very important part of teachers' decision-making processes (Liyanage & Bartlett, 2010; Panasuk & Todd, 2005). Liyanage and Bartlett (2010) explained the importance of the metacognitive strategies of advance organization when planning lesson content in previewing students' needs, learning preferences, proficiency levels, and available resources. These are the preconditions teachers should consider when planning a lesson. The presence of these aspects in the planned lesson defines its adaptability. Todd (2005) refers adaptability of lesson plans as adaptation to special needs. Todd raises the following questions: If there is an aide, how (very specific) will the aide be instructed to modify the lesson? How will the homework be modified? What will be done for a student who completes work early? These are specific modifications for specific students, and the presence or absence of such modifications defines quality of planned lesson in terms of its adaptability.

Haynes (2007) defines adaptability as differentiation. Differentiation is adapting educational activity to suit the diverse needs and characteristics of the learners (Haynes, 2007). Haynes divides differentiation into three types. The first one is that teachers can differentiate lessons by task. This involves planning how to modify the task to suit different students or setting different tasks. The second differentiation is by expected outcome. Students attempt the same task but perform it at different levels or to differing degrees of completion. It means here that the teacher plans performance expectations for individual students. The third one is differentiation of the kind and level of support. The teacher plans different kinds and levels of support for various students. According to Haynes (2007) the first step to recognize when planning lessons is that (a) differentiation is central to effective teaching and (b) it involves careful preparation (p.37). The author pointed out that teacher could differentiate lessons based on learning style, special educational needs, individual needs, and ability. Adaptive planning is teachers' proactive decisions on differentiation of lessons to accommodate the diversity of students' pre-existing knowledge and skills including how students with learning difficulties could be supported and how students who have mastered the material at hand could be challenged.

Differentiation could also mean adapting curriculum materials in a flexible way. Adapting materials refers to making changes to lesson plans to promote opportunities for student learning (Beyer & Davis, 2009; Drake & Sherin, 2009). The teacher needs to use curriculum materials in flexibly adaptive ways to meet the needs, interests, and experiences of their specific classroom (Barab & Luehmann, 2003; Brown, 2009; Enyedy & Goldberg, 2004; Pint´o, 2004; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). Differentiating is tailoring instruction (Clay, 1998; Tomlinson, 2003). It involves using various strategies for individualizing instruction to accommodate the needs of a range of learners, capitalizing on the capabilities and styles of their students, adjusting teaching for different conditions (Corno, 2008). Lesson plans adapted to preconditions takes into account all these aspects of differentiation to optimize individual students learning. A planned lesson which is meaningfully adaptive takes into account sequence of learning tasks with different levels of cognitive demands to suit and benefit all students in a class with different levels of abilities and skills. That is, adaptively planned lessons should consider tasks for the cognitive activation of all students of different ability levels. The next section discusses cognitive activation.

2.4.2 Cognitive activation.

One of the most important aspects that define the quality of lesson plan is how thoroughly activities or tasks are sequenced to engage all students in a high level cognitive thinking. The presence of deep learning tasks that engage students in the process of deep learning defines the quality of planned lessons. Deep learning tasks enable students in creating knowledge through the integration of their prior knowledge with the new material and apply the new knowledge in real contexts (Fullan & Langworthy, 2014). Oser and Baeriswyl (2001) clearly emphasized the cognitive activation of students in their definitions of lesson planning:

> organizing in advance a structured form of action (instructional plans) in which the mental models of the steps can stimulate cognitive operations in learners…the principal assumptions that form the basis for lesson preparation are…teachers always positively design blueprints for activating learning that has school based constraints, developmental constraints, children's prior knowledge, and motivational styles in mind…and teachers can hypothesize the kind of inner acts or mental operations students use when they learn. (p.1032)

Stender (2014) argued that one of the properties of a high quality lesson is that how the teacher mental plan of action (script) focuses the cognitive activation of students. The teacher should plan lessons so that s/he succeeds in cognitively activating the students. For this purpose the proposed instruction should stimulate a thinking process within the students. Cognitively activating instruction stimulates insightful learning. Baumert et al. (2010), quoting other researchers, summarized three components of instruction that are important to initiate and sustain insightful learning processes: cognitively challenging and well-structured learning opportunities; learning support through monitoring of the learning process, individual feedback, and adaptive instruction; and efficient classroom and time management.

Insightful learning is “an active individual construction process which involves modification of knowledge structures, dependent on learners’ individual cognitive characteristics (domain-specific prior knowledge), and controllable by motivational and metacognitive processes” (Baumert et al., 2013, p.3). Baumert et al. (2010) argued that the level of cognitive challenge is determined primarily by the type of tasks selected and the way the tasks are integrated and implemented. The authors pointed out that cognitively activating task draws on students’ prior knowledge by challenging and testing their pre-existing ideas and beliefs. They further argued that class discussion can also prompt cognitive activation if students are encouraged to evaluate the validity of their solutions or to try out multiple solution paths. Integrating deep learning tasks (cognitively activating tasks) can also leverage the social nature of learning through collaborative work. “A teacher who can integrate deep learning tasks into the sequence of lesson can make a move from a pedagogy that centers on individuals demonstrating their learning to a pedagogy that embraces groups demonstrating their learning” (Fullan & Langworthy, 2014, p.26).

Planning an instruction that cognitively activate students requires aligning topics and tasks to the curricular demands (or standards) (Baumert et al., 2010). Teachers can activate student cognitive process by appropriately embedding tasks in a lesson. Neubrand, Jordan, Krauss, Blum, and Löwen (2013) explained this, for mathematics instruction, as follows:

> For teachers, tasks are an important means of orchestrating instruction in two respects. First, the way a task is embedded in a lesson and the methods used to

> approach it influence student motivation and interest. Tasks can thus function as effective teaching tools. Second, students' learning activities are directly impacted by whether and in which order tasks with adequate cognitive potential are used to create meaningful learning opportunities in the classroom. Teachers who are aware of the potential of tasks and orchestrate them appropriately can thus influence students' understanding of mathematical concepts and procedures, their construction of complex conceptual networks, and ultimately, their image of mathematics. (p.126)

The cognitive processes potentially activated by a task include: development of mathematical thinking, activation of basic concepts, and understanding and decoding of information provided in text form (ibid, p.129).

The presence of deep learning tasks that calls for substantial engagement of students in the process of deep learning both individually as well as in groups defines the quality of planned lessons. The other aspect that defines the quality of planned lessons is how logically and meaningfully the sequences of different parts of the lesson are fitting with each other. That is, how different parts build up on one another constructively superimposing to give students a coherent insightful learning structure.

2.4.3 Coherence.

Cohesive decision making promises to plan a clear structured lesson where teacher decisions in the individual parts of the lesson planning areas should connect to one another and fit into the whole lesson (Stender, 2014). Todd (2005) uses the term "logical flow" when referring to the coherence of the lesson. Todd (2005) suggested considering two main questions to maintain the logical flow of a lesson. These are does the lesson build a bridge from the listed student prior knowledge to the assigned homework, and does the lesson flow from one idea to the next. A lesson is well-structured if all parts of the lessons are aligned with clearly defined lesson objectives (Todd, 2005). We understand from this that the adherence of the planning areas to the objectives and the alignment of assessment of student progress toward the objectives define lesson coherence. Aligning student work expectations and classroom assessments to the standards (what students should know and be able to do) and the learning objectives of the lesson defines the coherence of the lesson plan (Carpinelli et al, 2008). Coherence of lesson plan refers to how chains of activities are logically and meaningfully connected with each other (Oser & Baeriswyl, 2001).

One method to judge the quality of planned lesson is to determine whether or not the sequence of different parts of the planned lesson is consistently in agreement building on one another. That is, how logically and meaningfully the flow of the sequences of different parts of the lesson are fitting with each other defines whether the planned lesson is coherent or not. If the decisions of the planning teacher on each elements of lesson planning add up on each other superimposing, meeting, and fitting progressively forming a clearly structured meaningful learning experiences for students, the planned lesson can be said of high quality in developing and advancing students learning.

2.5 Concept mapping as a lesson planning tool

A concept map is a graphical tool for organizing and representing one's knowledge (Novak & Gowin, 1984; Novak & Cañas, 2008). Concept maps include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Concept maps provide a visual snapshot of an individual's knowledge structure (Singer, Nielsen, &

Schweingruber, 2012), and is a technique that paves the way to represent knowledge schematically (İngeç, 2009). Concept maps often include three components: concept terms, linking arrows, and linking phrases (Novak, 2010). Concept terms are key ideas and/or concepts in a domain. Linking arrows provide a directional relationship between two concepts. Linking phrases represent the specific relationships between a pair of terms. In science education, concept maps have been in use for many purposes including as learning and teaching tool, as an assessment tool, for research purpose and for curriculum and instructional planning.

Concept maps have been used as a knowledge representation tool for instruction, learning evaluation, research, and instructional planning. Concept mapping has been reported effective in a variety of contexts as a learning tool in science education. Concept maps improve conceptual understanding (Markow & Lonning, 1998), facilitate meaningful learning (İngeç, 2009), improve the creative skills of the students, such as thinking, analyzing and problem-solving, and help them to understand the concepts (Novak, Gowin, & Johansen, 1983) and improve students' learning achievement (Ayyildiz & Tarhan, 2012). Concept maps are a valid and reliable technique for deeper understanding of a more complex and integrated knowledge structures (Lopez, Shavelson, Nandagopal, Szu, & Penn, 2014). İngeç (2009) used concept mapping as an evaluation method in teaching physics. The author used concept maps to determine teacher candidates' knowledge about understanding of the concepts of impulse and momentum by comparing and contrasting students' concept maps and an achievement test.

Concept mapping is used in curriculum planning. According to Novak and Gowin (1984) at the top of a concept map broad and integrative concepts could be used for planning the curriculum for a given course of study, whereas more specific, less inclusive concepts at the lower portion of the concept maps could serve as guidelines for selecting specific instructional materials and activities. Instructional planning involves "slicing vertically through the curriculum map to achieve meaningful linkages between more general, inclusive concepts and more specific concepts" (Novak & Gowin, 1984, p.77). A concept map of a lesson shows the sequencing for the lesson in the form of "hierarchies of ideas that suggest psychologically valid sequences" (Novak & Gowin, 1984, p. 82). Concept maps show continuity and integration within a lesson by showing the main conceptual relationships with "both hierarchical relationships between concepts and crosslinks between sets of concepts..." (ibid., p. 82).

In science concept mapping is used as the basis for developing lesson plans (Martin, 1994). Martin (1994) used concept mapping as an aid to pre-service teachers in preparing lesson plans. The author reported that pre-service teachers developed a high quality lesson plans with the help of concept mapping. Starr and Krajcik (1990) used the concept mapping heuristic to help teachers develop a science curriculum. They reported that concept maps helped science teachers develop a hierarchically arranged, integrated, and conceptually driven science curriculum. Willerman and Mac Harg (1991) used teacher-constructed concept maps as an advance organizer in science and reported that concept mapping provided the teacher with guidance in how to show the relationships between important ideas and his/her lesson plans. Novak and Gowin (1984, p.77) explained the advantages of using concept maps over course outlines for instructional planning. The authors argued that (1) good concept maps show key concepts and propositions in very explicit and concise language whereas course outlines usually intermix instructional examples, concepts, and propositions in a matrix that may be hierarchical, but fails to show the superordinate-subordinate relationship between key concepts and propositions; and (2) concept maps visually emphasize both hierarchical relationships between concepts and propositions and cross links between sets of concepts and propositions. The authors pointed out that concept maps do not specify the exact sequence for presentation, but they do show hierarchies of ideas that suggest psychologically valid sequences. However, there is little research report about the use of concept mapping as tool for lesson planning by veteran physics teachers.

2.6 Formative assessment and formative feedback within classroom context

Any kind of assessment that is used to improve student learning and to make informed instructional decisions are called formative assessment. Assessment is formative when the assessment information is used to alter the student's performance gap (Black & William, 1998). It is a "frequent, interactive assessments of student progress and understanding to identify learning needs and adjust teaching appropriately" (Office of Economic Co-operation and Development [OCED], 2005, p.21). Formative assessment is "any task that creates feedback (information which helps a student learn from formative activities) or feedforward (information which will help a student amend or enhance activities in the future) to students about their learning achievements" **(**Irons, 2008, p. 7). Formative assessment is any teacher assessment which diagnoses students' difficulties and provides constructive feedback (Black & Wiliam, 1999). We understand from these conceptualizations that formative assessment coexists with formative feedback.

Hattie and Timperley (2007) conceptualized feedback as information provided regarding aspects of one's performance or understanding. Feedback fills a gap between what is understood and what is aimed to be understood through affective processes (increased effort, motivation, or engagement) and cognitive processes (Sadler, 1989).

Formative feedback guides and challenges the learner's thinking (Pellegrino et al., 2001). Coe (1998) explained the uses of feedback as follows:

> Feedback can have a diagnostic function, allowing people to see to what extent they are achieving their goals in different aspects of a task and so helping them to account for and learn from satisfactory outcomes and to modify less satisfactory ones. In both these ways, feedback may lead to improvements in performance, provided those receiving it have clear and demanding task goals which they believe to be attainable and which they are already motivated to achieve. (p. 68)

Students in a class have unique experiences and diverse academic backgrounds, thus resulting in large groups of mixed ability and diverse learning experiences. To make learning responsive to these diverse students, teachers need to take into account a range of student experiences, expectations and learning preferences by the way of enhancing teaching practices through formative assessment and formative feedback. Formative feedback enhances "student learning environment and learning opportunities through changes and improvements in pedagogy" **(**Irons, 2008, p.10). Formative assessment and formative feedback are "powerful means for meeting goals for high-performance, high-equity of student outcomes, and for providing students with knowledge and skills s for lifelong learning" (OECD, 2005, p.27). Formative assessment and formative feedback help teachers meet diverse students' needs through differentiation and adaptation of teaching to raise levels of student achievement and to achieve a greater equity of student outcomes" (OECD, 2005, p.21).

Formative assessment and feedback provides students an opportunity to enter into dialogue with their peers and the teacher about their formative activities and discuss their learning needs (Black & Wiliam, 1998; Black, 1999; Black & Wiliam, 1999; Gibbs, 2005; Hyatt, 2005; Juwah et al., 2004); motivates students to learn to enhance their knowledge and understanding (Knight, 2001); develops students' peer- and self-assessment practices and skills (Black & Wiliam, 1998) contributing to reflective learning. Formative assessments and feedback resulted in larger learning gains than any other educational interventions (Black & Wiliam, 1998). Stefani (1998) argued that feedback is an important element for promoting student learning. Hattie's (1987) meta-analysis indicated that feedback makes a difference to student achievement. However, there are also research reports that indicate that feedback had negative effects or no effect at all. For example, Kluger and DeNisi (1996) summaries from their meta-analysis of 131 studies on the effects of feedback showed that "feedback interventions do not always increase performance and under certain conditions are detrimental to performance" (Kluger & DeNisi, 1996, p.275). According to these authors there are mixed empirical evidence on the effect of feedback.

The basic principles of formative assessment and feedback are (1) "to contribute to student learning through the provision of information about performance" (Yorke, 2003, p. 478), (2) "to use the judgments about the quality of student works to shape and improve students' competences" (Sadler, 1989, p.120), (3) to promote "higher levels of student achievement, greater equity of student outcomes, and improved learning to learn skills" (OECD, 2005, p.22), and (4) "to help students understand the level of learning they have achieved and clarify expectations and standards" **(**Irons, 2008, p.17). From their review, Black and William identified six key elements of formative assessment:

> establishment of a classroom culture that encourages interaction and the use of assessment tools; establishment of learning goals, and tracking of individual student progress toward those goals; use of varied instruction methods to meet diverse student needs; use of varied approaches to assessing student understanding; feedback on student performance and adaptation of instruction to meet identified needs; and active involvement of students in the learning process. (Black &William 1998, p. 44)

According to Black (1999) the basic principles of formative feedback includes clarifying learning objectives to students; using feedback that measure (give guidance to) the student's current learning state; using formative feedback as a means for closing the gap between the student's learning state and the learning goals; and formative feedback needs to be high quality and effective in its advice. Irons (2008) also pointed out that using formative assessment and feedback practices should engage students in the feedback process, clarify how formative assessment activities are contributing to students learning, and ensure equity and equality taking into account the diversity of students. Sadler (1989) argued that in the practices of using formative assessment and feedback the teacher need to clearly identify and communicate the learning and performance goals, assess, or help the student to self-assess, current levels of understanding, and help the student with strategies and skills to reach the goal. The main purpose of feedback is to reduce discrepancies between current understandings and performance and the intended learning goal. Hattie and Timperley (2007) stressed that feedback helps a teacher and/or a student to address three questions in any attempt to reduce discrepancies:

> Where am I going? (What are the goals?) How am I going? (What progress is being made toward the goal?), and Where to next? (What activities need to be undertaken to make better progress?)….How effectively answers to these questions serve to reduce the gap is partly dependent on the level at which the feedback operates. These include the level of task performance, the level of process of understanding how to do a task, the regulatory or metacognitive process level, and/or the self or personal level (unrelated to the specifics of the task). (p.86)

According to Kluger and DeNisi (1996), the effective ways for students to reduce the gap between current and desired understandings in response to feedback is that "students can increase their effort, particularly when the effort leads to tackling more challenging tasks or appreciating higher quality experiences rather than just doing more" (p.260).

Researchers discuss the challenges in using formative assessment and formative feedback to improve learning and teaching. Some of these challenges are the time pressure and workloads of teachers influences the provision of quality feedback regularly (Liu & Carless, 2006); student may not recognize the usefulness of feedback (Tunstall & Gipps, 1996); feedback that is not understood by students doesn't contribute to their learning (Lea & Street, 1998); it may emphasizes the power relationship between teachers and students if all the feedback is provided without an opportunity for dialogue between teacher and students (Irons, 2008, p. 26); presence of large numbers of mixed ability students **(**Irons, 2008); and resistance from students in taking part in formative activities due to other demands and pressures on their time **(**Irons, 2008). Some of these challenges may also hamper teachers' the effective use of externally generated students' performance feedback data in adaptively planning lessons. Any assessment that can be used for formative function like adapting lessons based on analysis of assessment results can improve student learning. Therefore, externally generated feedback data on students' performance on standardized tests can be used for formative function by teachers in making informed instructional decisions. The use of feedback data for instructional decisions is discussed in the following sections.

2.7 Feedback data use for instructional decisions

Educators are under pressure to improve student achievement using student data (Hamilton et al., 2009). Policymakers argue that the only way to increase student achievement levels is to base instructional decisions on student's data and urge educators to use student data (Schildkamp & Kuiper, 2010). For instance, The Standing Conference of the Ministers of Education and Cultural Affairs of Germany (KMK, 2006) urged the use of feedback data for educational monitoring, quality assurance and development of school education. The Dutch school performance feedback system also insisted to use feedback data to improve the function of the school and students learning (Visscher, 2009). The No Child Left Behind Act of 2001 (NCLB) in United States also placed accountability on educators to improve individual student learning and achievement using students data. Marsh, Pane, and Hamilton (2006) reported that "NCLB required states to adopt test-based accountability systems…for the improvement of student performance" (p.2).

Researchers also stressed the importance of using assessment results to make informed instructional decisions (Schildkamp & Kuiper, 2010; Wayman, Cho, & Johnston, 2007; Wohlstetter, Datnow, & Park, 2008), and planning of lessons on the basis of an in-depth analysis of student data (Knapp et al., 2006). A logical way to customize instruction to the needs of individual students is to use student performance data in instructional decisions (Hamilton et al., 2009). Young (2006) also suggested that "using student data to improve instruction and overall school performance is a rational outlook on the core technology of schools: teaching" (p.545). Makar and Confrey (2004) stressed that "in a time when teachers are under increasing pressure to improve student scores on state-mandated tests, teachers are required to make instructional decisions based on…students' performance" (p. 334). Teachers can use student's assessment data to monitor students' progress, to identify learning needs, to innovate their teaching, and to evaluate and reflect on their own teaching practices (Knapp et al., 2006; Schildkamp & Kuiper, 2010). Student assessment data is useful for adapting instruction to individuals (Hamilton et al., 2009; Young, 2006). Quoting other researchers, Hamilton et al. (2009, p.5) summarized that educators can use students assessment data for: prioritizing instructional time (Brunner et al., 2005); individualized instruction (Brunner et al., 2005; Supovitz & Klein, 2003; Wayman & Stringfield, 2006); identifying individual students' strengths and instructional interventions that can help students continue to progress (Brunner et al., 2005; Wayman & Stringfield, 2006); gauging the instructional effectiveness of classroom lessons (Halverson, Prichett, & Watson, 2007; Supovitz & Klein, 2003); refining instructional methods (Fiarman, 2007; Halverson, Prichett, & Watson, 2007); and identifying learning needs and adapting the curriculum to meet the identified learning needs (Kerr, Marsh, Ikemoio, Darilek, & Barney, 2006; Marsh, Pane, & Hamilton, 2006).

Supovitz and Klein (2003) suggested that student performance data can be used to identify low-performing students and to set targets and goals. Student performance data is used "to identify at-risk students and provide them with a differentiated set of opportunities to improve their skills and performance…to monitor both student progress and, by extension, the effectiveness of these strategies" (p.20). Brunner et al. (2005) explained that teachers can use student assessment data in the following areas of instructional practice:

> (a) meeting the needs of diverse learners, with decisions about class priorities, weekly lesson plans, grouping…and giving individualized assignments and materials appropriate to the students' levels; (b) supporting conversations with parents, students, fellow teachers, and administrators about students' learning; (c) shaping teachers' professional development by reflecting on their own practice; and (d) encouraging self-directed learning by giving the data to students. (p.249)

Marsh et al. (2006) reported that teachers used "assessment data to make adjustments to their teaching in three distinct ways: tailoring instruction for the whole class based on aggregate results; dividing students into small groups and providing differentiated instruction to these groups; and customizing instruction for individual students" (p.7). Kerr et al. (2006) also described that teachers can use assessment data for "identifying objectives, grouping and individualizing instruction, aligning instruction with standards, refining course offerings, identifying low-performing students, and monitoring student progress" (p.498). Wayman and Stringfield (2006) found that "data use often resulted in improved teaching practice such as collaboration, better knowledge of student needs, and efficiency of effort" (Abstract, para.1). However, "teachers need accurate information about the specific processes and outcomes of student learning to effectively shape their teaching" (Halverson et al., 2007, p.5), from students' performance feedback data.

It is clear from these research reports that researchers are stressing the importance of using assessment data to improve student learning and achievement. However, there is no empirically proved method about how teachers use student assessment data to identify learning gaps, design intervention strategies, monitor students' academic progress, and evaluate their practices. In response to this problem, Hamilton et al. (2009) developed a framework for using student achievement data to support instructional decision making including how to adapt lessons in response to students' needs. The next section discusses a data use framework developed by Hamilton et al. (2009). Their framework presents how teachers can continually use and integrate assessment data in their everyday professional practices to adapt instruction.

2.7.1 Data use framework to improve instruction.

Hamilton et al. (2009) argued that teachers should adopt a systematic process for using data in order to improve their ability to meet students' learning needs. The authors developed a cyclical data use framework for the process of using student data to improve instruction. Their framework includes the following steps:

1) collecting and preparing data about student learning from a variety of relevant sources,
2) interpreting the data and developing hypotheses about factors contributing to students' performance and the specific actions they can take to meet students' needs,
3) testing the hypotheses by implementing changes to their instructional practice, and
4) restarting the cycle by collecting and interpreting new student performance data to evaluate their own instructional changes. (p.10)

Hamilton et al. (2009) claimed that their framework of data use is fundamental when using assessment data to guide instruction. The first step of their framework is collecting and preparing a variety of data about student learning. The authors emphasized that “to gain a robust understanding of students’ learning needs, teachers need to collect data from a variety of sources: annual state assessments, district and school assessments, curriculum-based assessments, chapter tests, and classroom projects” (p.11). The authors warned that “overreliance on a single data source, such as a high-stakes accountability test, can lead to the over alignment of instructional practices …resulting in false gains that are not reflected on other assessments of the same content” (p.11). The authors emphasized the importance of using classroom-level performance data sources including grades from students’ unit tests, projects, classwork, and homework in conjunction with non-achievement data such as attendance records and cumulative files, to interpret annual and interim assessment results.

The second step is interpreting data and developing hypotheses about how to improve student learning. The authors discussed two useful objectives that teachers need to consider when interpreting the data: “to identify each class’s overall areas of relative strengths and weaknesses so that they can allocate instructional time and resources to the content that is most pressing, ... to identify students’ individual strengths and weaknesses so that they can adapt their assignments, instructional methods, and feedback in ways that address those individual needs” (Hamilton et al., 2009, p.14). The third step is modifying instruction to test hypotheses and increase student learning. Teachers must make instructional changes to test their hypotheses about students learning and to raise student achievement. The authors also listed some of the kinds of changes teachers may choose to implement including one or more of the following:

> 1) allocating more time for topics with which students are struggling, 2) reordering the curriculum to shore up essential skills with which students are struggling, 3) designating particular students to receive additional help with particular skills (i.e., grouping or regrouping students), 4) attempting new ways of teaching difficult or complex concepts, especially based on best practices identified by teaching colleagues, 5) better aligning performance expectations among classrooms or between grade levels and/or better aligning curricular emphasis among grade levels. (p.15)

In summary, the authors urged the use of multiple data sources to address student learning needs where teachers engage in a form of action research in which they continuously modify instruction by developing hypotheses on students learning on the basis of the interpretation they draw out of the data, design strategy to test the hypotheses, implement the strategy, evaluate and reflect on the effect of the intervention, and continue these steps in a cycle. I also believe that this approach is practically feasible, and school teachers can adapt this framework of data use in an attempt to adapt lesson. However, effective use of this framework requires teachers to have a basic knowledge of action research in addition to the knowledge and skills s required to deal with data. Teachers can use standardized tests along with other forms of ongoing assessments to improve instruction and student learning outcomes. Standardized test scores can be used to "formatively reshape instruction" (Halverson et al., 2007, p.4). Analysis of student performance on standardized tests can be generated externally and can be given as feedback to teachers. Teachers can make use of the externally generated feedback data on their student performance on standardized tests in combination with their knowledge and experience about their students learning from ongoing assessments to adaptively plan instruction. However, there is little research on how teachers adapt lessons using external feedback data. On the other hand, many factors can influence the effectiveness of externally generated feedback data use for instructional decisions. The following section discusses some of these factors.

2.7.2 What factors influence the effectiveness of feedback data use

The factors that influence the effective use of students' performance feedback data in adapting (or differentiating) lessons could be categorized as factors related to the teacher, factors related to the feedback data, and other situational factors. Factors related to the teacher include (1) the beliefs and attitudes of the teacher about students' learning as well as about the use of feedback data; (2) the knowledge and skills of the teacher in dealing with the data and its further use; (3) teacher knowledge of and skills in action research.

The attitude of the teacher towards feedback data and her/his belief that s/he needs the data in order to improve instruction influences the willingness of the teacher to invest time and energy in dealing with the data and in using it to adaptively plan lessons (Schildkamp & Kuiper, 2010). One of teachers' beliefs that may influence the use of feedback data is teacher attributions about students' academic performance. Teachers' academic attributions are teachers' beliefs about the causes of success and failure (Georgiou et al., 2002). Teacher attributions about success and failure dictate teacher expectancies of future success. Teacher expectations are one example of how teacher beliefs about learning and teaching influence their instructional decisions, student learning and students learning outcomes (Turner, Christensen, & Meyer, 2009). Teacher expectations are inferences that teachers make about the future academic achievement of their students based on their knowledge and experience about their students learning. Such expectancies influence teachers' actions including how to adaptively plan lessons based on students' performance data. Furthermore, the extent of teachers' motivation towards the goals of the feedback, teachers view on their self-efficacy to use the data as well as their perception about credibility of the feedback data influence the effectiveness of the performance feedback data use (Visscher, 2009). Teachers' willingness to attribute student outcomes to their own teaching performance, teachers perceptions of personal control over the factors they attribute to students' academic performance, and the extent to which the teacher believed s/he had the capacity to affect student performance influence the use of feedback data to improve student learning. The core values and insights that the teacher brings into aspects of feedback data use in optimizing students learning influence the effectiveness of feedback data use (Knapp et al., 2006).

Teachers may belief in and have positive orientation towards using student performance feedback data. However, teachers' ability in dealing with feedback data and using it to making evidence based instructional decisions influences the effectiveness of feedback data use. Externally generated feedback data on students' performance is only useful if teachers are able to ask questions about their students' learning that can be answered with the data. In line with this, Knapp et al. (2006) pointed out that "data by themselves are not evidence of anything, until users of the data bring concepts, criteria, theories of action, and interpretive frames of reference to the task of making sense of the data" (p.10). One difficulty to make instructional decisions on the basis of feedback data on students' performance is the lack of knowledge and skills s needed to interpret data and to generate meaningful information that leads to action (Vanhoof et al., 2011). Teachers' ability to convert data into valuable and useable information influences the usefulness of feedback data (Earl & Fullan, 2003).

Therefore, teachers' ability to accurately interpret and diagnose the information from the data is one of the main potential challenges that hamper the effective use of feedback to improve instruction. Transforming the interpretation drawn out of the data into meaningful, relevant and useable information is a basis for making informed instructional decisions (Schildkamp & Kuiper, 2010). This primary depends on teacher ability to contextualize, categorize, connect, and summarize the data to innovate teaching. However, Schildkamp and Kuiper (2010) reported that teachers neither systematically analyze data nor apply outcomes of analyses to innovate teaching. The authors associated the limited implementation of data use to the complex skills successful implementation requires. They stressed the importance of developing teachers' competence to enhance teachers' effectiveness in informing practice from data. Wayman, Cho, and Johnston (2007) pointed out that one challenge in data based instructional decision making is that "most educators are not adequately prepared to inform practice from data" (p. 6). Visscher (2009) also suggested that the use feedback data presupposes the need to possess the skills to interpret the feedback data. Teachers data literacy defines how much and what they are able to do with data (Knapp et al., 2006), and teachers must learn how to use data to evaluate the curriculum and their own instructional effectiveness (Stecker, Fuchs, & Fuchs, 2005).

Even if teachers accurately interpret and generate information from the feedback data, teachers know-how on how to make use of the information they derived from the feedback data influences the effectiveness of feedback data use in an attempt to tailor instruction. That is, in addition to lack of capacities needed to interpret the data and generate useable information from it, lack of well-developed research skills such as the formulation of research questions and hypotheses, and developing an intervention strategies are also limiting factors in evidence based instructional decisions (e.g., Earl &

Fullan, 2003; Herman & Gribbons, 2001). Teachers' ability in anticipating the causes of underperformance implied by the feedback data and designing an intervention strategy are another potential challenge for effective use of feedback data (Visscher, 2009). Research reports indicated that lack of know-how on making use of the information generated from data is one barrier to the use of performance feedback (e.g., Kerr et al., 2006; Williams & Coles, 2007). In light of these, effective use of feedback data on students' performance presupposes teacher-as-researcher where they conduct systematic studies to improve their teaching practice and students learning. Teachers' knowledge and skills in action research influences the effectiveness of feedback data use to improve students' learning.

Action research is a contextualized research conducted by teacher, and combines diagnosis of students learning and teaching practices, developing action strategy, implementing the strategy (intervention) and reflecting on its effects. According to Kemmis and McTaggert (1988), it involves developing a plan for improvement, implementing the plan, observing and documenting the effects of the plan, and reflecting on the effects of the plan for further planning and informed action. Becoming teacher-as-researcher requires the teacher to explore an issue in teaching or learning, identify areas of concern, discuss how the issue might be addressed, collect and analyze data to determine the action to be taken, plan strategic actions based on the data to address the issue (Burns, 1999). It is evident from these that teachers' knowledge and skills in action research influences how best they can make use of the feedback data in innovating teaching practices and improving students learning outcomes.

The other variable that influences the effective use of feedback data by teachers is the levels of support they get in using feedback data. Availability of supportive environment influences the effectiveness of feedback data use. According to Schildkamp and Kuiper (2010) training and ongoing support is important for promoting feedback data use for instructional improvements. Visscher (2009) stated this as follows:

> If we manage to combine the provision of feedback with the required resources and with tailored training activities (training for the skills to analyse data, diagnose problems, and to design, implement and evaluate remedies), and the support (motivate staff, social support and encouragement from school management) of school staff for working with school performance feedback, then we may be able to make a difference. We may then be able to establish a basis for the improvement of processes at school and at classroom level, and via that line it may also be possible, where necessary, to improve the performance of students, teachers and schools. (p. 65)

Vanhoof et al. (2011) also suggested teachers need support both in the interpretation and further use of the feedback data. To justify the idea of the need to train and support teachers in feedback data use, Visscher (2009) argued that (1) data users (teachers) may not understand or believe in the feedback, (2) teacher may not have an idea of how to improve the underperformance implied by the feedback data, (3) teachers might have reduced motivation due to extra workload. Features of feedback (valid; reliable; up-to-date; relevant; absolute and/or relative performance; standard or tailored; complexity and clarity) may influence the quality of data use (Visscher, 2009). Other features of feedback data like aggregate level or disaggregate level feedback data are also expected to influence the effectiveness of performance feedback data use. Kerr et al. (2006) also found that among others the following factors affect data use "perceptions of data validity, training, and support for teachers with regard to data analysis and interpretation, and the alignment of data strategies with other instructional initiatives" (p. 496).

The synthesis of the above review reveals the complexity of using performance feedback data to improve instruction. The review shows that many variables come into play influencing the effectiveness of feedback data use to adapt instruction. Teacher related variables including teacher data literacy, teacher belief in particular teacher attributions to student academic success and academic failure, teachers' knowledge and skills of action research, and teacher pedagogical knowledge are expected to play a great role on the effectiveness of performance feedback data use for adaptive planning and teaching. I present reviews related to these variables in the following sections.

2.8 Data literacy

Data literacy can be defined as the ability to interpret, critically evaluate, and communicate about statistical information and messages (Ben-Zvi & Garfield, 2004; Gal, 2004). Wild and Pfannkuch (1999) identified five fundamental statistical thinking types: "recognition of need for data, transnumeration (changing representations to engender understanding), consideration of variation, reasoning with statistical models, and integrating the statistical and contextual knowledge" (p.227). Transnumeration involves "capturing qualities or characteristics of the real situation, transforming raw data into multiple graphical representations and statistical summaries to obtain meaning from the data, and communicating the meaning of the data in terms of the real situation" (Pfannkuch & Wild 2004, p.18). Pfannkuch and Wild (2004) put emphasis on aggregate-based reasoning to see variation about patterns of data via the idea of distribution. However, Konold, Pollatsek, Well, and Gagnon (1997), pointed out the difficulty to make the transition from thinking about and comparing individual cases to aggregate-based reasoning of data.

Scholars stress the importance of integrating data and context in using data to inform decisions. For example, Pfannkuch and Wild (2004) argued that

> Statistical thinking are linked to contextual knowledge, the integration of statistical knowledge and contextual knowledge is an identifiable fundamental element of statistical thinking…information about the real situation is contained in the statistical summaries, a synthesis of statistical and contextual knowledge must operate to draw out what can be learned from the data about the context sphere. (p.20)

The authors suggested that statistical thinking involves looking behind the data, connecting the data to the context from which they were generated. They argued that the contextual knowledge of the situation is important to justify the validity of extrapolation of data to future processes. Biehler and Steinbring (1991), quoted in Pfannkuch and Wild (2004), pointed out that linking data and context is necessary for proper interpretation of graphical representations. Cobb and Moore (1997) also emphasized that “statistics requires a different kind of thinking, because data are just not numbers, they are numbers with a context” (p.801). Context knowledge is also “essential for judging the quality and relevance of the data” (Pfannkuch & Wild, 2004, p. 38). Proper interpretation of statistical messages by data users depends on “their ability to place messages in a context, and to access their world knowledge” (Gal, 2004, p. 64). Moore (1990) argued that context is the source of meaning and basis for interpretation of obtained results. The author suggested that "teachers who understand that data are numbers in a context will always provide an appropriate context when posing problems for students" (p.96). According to Gal (2004, p.65) "the world knowledge, combined with some literacy skills, is prerequisite for enabling critical reflection about statistical messages and for understanding the implications of reported data".

Gal (2004) proposed a model of statistical literacy that involves a knowledge component (literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions) and a dispositional component (critical stance, and beliefs and attitudes). The author pointed out that "understanding and interpreting statistical information requires not only statistical knowledge per se but also the availability of other knowledge bases: literacy skills, mathematical knowledge, and context knowledge" (p.51). The author argued that critical evaluation of statistical information depends on the ability to access critical questions and to activate a critical stance (ibid., p.51). Gal further explained that the activation of critical instance is influenced by beliefs and attitudes of the data user. These elements of the knowledge component and dispositional component "jointly contribute to people's ability to comprehend, interpret, critically evaluate, and react to statistical messages" (Gal, 2004, p.51). According to Gal (2004) the literacy skills needed for statistical literacy refer to being aware of the meanings of certain statistical terms such as percentage, average, random, reliable, representative and include processing of prose text and examining document literacy skills including graphs, charts, and tables. Kirsch, Jungeblut, and Mosenthal (1998) view literacy as comprised of prose literacy, document literacy, and quantitative literacy. Kirsch et al. (1998) suggested that "prose literacy involves the knowledge and skills s needed to understand and use information organized in sentence and paragraph formats" (p.113). They claimed that document literacy tasks require people to identify, interpret, and use information given in lists, tables, indexes, schedules, charts, and graphical displays.

Kirsch et al (1998) described that the cognitive operations and processes involved in dealing with data displays include locating specific information, cycling through various parts of diverse displays, integrating information from several locations (e.g., across two graphs), generating new information (e.g., finding the difference between percentages in different parts of a table or between bars in a graph), making inferences perhaps apply mathematical operations to information contained in graphs or tables (Gal, 2004, p.56). Gal (2004) emphasized that "data users need to be familiar with basic concepts and data displays, concepts like percentages, mean, and effects of extreme values on means" (p.59). The author pointed out that graphical and tabular displays serve to organize data and to compare data, and thus data users' familiarities with graphical and tabular displays are important to make sense out of the data. When explaining the importance of the dispositional elements (critical instance, and beliefs and attitudes) in interpreting, explaining data and further use of the information, Gal (2004) argued that

> action or reaction …may involve taking some personal risks like exposing to others that one is naive about certain statistical issues…. People's beliefs and attitudes underlie their critical stance and willingness to invest mental effort or occasionally take risks as part of acts of statistical literacy. (p.69)

Makar and Confrey (2004) also claimed that

> capturing and influencing teachers' statistical reasoning is much more complex than trying to understand and describe students' reasoning…This is because

> teachers consider themselves experts and it is difficult for most experienced teachers to admit what they do not know and be open to learning and discussing their reasoning. (p.370)

Research reports indicated that teachers have difficulty in interpreting and explaining statistical data. Mickelson and Heaton (2004) found from their descriptive qualitative analysis of one third-grade teacher's statistical reasoning that the teacher struggled to merge statistical investigations into the existing school curriculum. Makar and Confrey (2004) studied the statistical reasoning of four secondary teachers during interviews conducted at the end of the professional development sequence, aimed at giving teachers rich experiences as investigators with school data. The authors examined teachers' reasoning about variation in the context of group comparisons in three areas: variation within a distribution, variation between groups (variation of measures) and how teachers distinguished between these two types of variation. Makar and Confrey (2004) anticipated that teachers

> would demonstrate their view of between-group variation by acting in one of four ways: (a) by calculating descriptive statistics for each group without making any comparisons; (b) by comparing descriptive statistics (e.g., indicating a difference in magnitude or that one was greater than the other); (c) by first comparing the descriptive measures of the two distributions as described earlier, then indicating whether they considered the difference to be meaningful by relying on informal techniques or intuition; or (d) by investigating whether the differences they found in the measures to be statistically significant using a formal test. (p.368)

Makar and Confrey (2004) findings indicated that all of their sample teachers clearly recognized variation within a single distribution but articulated a variety of meanings about variation between two distributions. The authors reported that none of the participant teachers used the size of the data set to examine the significance of the difference in means of the two distributions.

A research team in U.S. (U.S. Department of Education, 2011) investigated teachers' thinking about student data by administering interviews using a set of hypothetical education scenarios accompanied by standard data displays and questions. The sample teachers were from schools selected as exemplars of active data use. The research team identified five skill areas that are essential to use student data to improve instruction. These five skills are:

- Find the relevant pieces of data in the data system or display available to them (data location)
- Understand what the data signify (data comprehension)
- Figure out what the data mean (data interpretation)
- Select an instructional approach that addresses the situation identified through the data (instructional decision making)
- Frame instructionally relevant questions that can be addressed by the data in the system (question posing)

Data location skills are essential for identifying data that will be used to inform teachers' decisions about students. Data comprehension skills, such as understanding the meaning of a particular type of data display (e.g., a histogram) or representing data in different ways, are necessary for figuring out what data says. Data interpretation skills are required for

> teachers to make meaning of the data. Understanding the concept of measurement error and score reliability are important in data interpretation to make decisions about students learning based on test performance. (p. viii)

The research team designed data scenario interviews to assess into these five components of data literacy and use. To investigate teachers' thinking about student data the research team developed the target skills and processes required for each five skill areas.

1) To appropriately locate data (find the right data to use) the target skills and processes required includes finding relevant data in a complex table and graph, manipulating data from a complex table and graph to support reasoning.
2) The target skills and processes required for data comprehension (figuring out what the data say) includes moving fluently between different representations of data, distinguishing between a histogram and a bar chart, interpreting a contingency table, distinguishing between cross-sectional and longitudinal data.
3) Data interpretation (making meaning from the data) encompasses skills including considering score distributions, appreciating impact of extreme scores on the mean, understanding relationship between sample size and generalizability, understanding concept of measurement error and variability.
4) Question posing (figuring out questions that will generate useful data) includes skills like aligning question with purpose and data, forming queries that lead to actionable data, appreciating value of multiple measures.

5) Data use (applying the data to planning instruction) involves skills such as using subscale and item level data, understanding concept of differentiating instruction based on data. (p.8)

The research team stressed that student data do not speak for themselves. They reported their findings as follows:

> Even within districts such as those in these case studies, with a reputation for supporting data-driven decision making, some teachers struggled to make sense of the data representations in the assessment interviews…Especially when the question called for framing queries for data systems or making sense of differences or trends, a sizable proportion of case study teachers made invalid inferences…The most difficult data literacy concepts and skills appeared to be reasoning about data when multiple calculations were required, interpreting a contingency table, distinguishing a histogram from a bar graph, and recognizing differences between longitudinal and cross-sectional data…When given an open-ended invitation to explore data for the purpose of improving achievement, teachers had difficulty defining clear questions and did not ask questions that could eliminate rival hypotheses…Case study teachers had the most difficulty with data comprehension, data interpretation, and data query when they worked individually with summative assessment data. (pp. 61-62)

We infer from this findings that even in schools which established the use of assessment data into their system, teachers have difficulty in interpreting performance data, in generating hypothesis or defining clear question that leads to action. This clearly indicates that teacher data literacy influences the usefulness of performance feedback data to improve students' learning. Researchers have also clearly indicated that having data literacy per se may not guarantee the effective utilization of performance feedback data in adapting lessons unless otherwise teacher link the data interpretation with the data "literature", that is the contents and contexts of the data. Teacher ability to access and draw upon their world knowledge to place data interpretation in context is the focal point for meaningful instructional intervention. This greatly depends on teacher pedagogical knowledge, a knowledge that amalgamates many facets that are very important for adaptive planning and teaching to better students learning. The following section discusses about pedagogical content knowledge.

2.9 Pedagogical content knowledge

Shulman (1986) defines pedagogical content knowledge as:

> A second kind of content knowledge is pedagogical content knowledge, which goes beyond knowledge of the subject matter per se to the dimension of subject matter for teaching. The category of pedagogical content knowledge includes the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, demonstration in a word, ways of representing and formulating the subject that make it comprehensible to others....Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. (p. 9)

A report of the National Commission on Teaching and America's Future ([NCTAF], 1996) mentions two critical findings regarding teachers' content and pedagogical content knowledge: First, the teacher's expertise is one of the most important factors in student learning. Second, teachers' knowledge of the subject matter, student learning and development, and teaching methods are all important elements of teacher effectiveness.

Magnusson, Krajcik, and Borko (1999) conceptualized pedagogical content knowledge as teacher's understanding of how to help students understand specific subject matter and includes the knowledge of how to organize, represent, and adapt to the diverse interests and abilities of learners. Magnusson et al. (1999) identified five components of pedagogical content knowledge for science teaching. These are: teachers' orientations towards teaching science, that is teachers' knowledge and beliefs about the goals and processes of teaching science at a particular grade level, teachers' knowledge of science curricula, teachers' knowledge of students' understanding of science, teachers' knowledge of instructional strategies, and teachers' knowledge of assessment of scientific literacy (what and how to assess) (p. 97). The authors defined teachers' orientations toward teaching science as "teachers' knowledge and beliefs about the purposes and goals for teaching science at a particular grade level" (p.97). It is "a general way of viewing or conceptualizing science teaching" (ibid., p.98), which shapes and guides teachers' day to day instructional decisions including the strategies they use in their practices.

Teachers' knowledge of science curricula encompasses (i) the knowledge of mandated goals and objectives including teachers' knowledge of the goals and objectives for students in the subject(s) they are teaching, and knowledge about the vertical curriculum in their subject(s) (what students have learned/expected to learn in previous/later years), (ii) specific curricular programs and materials that are relevant to teaching a particular domain of science and specific topics within that domain including knowledge of the general learning goals of the curriculum as well as the activities and materials to be used in meeting those goals. The authors suggested that documents at national or state-level, districts level and schools that outline frameworks for guiding science curriculum and instruction for specific courses and what concepts are to be addressed to meet mandated goals are sources for teachers' knowledge of science curriculum.

Teachers' knowledge of students' understanding of science as a component of pedagogical content knowledge includes teachers' knowledge of requirements for learning specific science concepts and areas of science that students find difficult (Magnusson et al., 1999). The former refers to teachers' knowledge and beliefs about "the abilities and skills that students might need for learning specific scientific knowledge", and teachers' understanding of variations in students' approaches to learning (p.104). The later, knowledge of areas of student difficulty refers to "teachers' knowledge of the science concepts or topics that students find difficult to learn" (p.105). Students find learning difficult in science may be due to (1) the abstract nature of the concepts, (2) lack of any connection of the concepts to the students' common experiences, and (3) misconceptions (students' prior knowledge inconsistent with the targeted scientific concepts).

With regard to teachers' knowledge of assessment in science, Magnusson et al. (1999) conceptualized two knowledge requirements. The first one is teachers' knowledge of the aspects of students' learning that are important to assess. The authors pointed out that the important dimensions of science learning to assess include conceptual understanding, nature of science, scientific investigation, and practical reasoning. The other knowledge of assessment in science refers to knowledge of methods of assessment of those aspects of science learning. This includes both teachers' knowledge of how to assess the specific aspects of student learning (for instance, students' conceptual understanding, students' understanding of scientific investigation, problem solving) as well as knowledge of specific instruments or procedures, approaches or activities that can be used to assess important dimensions of science learning.

Teachers' knowledge of instructional strategies includes "knowledge of subject-specific strategies, and knowledge of topic-specific strategies" (Magnusson et al., 1999, pp. 109 -110). Teachers' knowledge of subject-specific strategies refers to teachers' knowledge of the general approaches for enacting science instruction including "the ability to describe and demonstrate a strategy and its phases" (p.110) and these may depend on increased knowledge of subject matter and the understandings of their students, teachers' beliefs about their role and students role. Teachers' knowledge of topic-specific strategies refers to "teachers' knowledge of specific strategies that are useful for helping students comprehend specific science concepts" (Magnusson et al., 1999, p.111). Teachers' knowledge of topic-specific strategies includes "teachers' knowledge of ways to represent specific concepts or principles in order to facilitate student learning" (p.111), and "teachers' knowledge of the activities that can be used to help students comprehend specific concepts or relationships", and teachers' knowledge of the extent to which "an activity clarifies important information about a specific concept or relationship" (p. 113). The authors argued that components of pedagogical content knowledge function as parts of a whole and interact in highly complex ways.

The authors pointed out that teacher's knowledge of a particular component may not be predictive of her/his teaching practice and they emphasized on the importance of understanding the interaction of the components and the effect of the interaction on teaching.

Teachers PCK is an important variable that may influence their ability in using student performance feedback data to adapt instruction meaningfully to students learning needs in two ways. The first one is that teachers PCK influences teachers' ability to integrate the feedback data and the context particularly their knowledge of the literature of the tasks that are used to assess students and their understanding of their students learning. That is, it impacts teachers' ability to identify students learning needs from the feedback data. The second one is that teachers' knowledge of instructional strategies as one component of PCK influences teachers' ability and creativity in designing an intervention strategy to bridge the gap between students' current performance revealed by the feedback data and the desired performance. However, irrespective of their pedagogical content knowledge, teachers belief about their students' performance in particular their attributions to their student academic success and academic failure influences the way they view their students' performance feedback data and their subsequent actions in the "how" of using the feedback data to adaptively plan lessons. The next section discusses academic attribution.

2.10 Academic Attribution

Academic attributions are beliefs through which teachers and/or students explain the cause of academic performance. Researchers have been attempting to understand teachers' attributions of students' academic success and academic failure and its impact on teachers' expectancies and students' academic behavior. Weiner et al. (1971)

developed an attributional model to analyze attributions to academic success and academic failure. The authors classified two dimensional attributions to academic success and academic failure. These are the locus of control (internality/externality) dimension and stability dimension. The locus of control dimension influences affective reactions to the success or failure and the stability dimension affects cognitive changes in expectancy following success or failure (Bar-Tal, 1978). Bar-Tal (1978) pointed out that failure attributed to lack of effort resulted in a higher expectancy for future success, whereas failure attributed to lack of ability, and difficulty of task resulted in low expectancy for future success. Later, Weiner (1985) proposed a three-dimensional taxonomy of attributions. According to this taxonomy, an attribution can be internal/external to the attributer, stable/unstable over time and controllable/uncontrollable by the attributer.

Cooper and Burger (1980) synthesized six categories of attributions as a general ability (academic, physical, and emotional abilities); a previous experience; acquired characteristics (habits, attitudes, and self-perceptions); effort (typical effort, immediate effort, interest in the subject matter, and attention); other people as an external unstable causes (quality of instruction by the teacher, other students, and family); and physiological processes (mood, maturity and health). Cooper and Lowe (1977) found that the presence of task information affect teacher attribution patterns. They also found that teachers believed that high performing students are more responsible for both their academic achievement. Cooper and Burger (1980) reported that a successful performance caused by large teacher role resulted in little intended change whereas failure caused by large teacher role led to most intended change. Cooper and Burger‘s (1980) also found that:

> Teachers attributed the cause of the performance to effort in preparation, student ability more often for bright than slow students…Teachers attributed the cause of performance to themselves significantly more often in the slow student's success…Bright student failure was more often attributed to immediate effort, while slow student failure was perceived more often as ability caused. (pp.106 -108)

Guskey (1982) reported that elementary teachers tend to attribute their lack of success with students to their effort but teachers at higher grade levels attributed the difficulty of the task (entry skills of students) in explaining poor learning outcomes. The results of Guskey’s investigation indicated that teachers do use different causal attributions in explaining positive versus negative learning outcomes on the part of their students. The author claimed that teachers attributed their ability and effort in teaching to student success but attributed difficulty of the task in teaching students who are unsuccessful. Hall, Villeme, and Burley (1989) found that teachers tended to ascribe the cause for academic success more to teacher influenced, and ascribed the cause for academic failure more to student influenced. Teacher attributions of student failure appear to be related to subsequent teacher behavior toward the failing student. Georgiou, Christou, Stavrinides, and Panaoura (2002) reported that a student who faces serious difficulties with his achievement receive better treatment by a teacher who is willing to accept part of the responsibility for the student’s failures. Nurmi, Viljaranta, Tolvanen, and Aunola (2012) examined the extent to which a student’s academic performance contributes to the active instruction given by a teacher to a particular student. They found that teachers adapted their instruction according to the previous academic performance of a particular student.

Teachers construct knowledge and beliefs about their student. They use their knowledge and experience to ascribe reasons behind their student performance, and this in turn influences teacher subsequent actions in instructional decisions. To fully understand how teachers use externally generated performance feedback data to adaptively plan lessons, it is worthwhile to examine teacher attributions to their student academic failure and the strategies they propose to intervene the supposed causes of failure.

3 The Research Questions

The quality of teachers' decisions in planning and sequencing lessons depends on (1) their ability to identify students leaning needs on the basis of an in-depth analysis of students learning data, and (2) their creativity and ability in applying and integrating learning and instructional theories, best practices outlined by research, and their lived experiences. However, much is not known about how teachers plan and sequence lessons and how they set priorities for student learning when making decisions. Stender (2014) developed an online lesson planning tool to assess the quality of physics teachers' lesson plans and how this quality is mediated by teacher competencies. However, Stender's research had two limitations. The first one is that teachers were asked to plan lessons using predefined vignettes that may not reflect the content of their ongoing practices. The second one is that teachers were presented with an ideal classroom for which teachers lack the context knowledge particularly about the learners. It is very hard to judge the quality of lesson plans where the context of the planning did not consider such conditions. It is, therefore, important to investigate the quality of lesson plans teachers develop for their actual classroom instruction. One characteristics of quality of a lesson plan is its adaptability. That is, how teachers' adaptively plan to accommodate the diversity in students learning needs. Such adaptive planning depends on (1) teacher's in-depth, differentiated, clearly structured, and transparent content knowledge of a specific topic as well as the knowledge and skills s students need to comprehend the new learning, (2) teacher's ability in diagnosing students' preconditions and learning processes, (3) teachers' knowledge of instructional strategies and their ability in using varied instructional strategies (Vogt & Rogalla, 2009; Wang, 1980).

To adaptively plan lessons, teachers need to make instructional decisions based on analysis of students' performance feedback data. Research reports indicated that feedback had positive effects on performance improvement. Most of the extant research reports on feedback effects come from contexts where teachers provide feedback and students receive it. In general, however, feedback can also be applied to contexts in which teachers are the recipients of their students' performance feedback data that is generated from outside the school institutions. Such feedback from external assessments of student achievement provides teachers with information about the extent to which learners have achieved learning goals and educational standards. Teachers can use the externally generated feedback data on students' performance to adaptively plan lessons to meet students learning needs. However, there is little research evidence on how teachers make use of their students' performance feedback data to make informed instructional decision on the bases of the interpretation they draw out of the feedback data.

Teachers' use of feedback data on their students' performance for adaptation of lessons demands teachers to understand and interpret the feedback data, ask questions from the data about students learning, anticipate the causes for underperformance implied by the data, and plan lessons adaptively. Such complex informed instructional decisions are also influenced (1) by teachers' ability to access their world knowledge and place the feedback data in a context, (2) by teachers' know-how to meaningfully use the information they generate from the data, and (3) by the values, beliefs, and theories of action that teachers bring into aspects of their practice.

Teacher's ability to interpret the feedback data, to draw useable information from the data, to anticipate causes of underperformance and to develop strategies for intervention against the anticipated causes influences the quality of teacher's adaptive planning. A recent research conducted in U.S. (U.S. Department of Education, 2011) indicated that even in schools with reputation in students data use, teachers had the most difficulty with data interpretation and data query. However, this study had limited generalizability because the research team used a fictitious or generated data. The participant teachers had neither the opportunity to place the data in context nor they can use their experience about the tested students. However, teachers' knowledge of the context of feedback data has an impact on their interpretation and explanation of students' data and its further use for adapting lessons. On the other hand, there is little research which investigated teachers' explanation and interpretation of feedback data on their students' performance. However, investigating how teachers explain and interpret externally generated performance feedback data of their students must be an integral part of studying the effect of feedback on teachers' lesson planning.

One inherent difficulty in planning instruction based on analysis of students' performance feedback data is identifying the exact causes of underperformance revealed by the data (Visscher, 2009). However, based on their experience and belief teachers can ascribe (or attribute) reasons for their students' performance. On the other hand, teachers' attributions to students' academic success and academic failure influence teachers' instructional decisions (Cooper & Burger, 1980; Georgiou et al., 2002; Guskey, 1982; Hall et al., 1989; Nurmi et al., 2012). However, studies related to teacher attributions to students' academic success and academic failure had the following limitations: (1) some of the studies were conducted on student teachers and on ideal classrooms, (2) most of the studies emphasized only affective behavior, (3) none of these studies explored how teachers propose an intervention strategy against the factors they attributed for student academic failure. I believe that, to fully understand how teachers use externally generated performance feedback data to adaptively plan lessons, it is necessary to examine teachers' attributions to student academic failure and the strategies they propose to intervene against the supposed causes of failure.

In general, teachers' effective use of externally generated feedback data on students' performance to tailor lessons to individual student learning needs might be influenced by teachers' attitude and beliefs including their attribution to students' academic performance, teachers' motivation, teachers' data literacy, teachers' pedagogical content knowledge, and teachers' knowledge of and skill in action research. There is little research work that investigated quality of lesson plans, teachers' interpretations and explanations of feedback data on students' performance, and teachers' thinking on how to use feedback data on students' performance for adaptive lesson planning. The study, therefore, focuses on investigating the quality of lesson plans, teachers' attributions to their students' academic success and academic failure, and teachers thinking about the use of externally generated feedback data to adapt lessons. To this end, the study is guided by the following basic research questions:

1) Do physics teachers plan high quality lessons? The intentions of this research question are (i) to assess the quality of physics teachers lesson plans in terms of its adaptability, and cognitive activation of students, (ii) to understand how physics teachers sequence lessons and what underlying criteria they use to sequence lessons.
2) What attributions do teachers hold for students' performance? The aim of this research question is to explore teachers thinking and casual's explanation of students' academic success and academic failure. Through this research question I wanted (i) to know teachers causual expalnations for their students' achievement, (ii) to know which of those factors attributed to students' academic failure, teachers

believe that they can control, change or influence, and (iii) to get insight into the kind of intervention strategies they propose to intervene against the supposed causes of failure. Understanding what teachers suggest as an intervention is very important to better understand how teacher use feedback data to adapt lessons.

3) How do physics teachers use performance feedback data? I wanted to learn about teachers thinking and feeling about their student's performance feedback data, how they interpret and explain the feedback data, and their thinking about the use of feedback data to adapt lessons to bridge the gap between the expected performance and the achieved performance, and whether they favor the use of feedback data to tailor lessons to individual student learning needs or not.

4 Research Methodology

4.1 Research design and participants

This study follows a qualitative approach with multiple data sources. The participants of this study were four physics teachers teaching at different grade levels. Two teachers were teaching 8th grade students, one teacher was teaching 9th grade students and the other one was teaching 10th grade students. The participants were teaching in schools located at different towns. The participants had a teaching experience of more than six years. The participants were given pseudonyms called HAS, Kaise, Land and Main. HAS had a teaching experience of six years. HAS was teaching mechanical work and energy to grade 8th students. Kaise had a teaching experience of 14 years. Kaise was teaching electromagnetic induction to 10th grade students. Land had a teaching experience of more than 10 years. Land was teaching thermodynamics to 9th grade students. Main was teaching fluid mechanics (buoyancy, sinking, and floating) to 8th grade students. To generate feedback data, a test was administered to 215 students.

4.2 Data Sources and Instrument of data collection

This study used multiple sources of data. The data sources of this study includes concept maps developed by the participant teachers, teachers' attributions to students' academic success and academic failure, lesson plans developed by participant teachers and interviews with audio-recording. Student scores on tests were also the source of data for generating feedback data. To this end, a questionnaire, an online lesson planning tool, standardized tests, semi-structured interviews were the main data collection instruments used in the study. The participant teachers also used Concept Mapping Tool software to develop a lesson.

An online lesson planning tool developed by Stender (2014) was used by the participant teachers on a workshop organized at the University. Stender (2014) developed concrete planning situations in a mechanics lesson for 9^{th} grade on the topic “Force”. This planning tool consisted of vignettes for three planning situation describing an introduction lesson (theory part of a lesson), experimentation lesson and transfer lesson. The planning situations initially consist of an introductory text that describes the situation. In the case of the experimental and transfer lesson the texts were followed by a short video showing an experiment and/or a classroom situation. Later, the online planning tool was modified to fit it to the participant teacher’s ongoing teaching activities. Teachers were then asked to develop five consecutive lessons for their actual class with the help of the modified online lesson planning tool.

To explore teachers’ attributions to their students’ academic success and academic failure relevant literature on attributions was reviewed. Teachers’ attributions from the literature were summarized, and some new ones were also included resulting to a list of about 19 factors (8 factors related to the teacher, 7 factors related to the student, and 4 factors related to other people like peers and family). Teachers were then asked the following questions. Which of these factors are, in your opinion and experience, mainly responsible for the success of your students? Which of these factors are, in your opinion and experience, mainly responsible for the failure of your students? Which of the factors that you have selected for the failure, can you change/influence? Please also briefly describe how you could change/influence the respective factors.

To generate feedback data, students of the participating teachers were tested. To this end, four tests consisting of 30 items were prepared. The tests consisted of two parts. The first part of the tests contained eight questions prepared from the contents on which teachers have planned lessons and taught the lessons. The four participant teachers were teaching on different physics contents. Therefore, the first parts of the tests were different for different teachers. For Land, who was teaching thermodynamics, eight questions were selected from thermal concept inventory test (Yeo & Zadnik, 2001) on the basis of the fit between the test items and the contents on which the teacher has already planned and taught lessons. For HAS, who was teaching mechanical work and energy, 15 questions were selected from energy and matter concept inventory test (Ding, Chabay & Sherwood, 2007) on the basis of the fit between the test items and the contents on which the teacher has already planned and taught the lessons. These questions were translated to German language. The translated version was checked by Professor Alexander Kauertz, and finally eight questions were selected for use. For Kaise who was teaching electromagnetic induction, a test consisting of 12 questions was collected and prepared first in English by the researcher. The questions were translated into German language. The content validity of this test items was checked and reformulated by Professor Alexander Kauertz and eight questions were finally selected for use. For Main, who was teaching on fluid mechanics (buoyancy, sinking and floating), a test consisting of 15 questions was prepared first in English by the researcher and then translated to German. The content validity of these questions was also checked by Professor Alexander Kauertz, and finally eight questions were selected for use.

The second parts of the tests were common for the four teachers. This part of the test consisted of 22 items from IQB item pool, a standards – based test prepared to assess students competence in Germany. The initial purposes of the second part of the test were (1) to use as a baseline data to compare teachers' interpretation of their students' performance feedback data, and (2) to check if the score on this part of the test predicts the score on the first part of the test.

An interview protocol consisting of three parts were prepared. The first part of the interview protocol consisted of questions that ask teachers about their processes of lesson planning which is directly related to the lessons the teachers have developed. In addition to this, this part also includes questions that ask teachers about the features of quality lesson plans like its adaptability and inclusion of deep learning tasks for cognitive activation of students. The second part of the interview protocol is related to the feedback data that was given to the participant teachers and adaptive planning. This part of the interview was intended to elicit teachers' idea about their feelings on the feedback data, their understanding and interpretation of the feedback data, and to get insight about teachers thinking on how to use the feedback data to optimize students learning. And the last part of the interview protocol included questions intended to assess teachers' reflection about the use of feedback data including teachers' beliefs about the difficulties of planning a lesson using the feedback data.

4.3 The Research Procedure

Data for this study was collected over the period of 11 weeks, from April 29 to July 22, 2014. The participant teachers were invited for participation in a one day workshop organized at the University as the initial phase of data collection processes for the research. The workshop was held on 29th of April, 2014. On this first phase of data collection in the form of a workshop the following activities were sequentially carried out. First, a 20 minute presentation on lesson planning and concept maps was made by Prof. Dr. Alexander Kauertz to the participant teachers. The intentions of the presentation on these topics were two folds: (1) to arouse participant teachers interest in actively taking part in the research processes of the project, and (2) to make teachers feel that they also gain something from the discussion with the professors. Second, teachers were asked to use Concept Mapping Tool software and draw concept maps to explain their own experience of lesson planning processes on the topic force. The intentions of the concept maps were to get insights about teachers' cognitive structure on lesson planning processes, and to catch teachers' idea about lesson planning processes that otherwise may not be obtained by the structured online lesson planning tool. Third, teachers were asked to discuss the concept maps they developed. The purpose of this discussion was to get new insights about lesson planning process that might evolve during the discussion.

Fourth, a 20 minute presentation on standardized assessment and use of students' data to adapt lessons was made by Prof. Dr. Ingmar Hosenfeld to the participant teachers. The intention of this presentation were (1) to inform the participant teachers the importance of using standardized assessments and their students' performance feedback data in meeting diverse learning needs of students, and (2) to arouse teachers' interest in using students' performance feedback data in adapting lessons in the other phase of the research project. Following this brief introduction, at the fifth stage, teachers were asked to ascribe reasons for their students' academic success and academic failure. Sixth, teachers were asked to work individually and plan lessons with the help of an online lesson planning tool developed by Stender (2014). After teachers planned the lessons, teachers were asked to discuss and reflect on the lesson planning tool. The intentions of this discussion and reflection were to get teachers impression about the planning tool for further modification of the planning tool itself for future use, and to get new insights about lesson planning process that might evolve during the discussion.

The second phase of this study consisted of the following activities. First, the online planning tool was modified so that teachers can use it to plan lessons for their ongoing practices. Second, teachers were asked to develop five consecutive lessons for their actual classes with the help of the modified online lesson planning tool. The intentions of having these consecutive lesson plans were (i) to explore the dynamics (or stability) of teachers decisions in sequencing lessons, (ii) to get rich in-depth evidence on teachers lesson planning processes, (iii) to prepare test items directly from what teachers have planned with the help of the planning tool and have already taught the contents in the class for the purpose of generating feedback data.

The third step in the second phase was preparing test and administering the test to students of the participating teachers to generate feedback data. Four tests consisting of 30 items were prepared. Test booklets consisting of 30 questions were prepared by Professor Ingmar Hosenfeld at his Institute. The test booklets were prepared in a way appropriate for scanning students responses to the questions. Students of the participating teachers were tested over a period of 40 minutes. For the purpose of comparison the first part of the test was also administered to other similar students in different schools. On the testing date teachers were asked to work on data literacy assessment. The initial intention of measurement of teachers' data literacy was to explore if teachers' competency in dealing with data has any effect on their understanding, interpretation and further use of students' performance feedback data in adapting lesson to close the learning gaps revealed by the data.

Fourth, the students' result was scanned, analyzed and feedback data was prepared for each participant teacher by Professor Ingmar Hosenfeld. The feedback data had three levels: aggregate level feedback, category level feedback, and item level feedback. Teachers received their own feedback data both electronically and through ordinary mail. Teachers were provided the tasks (questions) of the first part of the test along with the correct solutions. Teachers were purposely provided the questions and correct solutions with a believe that teachers' knowledge of the contents of the tasks (questions) and the correct solutions could help them in explaining their students result and designing an intervention strategy to customize lessons to individual students leaning needs revealed by the feedback data.

In the third phase of the project, first teachers were asked to adapt one of the lessons they already developed and taught on the basis of the interpretation they draw out of the feedback data. The intention of asking teachers to re-plan a lesson using students feedback data was to explore the kind intervention teachers propose to improve the poor performance revealed by the feedback data as well as to know how teacher develop a differentiated lessons for different levels of their students' performance. The second step of the third phase, and the final step of data collection, was conducting an interview. Interview protocols were prepared. Three teachers were interviewed, but one teacher withdrew from taking part in interview due to time pressure.

4.4 Method of Data Analysis

The qualitative data in this study was organized using the type of data as a criterion, for example, concepts maps, attributions, lesson plans, and interview transcripts each with separate files. Within each of these data files, data were also organized by source, and by time. In this study, both qualitative and quantitative data analyses were employed. Teachers' concept maps were qualitatively described. The lessons plans developed by participant teachers with the help of an online planning tool were analysed qualitatively and quantitatively. Teachers intervention strategises against the supposed causes of failure were qualitatively described by placing it with existing literature. The interview data was qualitatively analysed.

In the online lesson planning tool, the participant teachers were first asked, "In which part of the lesson planning area [contents, learning objectives, methods, social structures, exercises, experiments, others] would you make a decision first?" The responses of the teachers to this question were used to identify the sequences of teachers' decisions. The frequency of the decisions on each area of lesson planning was determined. Teachers' responses to the open ended questions like "What would you like to implement in your lesson in this part? How would you proceed?" were used to analyse the quality of planned lessons quantitatively. Teacher responses to these open ended questions were used to rate the quality of lesson plans particularly for its concreteness, adaptability, coherence, and cognitive activation. To this end, the lesson plan rating manual developed by Stender (2014) was used. Two steps are used to evaluate the features of the lesson plans. In the first step it is determined whether the teacher made a decision or a description of decision making process. In the second step the features of the lesson plans are rated from teachers responses to the open ended questions. In order to obtain a clear and distinct assessment of the features, the features are independently rated from one another. The features stand to some relation to previous decisions within a lesson plan, and in order to establish these relations, an entire lesson plan from one teacher is assessed. A 3-point scale is used to rate the features of lesson plans: 0 = feature not true; 1 = feature applies with restrictions; and 2 = feature applies.

The analytical units represent either single answers or an entire lesson plan. The entire lesson plan was the unit of analysis for the whole coherence of the lesson and cognitive activation. Table 1 presents two features of quality of lesson plan (adaptability and cognitive activation) and descriptions of indicators of the features.

Teachers' responses to the open ended questions were also used to analyse the lesson plans qualitatively. The qualitative data analysis in this study follows both a descriptive and an iterative approach. In the descriptive approach teachers statements are described and explained in detail by placing it in literature. In the iterative approaches, teachers' decisions and intentions of implementation were coded and interpretatively explained by linking with existing literature.

Table 1
Features of lesson plan and the corresponding indicators.

Features	Indicators
Adaptability	• the learning condition of the students including description of pre-requisites, prior knowledge, misconceptions, and learning needs. • differentiation by task to suit diverse needs and characteristics of learners, differentiation by outcome (planning expectations of different levels of performance on a task/activity), differentiation by support (different levels and kinds of scaffolding).
Cognitive activation	• The students can introduce their own ideas, concepts, solutions, etc. • planned lesson stimulates insightful learning. • inclusion of cognitively challenging tasks. • planned activities help students develop scientific process abilities required for constructing scientific knowledge and approaching complex problems. • planned lesson integrate learning of physics content with learning about the processes of science. • the planned teaching-learning activities engages learners in cognitively challenging activities that could result in mastery of subject matter, developing scientific reasoning, and cultivating interest in science. • planned lesson includes ongoing student reflection and discussion.

In an iterative approach, I adopted the method suggested by Tracy (2013). According to Tracy, "an iterative analysis alternates between emergent readings of the data and use of existing models, explanations, and theories" (p.184). This approach "encourages reflection upon the active interests, current literature, granted priorities, and various theories the researcher brings to the data" (ibid., p.184). This study follows the technique of fracturing the data into smaller slices and connecting these bits into larger categories during later coding cycles. I read through all my data a few times and conducted line-by-line open coding. In this initial coding my attempt was to identify data and its meaning. I examined the data and assigned words or phrases or I make use of the actual words or phrases within the datum itself. This was repeated many times with a consistent increase in depth and breadth in the open description of the basic activities and processes in the data. I used a manual approach on hard copies of the data to write the code in the margin. I also used Microsoft word-processing and Excel spreadsheet to code and describe the codes. During the primary-cycle coding, I created a list of self-explanatory codes. Along this I developed a systematic codebook – a data display that lists key codes, definitions, and examples to be used in the analysis. As a result of the emergent theme, I revisited literatures and theories that I'm unfamiliar with. This helped me to learn more. This was one of the exciting experience and learning I had when searching for literature that explains the emergent theme from the qualitative data I had.

In secondary-cycle coding, I critically examined the codes already identified in primary cycles and begins to organize, synthesize, and categorize them into interpretive concepts. Second-level coding includes "interpretation and identifying patterns or cause–effect progressions" (Tracy, 2013, p.194). In the second level coding, I used disciplinary concepts that best explicates the data and my theoretical knowledge.

Through time I get a better understanding how my data analysis attends to my research questions. To be able to synthesize and make meaning from my codes, I created a document that records all of my analysis activities, chronologically on Microsoft word and Excel spreadsheet. This was followed by analytic memos both as a part of the analysis process and as an analysis outcome. According to Tracy (2013) such analytic memos help in figuring out the fundamental stories in the data and serve as a key intermediary step between coding and writing a draft of the analysis. They include defining the code and providing examples of raw data that illustrate the code. To ensure the fidelity and credibility of emerging explanations, I also carefully considered negative case analysis by searching out deviant data that do not appear to support the emerging explanation to better fit all the emerging data.

5 Results and Discussions

This section discusses the results from concept maps mapped by participant teachers, analyses of quality of lesson plans, teachers' attributions, and the results from interviews. Initially it was also intended to investigate the effect of teachers' data literacy in understanding, interpreting and using students' performance feedback data. However, the data on participant teachers' data literacy was not analyzed. On one hand this data was entirely quantitative while other data were entirely qualitative; on the other hand the number of the participants is low to make comparisons.

5.1 Lesson plans from concept maps

Participant teachers were asked to plan a lesson on the topic force using the Concept Mapping Tool software. The intention was to get insights into teachers' cognitive structure about lesson planning processes. The concept maps mapped by the participant teachers were analyzed using the concept map scoring criteria developed by Novak and Gowin (1984). According to these authors, each relationship has 1 point, each hierarchy has 5 points, each crosslinks has 10 points, and each example has 1 point. Table 2 presents the scored summary of the concept maps mapped by the participant teachers. Table 2 demonstrates that the concept map mapped by Main had the lowest score compared to others, and the concept map mapped by HAS had the highest score. Table 2 illustrates that the lesson planned by Land with the help of the Concept Mapping Tool software had 11 relationships between concepts, 6 hierarchies, and 2 examples. There were no crosslinks between concepts in the mapped lessons (see figure 4).

Table 2

Comparison of scores on concept maps developed by participant teachers.

Participant	Relationships	Hierarchy	Crosslinks	Examples	Total score
Land	11*1	6*5	0*10	2*1	43
Kaise	8*1	7*5	0*10	1*1	44
HAS	12*1	7*5	0*10	0*1	47
Main	6*1	4*5	0*10	0*1	26

Table 2 shows that the lesson planned by Kaise with the help of the Concept Mapping Tool software had 8 relationships between concepts, 7 hierarchies, and 1 example. There were no crosslinks between concepts in the mapped lessons (see figure 5). Table 2 illustrates that the lesson planned by HAS with the help of the Concept Mapping Tool software had 12 relationships between concepts, and 7 hierarchies. There were no crosslinks between concepts in the mapped lessons, and also there were no examples (see figure 7).

Table 2 indicates that the lesson planned by Main with the help of the Concept Mapping Tool software had 6 relationships between concepts, and 4 hierarchies. There were no crosslinks between concepts, and also there were no examples (see figure 6). As can be noticed from figure 6, Main mentioned many concepts in a single rectangular box which could be further extended into a series of hierarchies. That is why the total score was low. This does not imply that the intended lesson is of poor quality. This might be due to lack of experience in using the concept mapping tools to hierarchically structure concepts linking each concept with another. Main and Kaise used a mathematical model, formal language of physics, and this mathematical model is not equivalent to a simple word representing a single concept. It is rather a system of relations representing different concepts to explain the deep structure of the physical phenomena. From this point of view the concept map scoring criteria is not a good method to analyze the planned lesson. Furthermore, these scores do not provide meaningful information about the cognitive structure of the planning teachers in sequencing lessons hierarchically. For better understanding, the mapped lessons by individual participant teachers were described qualitatively. Figure 4 presents the schematic diagram of the cognitive structure of Land about a lesson s/he planned on the topic force.

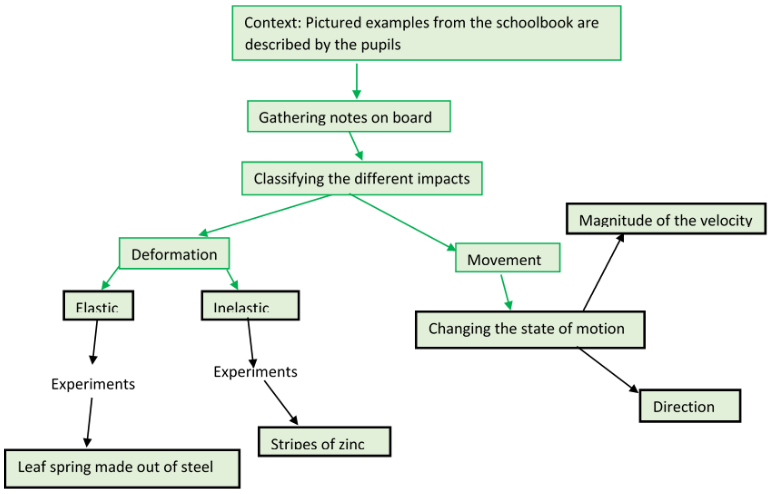

Figure 4. Concept map by Land.

As a starting point in sequencing the lesson, Land described the context. For Land this context refers to the learning environment where students describe the concept force from schoolbook pictures. The teacher then collects students' idea and writes it on the board. Afterwards, the sequence follows on classifying different impacts of force. Land explicitly stated on the concept maps that these impacts of force are: (1) changing the state of motion of an object which includes both change in magnitude of velocity and direction of motion, (2) the deforming effect of force including elastic deformation (the case where the object regains its original form when the acting force is removed) and inelastic (also called plastic) deformation (the case where the object remains deformed after the acting force is removed).

Figure 4 illustrates that the last sequence in the hierarchies of the lesson planned by Land was conducting an experiment on the effect of force in deforming the shape of an object. Land explicitly stated the materials to be used for each type of deformation. However, the "who" conducts the experiment was not stated. Students' involvement in the learning was only indicated at the beginning where the teacher planned to ask them so that they could describe force from school book pictures. We can say this lesson was partly adapted to preconditions in a sense that students' prior knowledge and possible misconceptions could be exposed, when they describe and explain force. The flow of the sequence is also coherent. However, it is difficult to judge the level of cognitive activation of students from the lesson planned.

Figure 5 presents the schematic diagram of the cognitive structure of Kaise about a lesson s/he planned on the topic force.

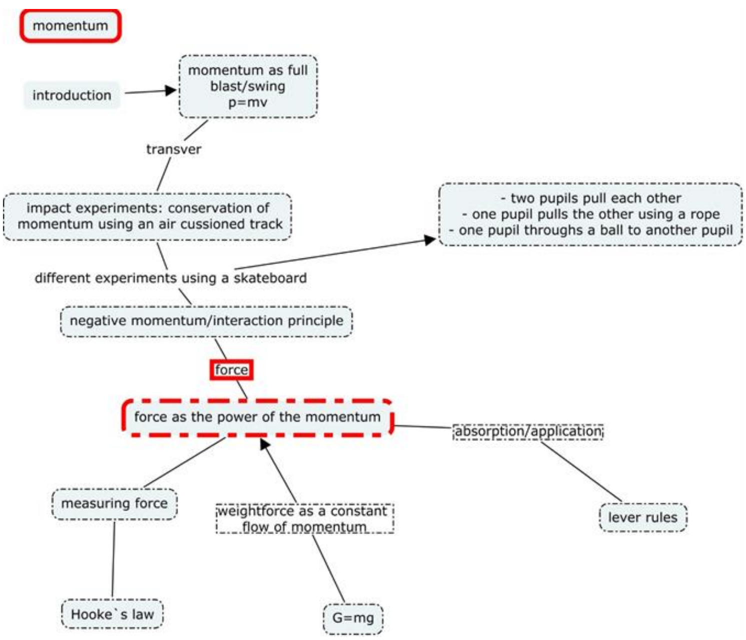

Figure 5. Concept map by Kaise.

Figure 5 demonstrates that at the top of the sequence, Kaise wanted to start by introducing the concept momentum with its mathematical model (formula). Following this, Kaise planned to transfer the concept learned about momentum to the more general principle "conservation of momentum" through experimentation. The planned lesson sequence engages students to conduct simple experiments like pulling each other so that students can make sense of the impact of momentum. Afterwards, Kaise planned to introduce the concept force in terms of momentum, defining momentum as "a power of force".

Implicitly, it seems that Kaise planned to use the analogy between work and power (a simple definition of power is the rate of doing work). This is because force is formally defined as the rate of change of momentum. That is why Kaise used the term "force as the power of momentum". In line with this, Kaise planned to define weight (mg) as a constant flow of momentum. The idea is that $mg = \Delta P/\Delta t = constant$. Following this, Kaise integrated an experiment on measuring the effects of force using Hook's law, and then applying the concept of force in a different situation, that is "lever rules". The use of analogy by Kaise to introduce the concept force shows the creativity of the teacher. Planning for teaching using analogy requires creativity on the part of the teacher.

Figure 6 presents the pictorial representation of the cognitive structure of Main about a lesson s/he planned on the topic force.

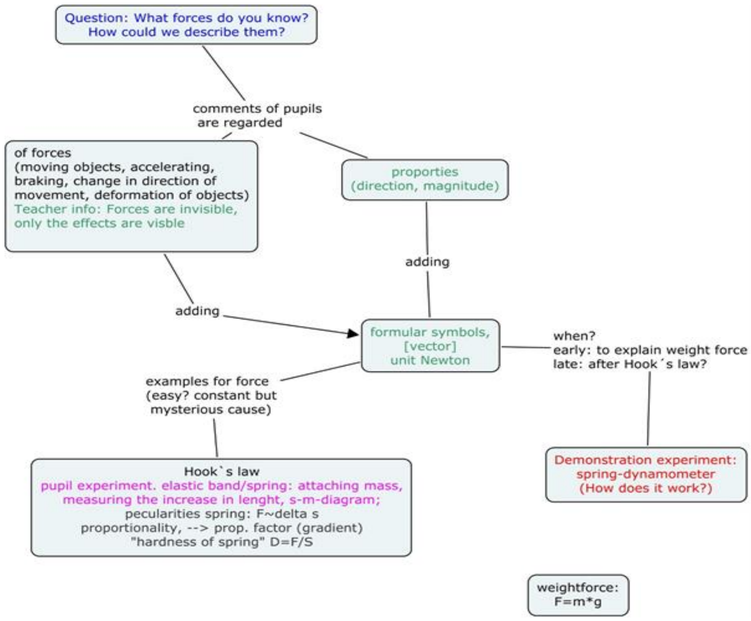

Figure 6. Concept map by Main.

Figure 6 depicts that Main started sequencing the lesson by activity. That is, by a task that requires students to describe their knowledge about force. After collecting students' prior knowledge about force, Main planned to comment on students' idea and to explain the concept force through its effects and properties. Following this, Main planned to introduce the mathematical model using symbols and vector notation at two points in the space of the instruction: the first is to use a formula to explain weight force, and the second is to use a formula to explain Hook's law.

The last phase of the sequence includes two different experiments. One is demonstrating the working principle of spring – dynamometer, and the other is that students will perform an experiment on Hook's law. Main clearly spelt out the materials to be used and the details of activities that students are expected to engage in including what to measure by varying what, what variable to plot (graph) against what variable, and what parameter to extrapolate from the graph. The sequence of the lesson mapped by Main was coherent, adapted to preconditions, and potentially engages students in cognitive activation if actualized as intended.

Figure 7 presents the roadmaps of the cognitive structure of HAS about a lesson s/he planned on the topic force. Figure 7 indicates that at the top of the sequence HAS planned to collect students’ statements about force from their everyday life experiences. Afterwards, HAS planned to contrast the everyday language students use to describe force with the physical meaning of force. This goes with the idea of knowing students prior knowledge, identifying possible misconceptions about force, and then teaching the correct physical meaning of force. After addressing students possible misconception about force, HAS thought and planned how students could detect the impact of force. For this, HAS integrated an experiment into the sequence of the lesson so that students could conduct an experiment to understand both (1) the deforming effect of force using hammer and object, and (2) the effect of force in changing the state of motion of an object using a toy car.

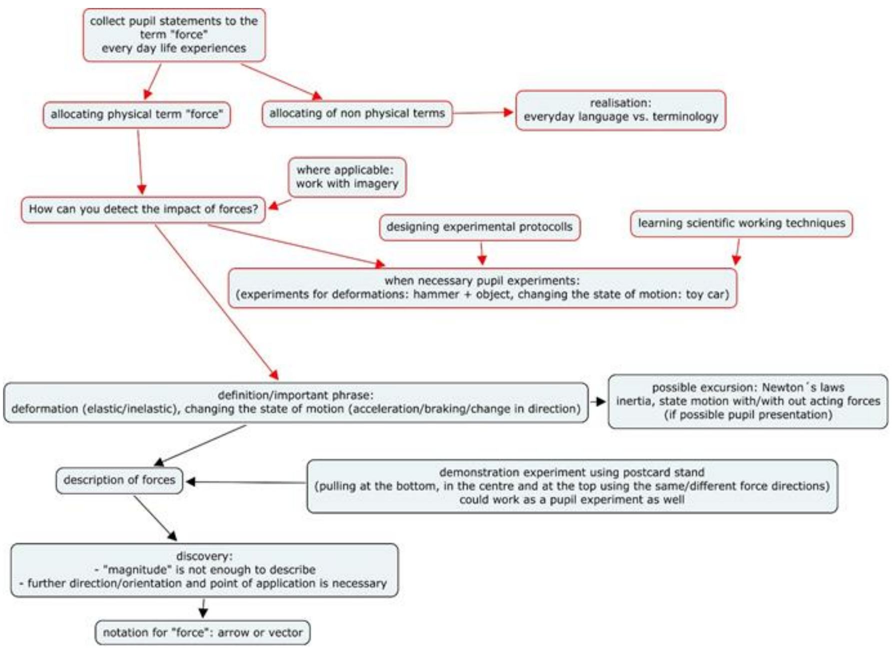

Figure 7. Concept Map by HAS.

The teacher stated in the concept mapped that in addition to learning the impacts of force, through experiments students learn also (1) how to design experimental protocols, and (2) scientific working techniques. HAS was referring to the importance of experimentation to the learning of both content and science process skills. HAS planned variety of approaches to the teaching and learning of force and its effects including (1) the possibility of organizing excursions, where students can organize an idea on Newton's laws, inertia, and state of motion with and without acting forces followed by the possibilities for student presentation, (2) describing force using hands on experiment with easily available material like postcard stand where students could pull the postcard stand at different positons (top, middle and bottom) and using the same or different force directions. The final sequence was developing a mathematical model of force using vector notation, which includes both magnitude and direction.

The participant teachers mapped their cognitive structures about lesson planning on a topic force with the help of the concept mapping tool software. The participant's concept maps showed similarities and differences about the mental models of these teachers on lesson planning. The most important similarities were diagnosing and identifying students' prior knowledge about force and the participants integrated experiments within the flow of the planned lesson. However, there were differences among the participants in their approach. The similarities and differences are discussed in detail under the section discussion.

5.2 Lesson plans from vignettes

On a workshop which was held on 29th of April, 2014, the participant teachers were asked to plan lessons with the help of an online lesson planning tool developed by Stender (2014). This online planning tool provided teachers three planning situations (theory, experiment, and transfer) along with vignettes on force and effect of inertia. Teachers were then asked to use these vignettes as a starting point to plan the lesson for their own students. However, due to internet failure the browsers on the teachers PCs were not able to open the video related to the planning situation transfer. Consequently, the participant teachers were able to plan only for the first two planning situations.

Table 3 presents the sequences of decisions made by the participant teachers on the areas of lesson planning. Table 3 shows that the sequences of decisions made by HAS on the theory part were different from the sequences of decisions made on experiment. Similarly, we see from the table that the sequences of decisions made by Main for the two planning situations were different. Kaise made the first decision on the planning area “contents” for both planning situations whereas Land made the first decision on the planning area “methods” for both planning situations. Table 3 depicts that the first two decisions made by Kaise for both planning situations were identical. However, the last two decisions in the sequence for the two planning situations were different. Table 3 demonstrates that the first two decisions made by Land for both planning situations were the same. The sequence of decisions for the two planning situations varied only on the last decisions. Therefore, it can be concluded from table 3 that the sequences of decisions made for the two planning situations by Land were similar. However, there were great variations between the sequences of decisions made by HAS. Similarly, the sequences of decisions made by Main for the two planning situations were different.

We infer from the table that there were differences among the participant teachers in sequencing decision areas for both planning situations. Most of the lesson planning approaches discussed in the review of literature suggests defining learning objectives as the first step in the processes of lesson planning. However, table 3 shows that the participant teachers started sequencing lessons with other planning areas over learning objectives. It is important to ask one question related to teachers sequence of decisions: what criteria do teachers use in sequencing lessons?

Table 3

Sequences of teachers' decisions when planning lessons from vignettes.

Teacher	Sequences of decisions of planned lessons
Kaise	Theory : Contents → Experiments→ Method → Exercises Eexperiment: Contents → Experiments → Experiments →Contents
HAS	Theory: Learning objectives →Contents → Methods → Social forms Experiment: Methods → Social forms →Others (not specified)
Main	Theory: Contents → Others (students present definition of force) → Experiments → Experiments Experiment: Learning objectives → Methods→ social forms
Land	Theory: Methods → Learning objectives → Exercises Experiment: Methods → Learning objectives →Experiments

Figures 8 -11 present the analyses of the qualities of the lessons planned by participant teachers. Specific coherence refers to the coherence between the individual decision on the lesson planning area and the intended implementation for that particular area. For example, if a teacher decides on experiment, then the teachers' responses to the questions "What would you like to implement in your lesson in this part?" were used to rate the coherence of teachers statements of intentions to the lesson planning area. That is, the unit of analysis for specific coherence is a single response corresponding to the specific decision made. The same holds also for concreteness and adaptability. However, the entire lesson plan was the unit of analysis for the whole coherence of the lesson and cognitive activation. Two independent raters rated the lesson plans. The coders received training on how to use the rating manual developed by Stender (2014). They also practiced rating lesson plans before they actually rated the lessons developed by the participant teachers. The coders had a discussion to resolve their disagreement. Finally, the agreed up rating was used to calculate the inter-rater reliability. Accordingly, the inter-rater reliability coefficients were: decision (α = 0.91), concreteness (α = 0.91), adaptability (α =0.92), specific coherence (α = 0.96), overall coherence (α = 0.40), and cognitive activation (α = 0.71).

Figure 8 presents the rated features of lesson plans developed by Kaise with the help of an online planning instrument. Note that the numbers on the vertical line are defined as: 0 = feature not true,1 = feature applies with restrictions, and 2 = feature applies. Kaise made a complete decision or stated a decision making processes for both planning situations. Figure 8 demonstrates that the lessons planned for both planning situations were rated concrete, coherent, and cognitive activation of students were fully considered. The figure depicts that for both planning situations, the lessons were only partly adapted to the pre-conditions. A lesson plan adapted to preconditions is characterized by explicit presence of description of pre-requisites required to learn the new material; students' prior knowledge and misconceptions; identification of students' learning needs; differentiation of the lesson by task to suit diverse needs and characteristics of learners, outcome (planning expectations of different levels of performance on a task/activity), and support (different levels of scaffolding).

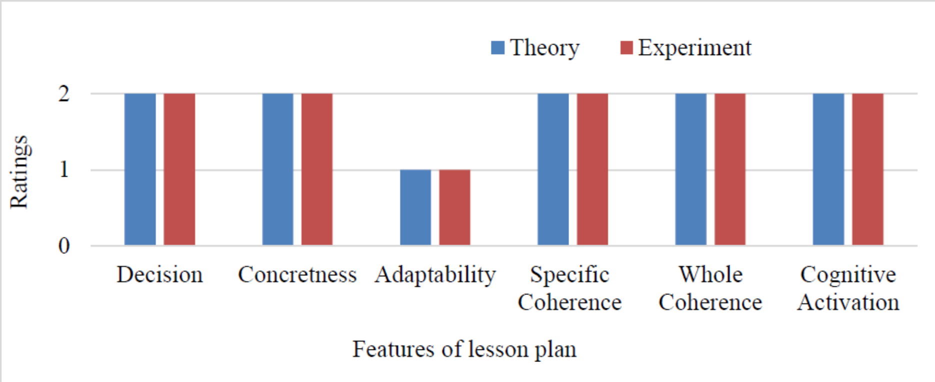

Figure 8. Quality of lessons planned by Kaise.

Figure 9 presents the rated features of lesson plans developed by Main. Figure 9 shows that the lesson planned by Main on theory was rated concrete and coherent. However, for the planning situation experiment, the decisions made by Main were only partially concrete and each decision was rated partially coherent. The overall coherence of the decisions made in different planning areas was rated coherent for the theory part but not coherent for the experiment part. Figure 9 illustrates that Main considered the cognitive activation of students when planning the lessons for both planning situations. However, the figure shows that for both planning situations the planned lessons were not adapted to pre-conditions.

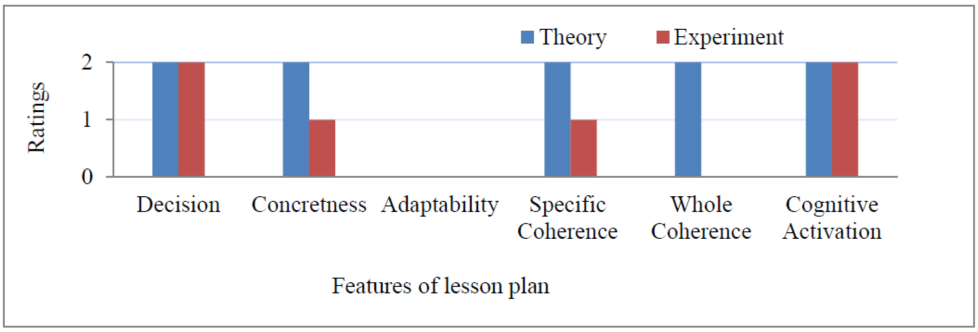

Figure 9. Quality of lessons planned by Main.

Figure 10 presents the rated features of lesson plans developed by HAS. Figure 10 illustrates that HAS made decision or stated decision making processes in a lesson s/he planned for the theory part. The decision made or decision making processes stated for the experiment part was not complete. Figure 10 indicates that the lesson plan produced by HAS for the theory part was rated concrete and coherent. However, the lesson plan developed for the experiment part was rated partially concrete and coherent. Figure 10 demonstrates that the cognitive activation of students was completely considered in the lesson planned for the theory part. However, the cognitive activation of students was only partially accounted in the lesson planned for the experiment part. The figure shows that for both planning situations, the planned lessons were not adapted to pre-conditions.

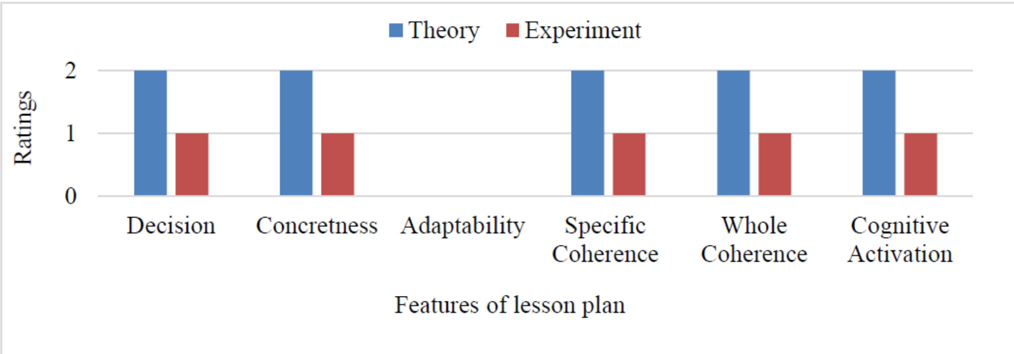

Figure 10. Quality of lessons planned by HAS.

Figure 11 presents the rated features of lesson plans developed by Land. Figure 11 shows that the lesson plan developed by Land for the experiment part was rated concrete. The figure demonstrates that Land considered the cognitive activation of students in the lesson planned for the experiment part. The lesson planned for the experiment part was not adapted to pre-conditions. The planned lesson on the experiment was rated coherent for individual decisions. However, when viewed as a whole the planned lesson did lack coherence. That is, the decisions and intended implementations of individual parts did not fit with each other to form a whole coherent structured lesson. The lesson planned for the theory part was rated coherent, partially concrete and adapted to pre-conditions. Figure 11 indicates that the lesson planned for the theory part could cognitively activate students when enacted.

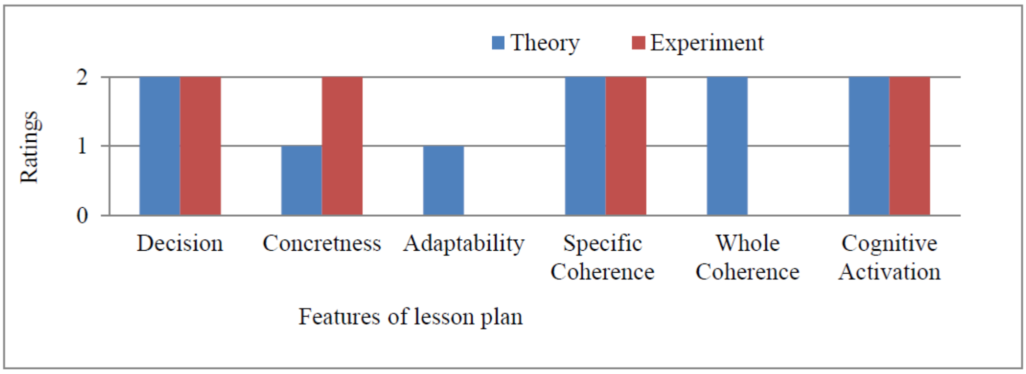

Figure 11. Quality of lessons planned by Land.

Figure 12 presents comparison of the quality of the lessons planned by the participant teachers. Figure 12 shows that compared to others, the lessons planned by Kaise had relatively better quality for both the planning situations. Compared to others, the lesson planned by Main for the experimental part had relatively poor quality. When we specifically see the feature adaptability, compared to others the lessons planned by both Main and HAS were not adapted to preconditions for both planning situations. The participant teachers used the same vignettes under the same setting as a starting to plan the lesson for their students. However, within this small number of participants, the analyzed data showed variations among these teachers' lesson plans. What was the source of the variation? Do these variations continue to exist among these teachers lesson plans when they plan for their actual ongoing class? In summary, figure 12 demonstrates that:

(1) The participant teachers did not consider preconditions in the planned lessons. That is, in the lessons planned, the teachers did neither take into account the pre-

requisites required to learn the new material, students' prior knowledge and misconceptions, and students' learning needs nor differentiated the lessons by task to suit diverse needs and characteristics of learners, outcome (planning expectations of different levels of performance on a task/activity), and support (different levels of scaffolding). What could be the possible reason for this? Is it because these teachers have an orientation towards the "one fits all" model of planning and teaching? Or is it because the vignettes and the planning situation they were provided to work with was not related to the context of their actual classroom experience, and consequently the teachers had no idea about what preconditions to consider? Or do teachers consider adapting lessons to preconditions only during actual instruction? My expectation is that when teachers plan lessons for their ongoing classes they would consider preconditions to accommodate the diversity of students pre-existing knowledge and skills.

(2) The overall coherence of lessons planned for the theory part was much better than that of the experiment part.

(3) Physics is a science of experimentation and observation. However, the lessons planned for the experiment part had relatively poor quality than the lessons planned for the theory part. This might imply that these participant teachers are more oriented towards teaching the theory part of physics over experiment.

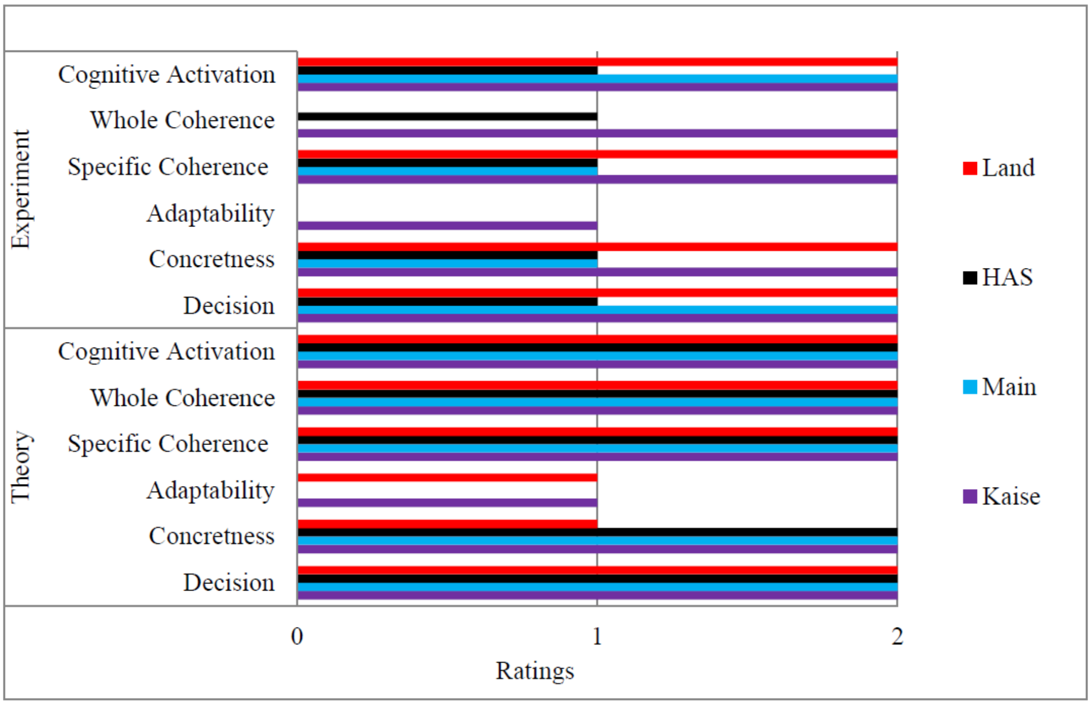

Figure 12. Comparison of the quality of lesson plans.

5.3 Contextualized lesson plans

Contextualized lesson plans refer to lessons the participant teachers planned for their actual ongoing instruction. The online lesson planning tool was modified to fit the ongoing teachers' instructions. In the modified versions the vignettes were removed. Questions that ask teachers to write down about the topic of their lesson plan, the concrete concepts within the topic and the purposes or functions of their lesson plan within the context of conceptual approach were included. Teachers were asked to plan five lessons with the help of the modified online planning tool. The sequences of individual teacher decisions on the areas of lesson planning and the quality of the planned lessons are presented separately.

5.3.1 Lessons planned by Kaise.

Kaise developed six lesson plans with the help of the modified online planning tool. Five of these lesson plans were developed on topics related to electromagnetic induction and transformers and the sixth lesson was planned on nuclear decay and radioactivity. These lessons were planned for 10^{th} graders. Table 4 presents the sequences of decisions made by Kaise on lesson planning areas.

Table 4

Sequences of decisions made by Kaise.

	Sequences of decisions on lesson planning areas
Lesson plan 1	Experiments → Social forms→ Learning objectives → Exercises
Lesson plan 2	Experiments → Others[not specified]→ Contents → Others (saving "the content")
Lesson plan 3	Experiments → Methods
Lesson plan 4	Others [understanding together the rule of transformers] → Experiments→ Methods→ Others [saving the content]
Lesson plan 5	Social forms → Experiments→ Social forms
Lesson plan 6	Methods → Social forms→ Exercise→ Others [Information]

Table 4 shows that the sequences of decisions made by Kaise in the areas of planning varied from lesson to lesson. Table 4 demonstrates that Kaise did not start planning by defining learning objectives or by organizing exercises.

Table 5 presents the frequencies of decisions made by Kaise on lesson planning areas. Table 5 indicates that Kaise made 21 decisions on lesson planning areas in 6 lesson plans. The table shows that the most frequently chosen area was experiment (5 times or 23.8 % of the total decisions). The second frequent decision was made on social forms (4 times, or 19.0 % of the total decisions made). The third frequent decision was made on methods (3 times, or 14.3 % of the total decisions). This was followed by exercises which appeared twice sharing 9.5 % of the total decisions made.

Table 5

Frequencies of decisions made by Kaise on lesson planning areas.

Planning area	Frequency	Percentage
Experiments	5	23.8
Social forms	4	19.0
Methods	3	14.3
Exercises	2	9.5
Learning objectives	1	4.8
Contents	1	4.8
Others	5	23.8
Total	21	100

Table 5 demonstrates that both the lesson planning areas learning objectives and contents appeared only once each making 4.8 % of the total decisions. The remaining 23.8 % of decisions were made on “others”, representing different things and /or things that were not clearly specified in the planned lessons. In summary, experiments → social forms → methods (the arrows indicate decreasing order of frequency) were the most important planning areas for Kaise. It seems that Kaise values experiments over theory for teaching and learning physics. For each decision made on the lesson planning areas, the intended implementation by the planning teacher was collected from the responses of the teacher to the questions “What would you like to implement for this part in the lesson?” These responses were rated to examine the quality of the planned lessons. The sixth lesson plan was not rated. Tables 6 and figure 13 present the summaries of the features of the lesson plans developed by Kaise. Note that the entire lesson was the unit of analysis used to evaluate the overall coherence of the lesson and the cognitive activation while individual decisions were the unit of analysis used to evaluate the other features of the lesson plans. That is why the numbers under the column "Total" for the whole coherence and cognitive activation in table 6 were less.

Table 6

Summary of frequencies of ratings of lessons planned by Kaise.

Features	0 = feature not true	1 = feature applies with restrictions	2 = feature applies	Total
Decision	0	0	21	21
Concreteness	1	1	19	21
Adaptability	18	1	2	21
Specific Coherence	0	6	15	21
Whole coherence	0	1	11	12
Cognitive Activation	4	4	4	12

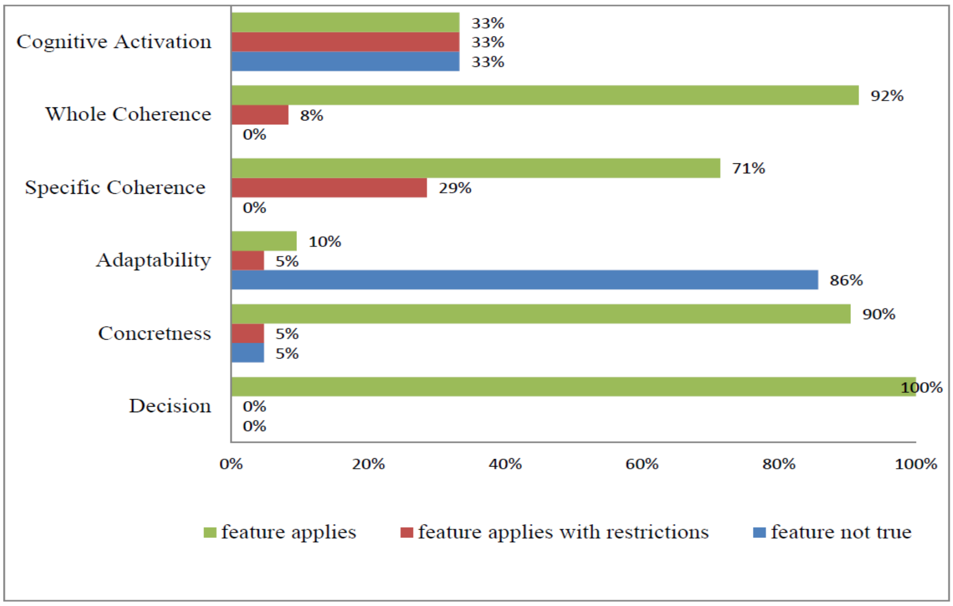

Figure 13. Summaries of the ratings of lessons planned by Kaise.

We see from table 6 that out of 21 decisions made by Kaise, in 18 decisions the planned lessons were not adapted to preconditions. Figure 13 also depicts that about 86 % of the ratings showed that the lesson plans were not adapted to preconditions. Table 6 and figure 13 show that the cognitive activation of students had the same distribution over the rating scales.

5.3.2 Lessons planned by Main.

Main planned five lessons on topics related to fluid mechanics (buoyancy, floating, and sinking) for 8th graders. Table 7 presents the sequences of decisions made on lesson planning areas by Main. Table 7 shows that the sequences of decisions made by Main on lesson planning areas did vary from lesson to lesson.

Table 7

Sequences of decisions made by Main.

	Sequences of decisions on lesson planning areas
Lesson plan 1	Contents→ Experiments→ Exercises→Learning objectives
Lesson plan 2	Contents→ Methods→ Exercises
Lesson plan 3	Exercises → Others [video clip]→ Exercises→Contents
Lesson plan 4	Exercises→Learning objectives → Contents
Lesson plan 5	Learning objectives → Contents → Contents

Table 7 illustrates that Main started sequencing lessons by first making decision on learning objectives only in the 5th lesson plan. In two lesson plans Main started sequencing lessons first by making decisions on exercises.

Table 8 presents the frequency of the decisions made by Main on lesson planning areas. Table 8 suggests that Main made 17 decisions on lesson planning areas in 5 lesson plans. The table shows that the most frequently chosen area was contents (6 times or 35.3 % of the total decisions made). This was followed by exercises which appeared 5 times sharing 29.4 % of the total decisions made. The third frequent decision was made on learning objectives and is sharing 17.6 % of the total decisions made. Main made the least frequent decisions on the lesson planning areas experiments and methods (each appearing only once, or each sharing 5.9 % of the total decisions made). The remaining 5.9 % of decisions was made on others, particularly video clips. For Main, social forms were not the priority decision area, and this planning area was not totally selected. In summary, contents → exercises→ learning objectives (the arrows indicate decreasing order of frequency) were the most important planning areas for Main.

Table 8

Frequencies of decisions made by Main on lesson planning areas.

Planning area	Frequency	Percentage
Contents	6	35.3
Exercises	5	29.4
Learning objectives	3	17.6
Experiments	1	5.9
Methods	1	5.9
Social forms	0	0.0
Others	1	5.9
Total	17	100

For each of the decisions made by Main on lesson planning areas, the intended implementation by the planning teacher was collected from the response of the teacher to the questions "What would you like to implement for this part in the lesson?" These responses were rated to explore the quality of the planned lessons. Table 9 and figure14 present the details of the ratings of the features of all lesson plans developed by Main.

Table 9

Summary of frequencies of ratings of lessons planned by Main.

Features	0 = feature not true	1 = feature applies with restrictions	2 = feature applies	Total
Decision	0	2	11	13
Concreteness	0	6	7	13
Adaptability	13	0	0	13
Specific coherence	0	3	10	13
Whole coherence	0	0	8	8
Cognitive activation	4	2	2	8

Table 9 shows that the lessons planned by Main were not adapted to preconditions. Figure 14 also illustrates that 100 % of the ratings revealed that the lessons were not adapted to preconditions. We see from table 9 and figure 14 that in about half of the decisions made by Main the cognitive activation of students were not considered.

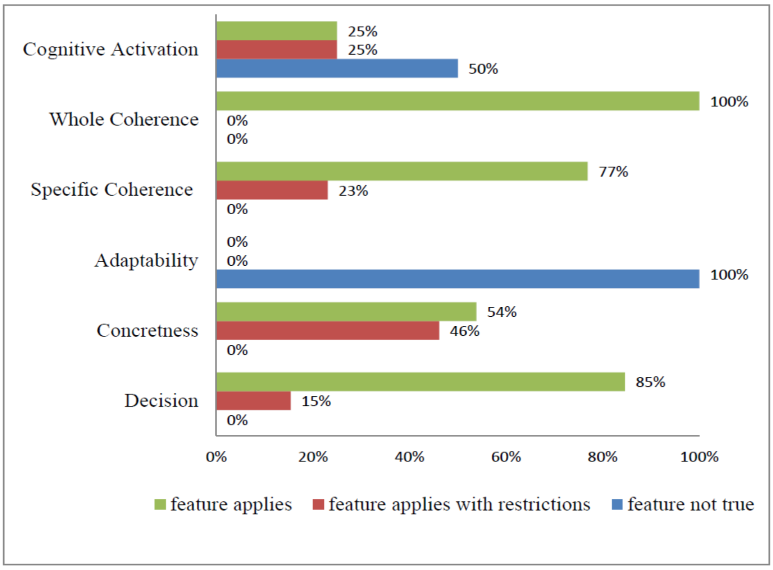

Figure 14. Summaries of the ratings of lessons planned by Main.

5.3.3 Lessons planned by HAS.

HAS planned three lessons on topics related to mechanical work and energy for 8th graders. Table 10 presents the sequences of decisions made on lesson planning areas by HAS.

Table 10

Sequences of decisions made by HAS.

	Sequences of decisions on of lesson planning areas
Lesson plan 1	Contents→ Social forms → Methods
Lesson plan 2	Learning objectives→ Methods → Methods →Exercises
Lesson plan 3	Contents→ Social forms → Methods →Learning objectives

Table 10 illustrates that the sequences of decisions made by HAS on lesson planning areas showed slight variations from lesson to lesson. In the second lesson, HAS started sequencing the lesson by first making decision on learning objectives. In the other two lessons HAS started planning by first deciding on contents.

Table 11 presents the frequency of decisions made by HAS on lesson planning areas. Table 11 illustrates that HAS made eleven decisions on lesson planning areas in 3 lesson plans. The most frequently chosen area was methods (3 times or 27.3 % of the total decisions made). The second frequent decision was made on contents, learning objectives and social forms, each appearing twice, or each sharing 18.2 % of the total decisions made. This was followed by exercises and experiment each appearing only once, or each sharing 9.1 % of the total decisions made. In conclusion, methods, contents, learning objectives and social forms are relatively the most important planning areas for HAS. For each decisions made on lesson planning areas, the intended implementation by the planning teacher was collected from the response of the teacher to the questions “What would you like to implement for this part in the lesson?” These responses were rated to identify the quality of the planned lessons.

Table 11

Frequencies of decisions made by HAS on lesson planning areas.

Planning area	Frequency	Percentage
Methods	3	27.3
Contents	2	18.2
Learning objectives	2	18.2
Social forms	2	18.2
Experiments	1	9.1
Exercises	1	9.1
Total	11	100

Table12 and figure 15 present the details the ratings of the features of all lessons planned by HAS. Table 12 shows that out of 11 decisions made by HAS, in 8 decisions the intended implementations were not adapted to preconditions. That is, 73 % of the ratings revealed that the lesson plans were not adapted to preconditions. Table 12 and figure 15 show that HAS considered the cognitive activation of students.

Table 12

Summary of frequencies of ratings of lessons planned by HAS.

Features	0 = feature not true	1= feature applies with restrictions	2= feature applies	Total
Decision	0	0	11	11
Concreteness	0	0	11	11
Adaptability	8	3	0	11
Specific coherence	0	5	6	11
Whole coherence	0	0	6	6
Cognitive activation	0	0	6	6

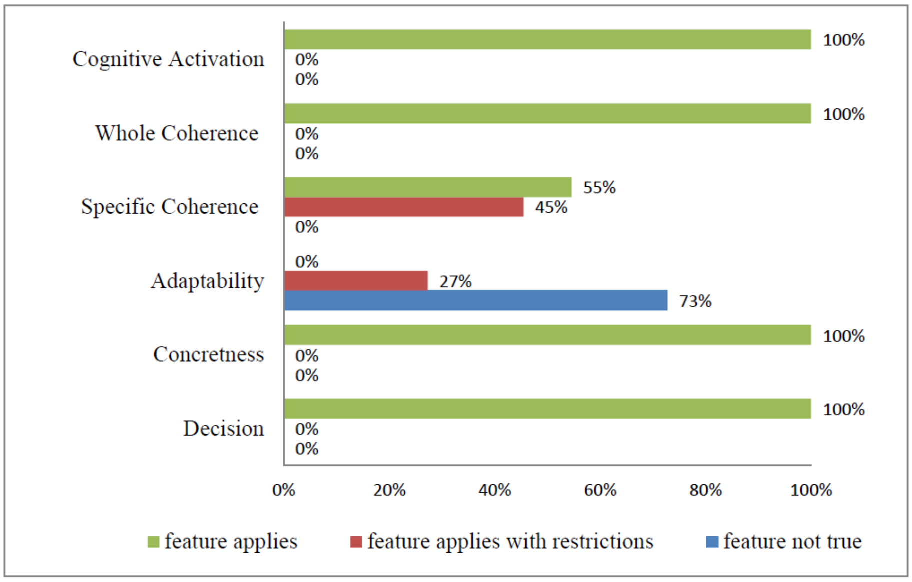

Figure 15. Summaries of the ratings of lessons planned by HAS.

5.3.4 Lessons planned by Land.

Land planned six lessons on topics related to thermodynamics for the 9th graders. Table 13 presents the sequences of decisions made by Land on lesson planning areas. Table 13 demonstrates that the sequences of decisions made by Land on lesson planning areas did vary from lesson to lesson. The table shows that in only two lesson plans Land started sequencing the lessons by first making decision on learning objectives.

Table 13

Sequences of decisions made by Land.

	Sequences of decisions on lesson planning areas
Lesson plan 1	Learning objectives → Experiments→ Methods→ Social forms
Lesson plan 2	Methods → Exercises→ Others [application to real life situation]
Lesson plan 3	Social forms→ Others: Media (Board, model (bimetal) → Experiments
Lesson plan 4	Experiments→ Exercises→ Others: Media
Lesson plan 5	Learning objectives → Social forms→ Experiments
Lesson plan 6	Experiments → Contents → Social forms

Table 14 presents the frequency of decisions made on lesson planning areas by Land. Table 14 illustrates that Land made 19 decisions on lesson planning areas in 6 lesson plans. The table indicates that the most frequently chosen lesson planning area was experiment which appeared 5 times sharing 26.3 % of the total decisions made.

Table 14

Frequencies of decisions made by Land on lesson planning areas.

Planning area	Frequency	Percentage
Experiments	5	26.3
Social forms	4	21.1
Learning objectives	2	10.5
Exercises	2	10.5
Methods	2	10.5
Contents	1	5.3
Others	3	15.8
Total	19	100

The second frequent decision made by Land was on social forms which appeared 4 times sharing 21.1 % of the total decisions made. This was followed by learning objectives, methods, and exercises each appearing twice, or each sharing 10.5 % of the total decisions made). Land made decision on the lesson planning area contents only once sharing only 5 % of the total decision made. The remaining 15.8 % of decisions were made on "others", referring to the use of media and application to real life situations. In summary, experiments → social forms→ learning objectives, methods, and exercises (the arrows indicate decreasing order of frequency) are the most important planning areas for Land. For Land contents was not the priority decision area. For each decisions made on lesson planning areas discussed above, the intended implementation by the planning teacher was collected from the responses of the teacher to the question "What would you like to implement for this part in the lesson?" These responses were rated to examine the quality of the planned lessons. Table 15 and figure 16 present the details of the ratings of the lessons planned by Land.

Table 15

Summary of frequencies of ratings of lessons planned by Land.

Features	0 = feature not true	1= feature applies with restrictions	2= feature applies	Total
Decision	1	0	19	20
Concreteness	0	3	17	20
Adaptability	14	5	1	20
Specific coherence	0	3	17	20
Whole coherence	0	0	12	12
Cognitive activation	0	8	4	12

Table 15 shows that in 14 decisions out of 20, the lessons planned by Land were not adapted to preconditions. Figure 16 also illustrates that 70 % of the ratings indicated that the planned lessons were not adapted to preconditions. Figure 16 shows that 67 % of the ratings suggested that the cognitive activation of students was partially considered. About 33 % of the ratings demonstrated that Land considered the cognitive activation of students.

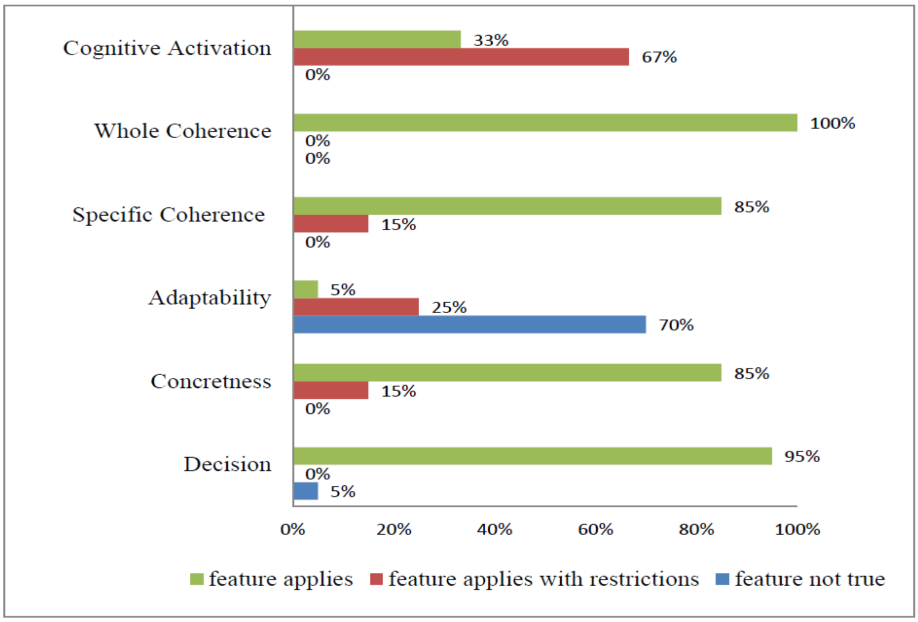

Figure 16. Summaries of the ratings of lessons planned by Land.

5.3.5 Comparison of sequences of decisions and quality of lesson plans.

Table 16 presents the comparison of sequences of decisions made by the participant teachers on lesson planning areas. To understand the patterns of the sequences of decisions, an attempt was made to code the occurrence of a particular lesson planning area, e.g., experiments preceding all other parts, in a matrix form. However, as can be seen from table 16 the sequences of decisions had no pattern and the attempt did not provide any insights about the patterns of sequences. Table 16 reveals that there existed within and between variations in the sequences of decisions. The within variation here refers to the variations of individual teachers decisions of sequences for different lessons plans. The between variation signify the variation between teachers in sequencing lessons.

One might expect the between variation since the participant teachers planned on different physics topics for different grade levels. It is natural to ask why individual teacher sequences of decisions vary from lesson to lesson. What underlying criteria teachers do use in sequencing lessons? Table 16 illustrates that in most of the lessons planned, the participant teachers didn’t start sequencing lessons by first defining learning objectives. However, researchers reported that defining learning objectives is the first key step to plan a lesson customized to students learning needs (Carpinelli et al., 2008; Eylon & Bango, 2006; Hiebert, Morris, Berk, & Jansen, 2007; Jalongo, Rieg, & Helterbran, 2007; Oser & Baeriswyl, 2001; Panasuk & Todd, 2005). What criteria do the participants use while sequencing lessons?

Table 16

Comparison sequences of decisions made by participant teachers.

	Sequences of teachers' decisions on lesson planning areas
Kaise	1. Experiments → Social forms→ Learning objectives → Exercises
	2. Experiments → Others[not specified]→ Contents → Others(saving the content)
	3. Experiments → Methods
	4. Others [understanding together the rule of transformers] → Experiments→ Methods→ Others [saving the content]
	5. Social forms → Experiments→ Social forms
	6. Methods → Social forms→ Exercises→ Others [Information]
Main	1. Contents→ Experiments→ Exercises→Learning objectives
	2. Contents→ Methods→ Exercises
	3. Exercises → Others [video clip]→ Exercises→Contents
	4. Exercises→Learning objectives → Contents
	5. Learning objectives → Contents → Contents
HAS	1. Contents→ Social forms → Methods
	2. Learning objectives→ Methods → Methods →Exercises
	3. Contents→ Social forms → Methods →Learning objectives
Land	1. Learning objectives → Experiments→ Methods→ Social forms
	2. Methods → Exercises→ Others [application to real life situation]
	3. Social forms→ Others[Media (Board, model (bimetal)] → Experiment
	4. Experiments→ Exercises→ Others[Media]
	5. Learning objectives → Social forms→ Experiments
	6. Experiments → Contents → Social forms

Figure 17 presents comparison of the quality of lessons planned by the participant's teachers. The data presented in figure 17 was the overall normalized ratings for adaptability and cognitive activation. The normalized rating is the ratio of the number of times a particular feature is rated for a particular scale to the total number of possible ratings. The figure demonstrates that the lessons were not adapted to preconditions. Figure 17 also indicates that the lessons planned by Land, Kaise and Main had limitations with regard to cognitive activation of students.

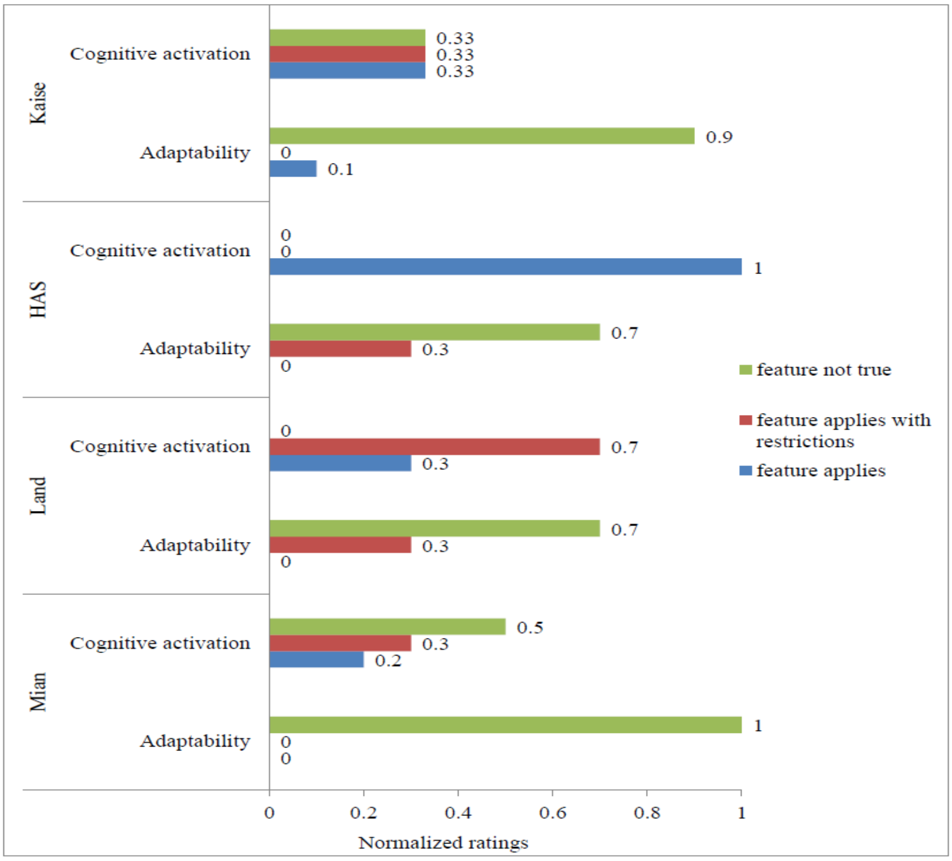

Figure 17. Comparisons of quality of planned lessons

5.3.6 Qualitative analysis of the planned lessons.

Participant teachers were asked to plan lessons for their actual ongoing practices with the help of an online lesson planning tool. On this online planning tool they were asked first to make decisions on the areas of lesson planning (learning objectives, contents, methods, social forms, experiments, exercises). The sequences of teachers' decisions are presented in the previous sections. For each decisions teachers made, they were asked, "what would you like to implement for this part in the lesson?" The qualities of the lesson plans (operationalized in terms of the features of lesson plans) presented above were analysed from teacher's response to such questions. To understand more about teacher's intentions for each areas of lesson planning and the broad language teachers use to describe these areas, teacher responses to the open ended question for each planning area was coded by the researcher. To this end, teacher's statements and/or intended implementations were coded as follows:

1) Statements related to objectives were coded as cognitive objectives if the planning teacher stated the learning actions, or processes or outcomes of students and as pedagogic objectives if the teacher stated teaching actions or processes.
2) The intended implementations on the planning area "social forms" were coded as individual work, pair work, group work, teacher- student discussion, teacher – the whole class discussion, a student presentation or a student demonstration.
3) The intended implementations on the planning area "methods" were coded as teaching methods (actions, processes, procedures, approaches/techniques, or combinations of these), learning methods (actions, processes/ procedures, or a combination of these), classroom arrangement (individual work, pair work, group work, or a combination of these), instructional environment (inquiry based, guided discovery, problem solving, direct teaching, lab/experiment, movies and media). The coding action, and process/procedure are defined as follows:

   An action: statement that indicates what the planning teacher and/or students is expected to do during instruction.

   Process/procedure: statement that indicates the teaching or learning processes, or scientific processes, for example deriving a mathematical model (formal language of physics) from the analysis of experimental data that can explain the phenomena being investigated.
4) The intended implementations on the planning area "experiments" were coded as either demonstrative (students demonstration, teacher demonstration) or investigative. The result of this coding is separately presented.

Table 17 presents the summaries of the first three coding. Table 17 demonstrates that the stated objectives by the participant teachers were cognitive objectives. It refers to either the learning actions of students or the expected learning outcomes. The table further illustrates that the languages teachers used to refer the lesson planning areas "methods" represent various things including instructional approaches, classroom arrangements, teaching and learning methods, and the procedures or processes of conducting an experiment.

Table 17

Summaries of coding from teachers statement/intentions of implementation.

	Objectives	Methods	Social forms
Kaise	cognitive	• classroom arrangement (e.g. grouping students for experiment) • instructional approach (e.g. applying mathematical model, problem solving) • instructional environment (e.g learning from movies/media)	• individual work, • discussion with peers, • a group of students discussing to the class, • student presentation, • student demonstration
Main	cognitive	• discussion • instructional environment (demonstration)	
HAS	cognitive	• classroom arrangement • teaching method (action) • learning method (procedure, process, and action)	• group work
Land	cognitive	• procedure and process • procedure	• individual work, • partner work, • discussion between teacher & students, • group work

Participant teachers' decisions on the lesson planning area experiments were coded as either demonstrative or investigative. The result of this coding is presented in table 18. The participant teachers approach to laboratory/experiment was coded to fall into two categories. These were demonstrative and investigative. In the demonstrative approach the participant teachers integrated a laboratory experience in the lessons planned to deepen students understanding of a concept previously developed in a class. In the investigative approach the teachers planned a laboratory activity where students conduct an experiment about a physical phenomenon before the teacher introduces the content. In this approach, students are expected to explain the physical phenomena they observed, and also derive a mathematical model from the data that explains the phenomena. The investigative approach focused on the process of scientific discovery involving inductive reasoning to draw conclusion from the laboratory observations.

Table 18

Coding's of teachers' intentions of implementation on experiments.

	Teachers' intention of the implementation on planning area "experiments"		
	Demonstrative	Investigative	Remark
Kaise	4 (80%)	1 (20%)	decision was made on experiment 5 times
HAS	0 (0%)	0 (0%)	experiment was not selected as a decision area
Land	2 (40%)	3 (60%)	decision was made on experiment 5 times
Main	1 (100%)	0 (0%)	decision was made on experiment only once

Table 18 indicates that Kaise followed a demonstrative approach whereas Land followed an investigative approach when integrating laboratory activities into the flow of instruction. This investigative approach is an inquiry-based teaching and learning model which fits with the constructivist ideas of the nature of science. According to this model, teachers design instructional activities into three phases in specific sequence. These sequences in order are exploration phase, conceptual invention phase, and the application phase. In these sequences, teachers integrate laboratory experiences with other forms of instruction in a “learning cycle” of these three phases (Atkin & Karplus, 1962).

The exploration phase aims at giving students the first experience with a concept to be developed through experiment. “During exploration, the students gain experience with the environment-they learn through their own actions and reactions in a new situation. In this phase, they explore new materials and new ideas with minimal guidance” (Karplus, 1977, p.173). In the conceptual invention phase students derive the concept from the data, and this phase “helps the students apply a new pattern of reasoning to their experiences” (Karplus, 1977, p.174). The application phase gives the student the opportunity to apply the concept in solving problems, and enable students “to extend the range of applicability of the new concept” (Lawson, Abraham, & Renner, 1989, p.5). The data generated by the laboratory from the exploration phase will be used inductively by students during the concept invention phase to generalize a concept/theory. Abraham and Renner (1986) wrote:

> The learning cycle approach is a generalized, teaching model which can be used in designing curriculum materials and instructional strategies for science. The model is derived from the developmental theory of Jean Piaget and divides instruction into three phases: (1) the gathering data (or exploration) phase, (2) the conceptual invention phase, and (3) the conceptual expansion phase. Each learning cycle begins with an activity which gives students experiences with the concepts to be developed before those concepts are discussed, read about, or named. This activity is usually a laboratory experiment. (p.121)

To clearly distinguish between the demonstrative and investigative approaches, it is imperative to see the lessons planned by Kaise and Land. Let us see first the decision sequences and the intended implementations made by Kaise in two consecutive lesson plans. The integrated laboratory activities within these planned lessons were coded as demonstrative.

Lesson Plan 1: The concrete topic of this lesson was “induction in a coil, when it is put over a magnet.” The function of the lesson planned in the context of the conceptual approach was “repetition of induction in a conductor, diversification: gain of current through the parallel coil windings.” Kaise detailed that the following information were necessary to understand this lesson plan: “it is important, that there has to be a change in the magnetic field in the conductor to induce a current. I want to get away from the left-hand-rule and formulate the principle: if the magnetic field in a coil changes, current will run through it (if the electric circuit is closed).”

The sequences of decision areas made by Kaise were: Experiments→ Social forms→ Learning objectives → Exercises. The first decision was made on experiment. The response of the teacher to the question “what would you implement for this area in your lesson?” was “first I want to put a coil over the magnet and then induct the magnet into the coil.” The second decision was made on social forms. The response of the teacher to the question “what would you implement for this area in your lesson?” was “the most suitable way to show it would be a frontal experiment, possibly you could ask one student to perform the experiment.” The third decision was made on learning objectives. The responses of the teacher to the question “what would you implement for this area in your lesson?” were: “(1)the students shall realize that the coil is an extension of the simple conductor, (2) students shall realize that what matters is the relative movement between coil and magnet, (3) students shall realize the simplicity of the premise: the magnetic field changes inside the coil (because the left-hand-rule is not valid here), (4) students shall save (remember) the principle, and (5) students shall be able to answer the exercises". The fourth and final decision was made on exercise. The responses of the teacher to the question "what would you implement for this area in your lesson?" were: "(1) how the potential/the inducted current can be increased (quicker induction of the magnet, stronger magnet, more coil windings)? (2) draw the process of the potential/the current for when you push a horseshoe magnet into the coil with a jerk, leave it there and pull it out with a jerk again (surge, no potential, surge with reverse signs), and (3) draw the process of the potential/current for when you let a bar magnet fall through the coil (like in 2. just without a break)".

We understand from Kaise's statements that

(1) The concrete concept of the planned lesson was inducing a current in a coil by putting the coil over the magnet. The purposes of the lesson were repetition and diversification. It is repeating the concept of induction that students have already learned but this time it moves from simple to complex, from induction in a single coil to the induction of current through the parallel coil windings. The teacher wanted to demonstrate the experiment with the possibility of involving one student in the processes of demonstration. However, the details of the experimental demonstration like what variables to vary (for instance, the position between the magnet and the loop or the shape of the loop), what variable to measure (e.g., current at different distances of the coil from the magnet, with different shapes (area) of the coil), what variable to extrapolate or determine from the measurement (e.g. change in induced current), how to

present the result of the measurement (e.g. table, graph, or calculating average and estimating uncertainties) were not described. More importantly, what is expected of students, the kind of activities they are to be engaged in when the teacher demonstrates the experiment was not stated in the planned lesson. The teacher simply stated what s/he wanted to do not what s/he wanted the students learn. We just see here from the language the teacher used “I want to” referring to teaching actions not learning actions. The plan on the experiment did lack information about the role of students. Most importantly, it did lack explication of the scientific work approaches. The structure of the social forms to take place during the lesson was one student could demonstrate the experiment together with the teacher and others observe the demonstration.

(2) The learning objectives were clearly defined. However, the level of cognitive engagement expected from students was at the level of realization, “students shall realize”). As the stated objectives were not cognitively demanding students in learning, better understanding of the underlying principle might not be attained by the students.

(3) The teacher clearly stated the questions that s/he wanted to ask students. The questions were relevant to the concrete concepts of the topic. It could also give an opportunity for students to consider various conditions that affect the magnitude of the induced current.

Lesson Plan 2: The concrete topic of this lesson was “causing a permanent flow of current in a secondary coil with the help of alternating current in a primary coil.” The purpose of the lesson was “transition from one coil to two linked coils -> transformer.” It seems that Kaise was worried about covering the content and moving to other content as evident from Kaise's response to the question "what additional information is necessary to understand your planning" The response was "…important: finish the topic as soon as possible to be able to teach the topics nuclear power and radioactivity as well."

The sequences of decisions were: Experiments → Others [not specified]→ Contents → Others (ways of saving "the content"). The first decision was made on experiment. The response of the teacher to the question "what would you implement for this area in your lesson?" was "the primary coil is hidden under a shoe box, only the secondary coil is visible for the students. The secondary coil glows without a visible power supply, but only if it is located on one particular spot on the box." The second decision was made on "others" but nothing was specified what this "others" stands for. The response of the teacher to the question "what would you implement for this area in your lesson?" was "homework which has to be discussed and provides a good premise." The third decision was made in the area of content. The response of the teacher to the question "What would you implement for this area in your lesson?" was "students shall also realize that energy transmission is independent from the coil used." The fourth and final decision was made on others ("ways of saving the content"). The teachers response to the question "what would you like to implement for this area in your lesson?" was "to save time I created a worksheet."

We understand from the above statements that

(1) Kaise clearly described the working principle of transformers, which is an alternating current in a primary coil induces current in the secondary coil. Kaise explained that the purpose of the planned lesson was to move students

learning of the concept induction in one coil to a more complex concept that involved linked coils (transformer). Kaise wanted to rash this topic so that s/he can cover other contents “nuclear power and radioactivity”. This might be due to time pressure and wide content included in the curricula. The first decision was on experiment. However, no explanation was given about the details of the experiment. For example, the concrete idea of the experiment, what variables to vary and what variables to measure or observe, what variable to extrapolate or determine from the measurement, how to present the result of the measurement (e.g., table, graph, or calculating average and estimating uncertainties) were not stated. Moreover, the “who” and the “how” of conducting the experiment were not clearly delineated. Particularly what is expected of students, the kind of activities students are to be engaged in, during the experiment was not described. The teacher detailed only here the instrument and the concepts within the content. No explicit description was given about what to observe/measure, why and how the experiment is important in supporting students learning of the underlying concepts, students’ responsibility, and the responsibility of the teacher during the experimentation. The teacher did not describe or explain how to vary alternating current source in the primary coil, and how to take measurement of the current induced in the secondary coil, for every variation of the current in the primary coil.

(2) The teacher wanted to implement homework related activities for this lesson. However, the homework exercises or the kind of activities the teacher wanted the students to work on was not stated in the planned lessons.

(3) At the third decision, the teacher didn't describe the contents rather the teacher stated objectives. The decision area and what the teacher wanted to implement seems inconsistent.

(4) The teacher prepared worksheet on which students can work with the aim of saving teacher time to cover other contents.

When we see the two lesson plans together, Kaise integrated an experiment in the form of a demonstrative approach. It is very hard, to know the expected level of students engagement in their learning from the planned lessons. It seems that Kaise targeted content and content coverage over students and students learning.

Let us see the lessons planned by Land. The approaches used by Land to integrate laboratory activities in these lessons were coded as investigative.

Lesson Plan 1: The concrete topic of this lesson was "change in length of solid body's when temperature changes." The function of the lesson planned in the context of the conceptual approach was "leading to a quantitative observation and statement." The sequences of decision areas were: Learning objectives→ Experiments→ Methods→ Social forms.

The first decision was made on learning objectives. The objective of this lesson plan was to develop students' ability in quantitatively predicting or calculating the change in length of two different metals when the temperatures of these metals are changed. After stating the objectives, Land made the second decision on experiment. The response of the teacher to the question "what would you implement for this area in your lesson?" was "an experiment which allows to quantitatively determine the increase in length of two different metals." The third decision was made on methods. The response of the teacher to the question "what would you implement for this area in your lesson?" was "investigating the linear thermal expansion coefficient by tracing back the measurement results step by step towards the standardized conditions (l_0=1m, ΔT=1K)." The fourth and last decision was made on social forms. The response of the teacher to the question "what would you implement for this area in your lesson?" was "demonstration experiment, frontal instruction, discussion between teacher and students, seatwork."

We understand from the above statements that

(1) The purpose of the planned lesson was to help students learn quantitative observation and measurement, and explaining the physical phenomena using the measurement and observation data. This is a kind of conceptual invention from experimental observation. To achieve this, the teacher stated out the learning objectives. Of course, in the stated learning objectives the expected levels of cognitive engagements were not clearly and explicitly defined. However, implicitly the objectives were to develop students' ability in predicting and calculating the increase in length of varous metals when the temperature of these metals increases.

(2) The teacher wanted involving students in conducting an experiment which allows them to quantitatively determine the increase in length of two different metals subject to temperature changes. However, the details of the experiment like what variables to vary (e.g., temperature), what variables to measure (e.g., initial length, and lengths at different temperatures), for what intervals of temperature to measure length, what variables to extrapolate or determine from the measurement (e.g., change in length, change in temperature), how to present

the result of the measurement (e.g., table, graph, or calculating average and estimating uncertainties) were not mentioned. However, parts of these were implied in the subsequent decision.

(3) In the third decision, the teacher implied that students will use metals with an initial length of 1m, take measurements for every change in temperature of the metal by one degree kelvin. For Land at this point the planning area “methods” refers to the techniques (procedures) to be used to determine the linear thermal expansion coefficients of the metal from the data. In Land’s word the intended implementation was “…investigating the linear thermal expansion coefficient by tracing back the measurement results step by step…” However, how students determine the coefficient of thermal expansion was not addressed in the planned lesson. Plotting graphs of length versus temperature, determining the coefficient of thermal expansion from the slope of this graph…such explanations and clarifications were lacking from the planned lesson.

(4) The teacher planned for social interaction to provide students the opportunity to discuss, and exchange or share ideas, to reflect on the results of the investigation, and to build on students learning with additional demonstration and frontal teaching.

Let us see the next lesson plan, to have a clear picture about how this teacher sequenced the lessons.

Lesson Plan 2: This lesson was a continuation and extension of the previous lesson. The teacher stated that the concrete topic of this lesson was “using conditional equation to calculate the increase in length of solid materials.” The equation was not given, and it is to be derived from data. The purpose of the planned lesson was “generalization of the experimental observations and standardisations (linear expansion coefficient)”. The sequences of decision areas made by the teacher were: Methods → Exercise→ Application to real life situation.

The first decision was made on methods. The methods stated were “investigating the linear expansion coefficient by tracing back the measurement results step by step towards the standardized conditions (l_0=1m, ΔT=1K) and comparing with literature.” The second decision was made on exercises. The response of the teacher to the question “what would you implement for this area in your lesson?” was “working on an exercise sheet containing linear and volume expansion of solid and gaseous materials. The schoolbook is used to gather information of the increase in volume of gases.” The third and last decision was made on others referring “applying the learned in everyday life and technical content”. The teacher stated “context related homework from book *: pg.224/4/6/8/10/11, *U. Backhaus u.a., Fokus Physik Gymnasium Rheinland-Pfalz, Gesamtband, Berlin 2008, Cornelsenverlag”.

We understand from the above statements of Land that

(1) The purpose of the lesson was to enable students generalize and summarize the results of the experimental observation. This involves deriving a general equation of linear thermal expansion of solids, reflecting on the results of the experiment from earlier class, contrasting the results of the experiment with standard value of coefficient of linear expansion, explanation of sources of error and uncertainties in measurement as reasons for the deviation of the observed result from the standard value. What is important here is that students will reflect on their findings of the experimental observation by contrasting it with literature value. Comparing the final results with literature value, explaining the

deviation (or simply the difference) of the measured value from the literature value, anticipating possible causes of the difference like error in measurements or uncertainties helps students learn the scientific approaches, learning physics as a process, as a way of thinking than learning to memorize facts.

(2) Students transfer the knowledge they learned in class about thermal expansion of solids and gasses. They apply their knowledge and skills to solve problems related to everyday life. This provides an opportunity to students to integrate what they learned in a class with what they have been observing from their everyday life and to apply the physics principle they learned to reason and solve problems. This helps students in understanding more the underlying principles of the change in dimensions of solids and gases when their temperature changes. Important idea here is context, application to real life situations, in teacher own statement "applying the learned in everyday life…and working on context related homework tasks."

If one considers only a single decision and intention of implementation stated by the teacher for the corresponding decision, one might not get the exact picture of how the teacher sequenced lessons meaningfully. The above analysis tells us that Land was taking into account what has been decided before and to be decided next when making current decision in sequencing lessons. The planned lessons were highly coherent and intellectually demanding on the side of the learners. When we see the two lesson plans together, the lesson plans fit well with the learning cycle approach of an inquiry-based learning method. The intentions of the teacher as mentioned in these lesson plans were (1) to give students firsthand experience through experimental observation "experience first" approach, (2) students work on the data of the experimental observation to determine coefficient of linear expansion leading to invention of the concept “coefficient of linear expansion”, and (3) finally, students integrate the experience and the concept learned to solve contextualized problems, the phase of application and transfer of knowledge. Such lesson plan if actualized as per the intention, is highly likely to result in better learning of both the content and the science process skills. In summary, Land followed this approach: experience first (experiential learning, starting from laboratory investigation) → conceptual invention (deriving a concept from data)→ application (applying and transferring gained knowledge to solve problems contextualized to real life situation). This is intellectually demanding approach to learning.

The above explanations clearly indicated the variations between the two teachers approach in integrating and sequencing laboratory activities with other forms of instruction. More than this, we have seen that the lessons planned by Land which was coded as investigative approach to laboratory activities substantially engage students. However, in the lessons planned by Kaise which was coded as demonstrative approach to laboratory activities are more of teacher centered and content centered over students and students learning.

In summary, the analysis of the lesson plans indicated that:

- sequences of individual teacher decisions vary from lesson to lesson,
- the lessons were not adapted to preconditions,
- most of the planned lessons lack deep learning tasks that are cognitively challenging and enable students in constructing and applying knowledge.
- the approach used to integrate laboratory activities in the sequence of the lessons varies from teacher to teacher ranging from complete absence of

laboratory activities in the planned lessons through the demonstrative to the investigative approach.

It is very important to know the underlying criteria the participant teachers use in sequencing lessons. To understand this and to get insight about the participant teachers thinking on how to differentiate lessons to accommodate the diversity of students pre-existing knowledge and skills, and how to engage students in cognitive activity, teachers were interviewed. The analysis of the interview data on lesson planning is presented in the next section.

5.4 Data from Interview on lesson planning

Teachers participated in 37 to 64 -minute interviews with two interviewers. HAS participated in 38 - minute interview. Approximately the first 14 minutes of the interview were dedicated to questions concerning the lessons planned by the teacher. Land participated in 55-minute interview. Approximately the first 30 minutes were spent on questions related to lesson planning. Kaise participated in 64-minute interview. Approximately the first 33 minutes were spent on questions related to lesson planning.

5.4.1 What criteria do teachers use in sequencing lessons?.

To explore the criteria teachers use in making decisions in lesson planning areas and in sequencing lessons, teachers were asked on an interview questions like: “What were your criteria when making the first decision in the areas of lesson planning? What were your criteria when making the next decision in the areas of lesson planning?” Teachers’ responses to such questions were analyzed and presented below case by case.

HAS:

HAS did use most frequently three criteria when making decisions on lesson planning areas. These are (1) deciding on what to optimize and what new things to try out with in the learning content that is already known before planning, (2) formulating learning objectives, and (3) delineating methods of achieving the learning objectives. The verbal expression of the teacher indicated that s/he considers whether the students can work independently or whether they need guidance. The verbal expression of the teacher illustrated that the teacher also considers how to achieve the formulated learning objectives in different classes. HAS said that the sequences of decisions can vary from lesson to lesson and from class to class depending on the experience the teacher had with students and students learning. The experience and knowledge the teacher had about students learning dictates the decisions the teacher makes in sequencing lessons. This was clearly demonstrated in the verbal expressions of the teacher as follows: “If I would get a new class now, it would be difficult for me to swiftly plan a lesson. I would need at least 1-2 lessons or more to see how competent the class is.” The implication is that the teacher draws upon her/his knowledge about students’ knowledge, abilities and skills while planning and sequencing lessons. One component of teacher pedagogical content knowledge that is teachers’ knowledge about students and students learning guides the decisions the teacher makes to sequence lessons.

Kaise:

Kaise thinks and decides what and how the planning parts fits well with her/his mental models of the lesson s/he already planned in head before writing down the lessons. Kaise draws upon her/his experience with content and uses mostly content as a criterion and as a guide when making decisions to sequence lessons.

The verbal expression of Kaise illustrated that s/he always chooses first content and then chooses the next subsequent planning areas that fit well with the content. The teacher had list of content (in mind or as an outline) before planning, and the work of the teacher during planning is to restructure the lesson sequence and flow explicitly in order in terms of what comes in what hour. After deciding on learning content, Kaise said that s/he usually thinks and checks for the possibility of integrating an experiment in the flow of the instruction. Kaise believed that it is easier for students if a lesson is structured in such a way that the theoretical part (contents) is followed by experiment (and/or tasks) so that students have a practice phase. The verbal expression of the teacher showed that this approach was what the teacher learned at teacher training institution during her/his teacher traineeship. The implication is that the training the trainees received during their studies guides teachers' actions and decisions during their ongoing practices even for veteran teachers.

Land:

For Land experiments were the criteria when making the first decisions in areas of lesson planning. The verbal expression of Land revealed that as criteria the teacher always looks for the possibility of integrating experiments in making decisions on the sequences of the lesson. In integrating experiments into the flow of instruction, Land claimed that s/he takes into account the following factors: (1) the level of knowledge of the students, (2) students workload in a given school day, (3) students motivation, and (4) the location on the time space at which the instruction is to take place, that is, whether the lesson to be planned is scheduled on the first period or sixth period. The last one was to consider the attention and concentration of students. The verbal expression of Land revealed that once the teacher makes decision on integrating experiments, s/he then makes decision on methods. For Land methods is not merely referring to the procedures of conducting the experiment and how to use materials. It also refers to making decision whether to design students experiment (investigative approach) or teacher experiment (demonstrative approach). Land believed that decisions on these approaches also influence the nature of the social forms to take place during the lesson. The teacher explained that student experiment (investigative approach) has a different social form than teacher experiment (demonstration). Land argued that teacher demonstration involves more frontal instruction and sometimes involves collection of feedback from students but student experiment requires different levels of social communication within the groups. The other important thing is that, for Land, method refers to how to get insight from the observation data like representing the observation data in graphical forms and mathematical forms to draw conclusions about the observation (the science process skills). The teacher is referring method as the science process skills. S/he explained method as follows:

> "*what physically happens is converted to numbers using measurement devices in experiments, the numbers (observation data) is further processed into diagrams (other forms of representation), and using mathematical methods like gradients to derive equations that govern the observed phenomena, and these derived equations are used to explain the phenomena theoretically, and the derived equations can be transferred (applied) to physical facts and laws using exercises. This is a circulation between experimental physics and theoretical physics, mathematical methods and what actually happens. This is a unique approach to how physical science*

does. This is always how it is conducted and displayed within the different topics."

The teacher decides on the deep structure of methods (the science process skills) over the surface structure of methods which is a mere procedure. The former is about how to process measurements from observations in different forms (graphical and mathematical), derive equations that explain the observed physical phenomena theoretically, and apply the derived equations for problem solving. The latter is about what instruments to use, how to take measurements and steps (procedures) to follow.

The analysis of the lessons planned by the participant teachers showed that the frequency of decisions made on lesson planning areas (learning contents, learning objectives, exercises, methods, experiments, social forms) by individual participant teachers were different. This was also different from teacher to teacher. It seems that the participant teachers place importance on some areas over others. I want to learn, understand and get insight about teacher decisions on lesson planning areas. To this end the participant teachers were asked, "We discovered from your lesson plans, that you most frequently made decisions in the areas "this " and "that" whereas you made less frequent decisions in the areas "this" and "that". One could interpret, that you think, that the most frequently chosen area is more important than others. Is that correct? Please explain."

HAS:

> The analysis of the lessons planned by HAS showed that the most frequent decision was made on methods, and the least frequent decision was made on experiments and exercises. The teacher was asked, "We discovered from your three lesson plans, that you most frequently made decisions in the area "methods", whereas you made decisions in the areas "experiments" and

"exercises" only once. One could interpret, that you think, that this area is more important than others. Is that correct? Please explain." According to HAS, a frequently chosen area doesn't imply that it was important than other lesson planning areas. The verbal expressions of HAS suggested that the teacher first examines whether an experiment is important in conveying the content, and does think how to usefully implement experiments in particular the suitable stage of conducting the experiment in the flow of instruction. The core values and beliefs the teacher brings into aspects of teaching and learning influences her/his decisions in sequencing lessons. This can be inferred from statement made by HAS "*If I decide that the lesson should focus less on learning contents but more on scientific research like experimenting, observing, reflecting, evaluating, etc. then obviously experimenting becomes very essential*."

Kaise:

The analysis of the lessons planned by Kaise showed that the most frequent decision was made on experiment and social forms, whereas the least frequent decision was made on content and learning objectives. To understand why Kaise emphasized experiments and social forms over learning objectives and content the teacher was asked, "We found from your six lesson plans that you most frequently made decisions in areas of "experiments" and "social forms" whereas you made decisions in the areas "contents" and "learning objectives" only once. One could assume that in your opinion these two areas are more important than others. Is that true? Please explain."

Kaise also believed that the most frequently chosen area doesn't imply that it was more important than the other areas. However, Kaise explained contrasting ideas about the frequency of decisions s/he made. Kaise said that (1) s/he had a problem in properly using the planning tool, (2) s/he did not recognize and overlooked to make decision on contents, (3) s/he doesn´t know why s/he selected contents less frequent. Even though the planning area contents was the least frequently chosen area, Kaise had a belief that, of all lesson planning areas, content is the most important. The teacher believes that "*it is important to plan for what to write on the blackboard, that is something transferred to the notes, and this is what the students learn and take it home in the end*." The teacher underscores the importance of having the visible structure of the learning material. Kaise had an orientation towards the transmission model of teaching. The verbal expression of the teacher imply that s/he plans for visible contents to be transmitted in terms of notes by the teacher and to be received (copied) by students over deep structure of students learning (mental engagement of students).

Land:

The analysis of the lessons planned by Land showed that the most frequent decision was made on experiments. The second frequent decision was made on social forms, and the least frequent decision was made on contents. To understand why Land made decisions most frequently in the areas experiments and social forms over contents the teacher was asked, "We found from your six lesson plans that you most frequently made decisions in areas of "experiments" and "social forms" whereas you made decision on the area "contents" only once. One could interpret this that you think that these two areas are more important than others. Is that correct? Please explain."

Land's verbal expression suggested that the most frequently chosen area doesn't imply that it was more important than the other areas. Land pointed out that even though content was the least frequently chosen area s/he is tacitly following specific content in sequencing lessons. Land expressed her/his views like this:

"*…I do not just come here (to school) to exercise social form… since the content is given in the book I only have to read it…I read the book and then think about what is useful to make content related decisions…I neglected this when documenting my lesson plans because this is so obvious for me….Due to the fact that I have already been teaching for a couple of years the content is already apparent to me…I do not really have to think about content.*"

According to Land, decision on lesson planning area is context related and depends on (1) the group of students, (2) the learning situations of students, (3) what happened in previous class, and (4) aspects of students' motivation. Land claimed that s/he had no blueprint or structure that s/he follows when planning lessons. The teacher said that s/he always modifies or adjusts lessons and uses different procedures when planning different lessons based on the situation.

The analysis of the lessons planned by the participant teachers also revealed that the sequences of teacher decision areas were varying from lesson to lesson and from teacher to teacher. I wanted to explore the reasons behind these variations and the underlying criteria the participant teachers did use in sequencing these decisions. For this purpose, teachers were asked, "We also found out, that the sequences of your decision areas are varying from lesson to lesson. What underlying criteria did you use in sequencing these decisions? Do you have a certain structure (scheme) or blueprint when planning a lesson?"

HAS:

HAS noted that the sequences of decisions rely on two variables. The first one was the nature of the topic at hand. The second was her/his experience with and knowledge about students and students learning. Consequently, s/he has no permanent scheme or criteria in sequencing lessons. The verbal expression of the teacher implied that using the same scheme eventually becomes boring and tiring both for students and the teacher. For this, s/he changes the sequences of decision from lesson to lesson to keep students active.

Kaise:

Kaise claimed that the lessons planned with the help of the planning tool doesn´t reflect the planning s/he would do without the tool. In teacher own word, "*for me it was like an endless loop, where always the same things appeared….I printed it once…and I couldn´t use it at all in the lesson... so I still had to make my own notes ….and I only logged on to the planning tool because I had promised it …but actually I didn´t profit from it personally…. I had expected more from it*." However, regarding the scheme or structure of the lessons, Kaise follows typical procedure for lesson planning. The teacher first decides on the contents and then integrates an experiment (and/or tasks) to give students the opportunity to practice and consolidate the content learned.

Land:

For Land, lesson planning is influenced by what happened in the class in the previous lesson and the speed at which the students learning was progressing. The verbal expressions of the teacher illustrated that the teacher has no permanent structure or scheme that s/he uses when planning lessons. Based on the learning progress, the teacher selectively decides what aspects to change or to consider that s/he regards important. Land stressed that s/he has no blueprint or structure and always modifies or adjusts lessons using different procedures based on the situation. Land responded to the interview question as follows:

"*I cannot formulate a norm now using some sort of criteria, the planning of a lesson is always based on what has occurred in the previous lesson. This does not include what was planned in the previous lesson but what happened in that lesson. Decision making during lesson planning depends on whether the learning progress is proceeding slowly or with speed. Learning progress is different from class to class, from season to season, from school to school….for these reasons criteria can't be attached to one another creating a sequence of lesson plans.*"

With regard to what criteria the participant teachers' use when making decisions and sequencing lessons, the analysis of the interview data indicated that implicitly or explicitly the teachers follow the content of the syllabus as a guiding criterion. However, there were variations among the participant teachers. For example, HAS uses most frequently three criteria, (1) what and how to optimize aspects related to the learning content that is already known before planning, (2) formulating learning objectives, and (3) delineating methods of achieving the learning objectives. HAS specifically considers the "how" (the method) of achieving the learning objectives with different students or different classes. HAS decides the method of achieving the learning objectives for such difference based on her/his experience and knowledge about the competence level of her/his students. Land always looks first for the possibility of integrating experiments in the flow of instruction as a criterion in making decisions on lesson planning. Land also used her/his knowledge about students including their level of understanding and knowledge, and their motivation. Taking those factors into account Land makes decision on methods at deep level (the science process skills). Kaise uses her/his knowledge of the content from experience as a criterion and decides what s/he thinks fits best the content from her/his perspective. Kaise underscored the importance of having the visible structure of the learning material that the teacher writes on blackboard during instruction and that the students copy and take it home.

It seems that Kaise had an objectivist view of knowledge. According to this view knowledge exists independently of the knower and is seen as decontextualized. That is knowledge can be learned, tested, and applied independent of contexts. In this view, teaching is a matter of transmitting this knowledge, and learning receiving this knowledge accurately. A teacher having such orientations plan lessons from their own perspective emphasizing on (1) transmitting content over students learning, and (2) their orchestration on stage over what the learner should do. However, both Land and HAS seem to consider learners as a foci when planning lessons. It seems they both have subjectivist view of knowledge. According to this view learners construct their knowledge and learners' prior knowledge determine the quality of the learning to take place. Teacher with such orientation views lesson planning from student perspective and plan for what students do over what s/he can orchestrates on the stage in classroom.

All participant teachers stressed that a frequently chosen area doesn't imply that it is important than other lesson planning areas. HAS and Land have no scheme or structure or blueprint which they use in sequencing lessons. HAS varies the sequences of decisions based on (1) the nature of the topic, and (2) her/his knowledge about students learning. HAS varies sequences of decisions from lesson to lesson because s/he believes that this way students can be made active, otherwise the lesson becomes boring. According to Land, the sequences of decisions are influenced by what happened in the class in the previous lesson and the speed at which students learning is progressing. And based on the progress of students learning, Land selectively modifies her/his decision from lesson to lesson. However, Kaise follows typical procedure where s/he always first decides on the contents and then integrates an experiment (and/or tasks) to give students the opportunity to practice and consolidate the content learned. HAS and Land take into account the context of their students learning and they vary the sequence of decisions from lesson to lesson based on the context.

5.4.2 Planning for differences in students learning.

The main theme of this research study was actually to explore how teachers use externally generated feedback data on their students' performance and adapt lessons to individual learning needs implied by the feedback data. To understand the effect of such feedback data in adapting lessons to differences in students learning, it is very important to understand whether the participant teachers normally consider the variations in students learning in a class when planning lessons. To this end, the quality of lessons planned by the participant teachers was analyzed with reference to its adaptability. The analysis of the planned lessons clearly showed that the participant teachers did not consider preconditions while planning and sequencing lessons. I want to know and learn in depth from teacher interviews whether they take into account the differences in students learning in class and how they do it when planning physics lessons. For this, the participant teachers were asked the following three main questions:

(1) There is a normative opinion that a teacher should consider the differences of students in a class when planning a lesson. Do you agree or disagree? Could you explain, please?

(2) In light of this, how do you see the lessons you planned with the help of the planning tool?

(3) This (considering the differences of students in a class when planning a lesson) can be subsumed under the keyword “adaptation” of the lesson to preconditions. Do you think that you considered the preconditions in your lesson plans?

The analysis of teacher’s responses to these questions is presented below.

Interviewer: There is a normative opinion that a teacher should consider the differences of students in a class when planning a lesson. Do you agree or disagree? Could you explain, please?

HAS:

HAS agreed that a teacher should consider the differences of students in a class when planning a lesson. The verbal expressions of HAS illustrated that the teacher considers the differences of students in a class when planning a lesson based on her/his experiences about students and students learning. These experiences include (1) knowledge regarding the migratory background and different language competencies, (2) knowledge of the competencies of the individual students, and (3) prominent learning disability. This means that one component of teacher’s pedagogical content knowledge, that is the knowledge of students and students understanding plays a great role in accounting for differences in students in a class.

Kaise:

Basically, Kaise also believed that it is important to differentiate between students when planning lessons. However, Kaise’s verbal expression demonstrated that s/he doesn’t consider the differences in students learning and makes little differentiation when planning physics lessons. Kaise said that s/he doesn´t take into account how every student learns physics when planning lessons. Kaise described her/his idea verbally as follows: "*...I realized that I only differentiate a little bit when it comes to physics and that I don´t really think about how every physics student …eh…is and how he learns*." The verbal expression of Kaise implied that the teacher did not know how to differentiate and desired to have training on lesson differentiation. The teacher stated that if there were occasions for further education on how to differentiate physics lessons, it would be very useful to differentiate physics lesson to account for the differences in students learning. Kaise knew the idea of differentiation from mathematics, and used to give way more thoughts on how to differentiate mathematics lessons than in physics. According to Kaise, differences in students can be accounted through the selection and use of application problems. The verbal expression of Kaise suggested that the teacher was aware of variations in students learning preferences: *“...some students like to calculate and learn with formulas, others prefer to explain or make experiments….*” Kaise also believed in the importance of considering students own conditions and learning preferences when planning lessons. However, the verbal expression of the teacher indicated that s/he lacks consciousness and overlooks the presence of variations in students when planning lessons: *".... I am lacking a little bit the consciousness that there are those two groups... I try to classify who learns how and what is important to whom*." In principle, the teacher believes on the importance of differentiation but the teacher witnessed that s/he doesn't consider it while planning and sequencing lessons.

Land:

Land had a belief that a teacher should consider the variations in students in a class when planning a lesson. Land claimed that s/he takes into account differences in students in a class when planning a lesson by (1) setting different levels of performance to be acquired by students of different competency levels, (2) selecting topics that are related to everyday life and which do not require high intellectual competencies and mathematics for the weaker performing students. Land believes that the latter provides an opportunity for weaker students to bring them in contact with the language of physics.

The participant teachers were also asked to reflect on how they did consider the variations in students in a class in lessons they planned with the help of the planning tool. Teacher responses to this question are summarized and presented below.

HAS:

HAS witnessed that the lessons s/he planned with the help of the planning tool were less adapted to the individual needs of the students. In teacher own word *"...significantly …ehmm… less adapted to the individual needs of the kids… less differentiated*." HAS was further asked whether the reason why s/he did less differentiation was because s/he already had it in her/his mind but didn't write it down or not. HAS replied to this question saying "…*No!... being honest I did not think about differentiating in that moment… during the group work I …ehmm… allocated the exercises to each group regarding the difficulty of the exercises. So there I differentiated, but you could convey this (differentiation) more thoroughly in a normal instruction.*" The implication is that HAS implicitly considers variations within students when planning but adapt lessons to individual differences during instruction.

Kaise:

When asked to reflect whether students learning differences were considered in the planned lessons with the help of the planning tool, Kaise doubts if the lessons s/he planned with the planning tool reflects her/his usual lesson planning. Kaise claimed that the planning tool didn't encourage her/him to differentiate lessons to individual student differences. Kaise noted that "*there were no clues on the online planning tool for differentiation of the lesson*". The implication is that Kaise did not take into account the variations in students in the planned lessons. Because Kaise claimed that the planning tool didn't ask for differentiation, s/he was further asked a question whether s/he did differentiate when planning physics lessons in her/his everyday ongoing instructional decisions. The verbal expression of the teacher to this question suggested that Kaise has differentiation of lesson only in mind and doesn't write down her/his mental models of differentiation of lessons while planning. However, Kaise believes that the variations in students in a class can be addressed by (1) planning for variety of approaches of teaching and learning including engaging students in calculating, experimenting, explaining and listening to each other (discussion), (2) using tasks of different difficulties. However, Kaise claimed that unlike mathematics books, physics books do not have tasks differentiated according to their difficulty levels. During the interview, Kaise tried to compare and contrast tasks available in school physics books with the tasks included in the exam prepared for the purpose of generating feedback data. In teacher own word, " *...I don´t have tasks of different difficulties like I have it in math….Like for example those in the test* *regarding induction...If you move the coil which force will work on the coil…you don´t find something like that in a physics book…there you have to calculate the inductive potential inside a coil, nothing more.*" This verbal expression of Kaise might imply that the teacher takes school books for granted and directly follow it in a cook book form. This is partly because the teacher might believe that sticking to what is there in the book is important because it is prepared by "experts in the field", and partly because teachers have no time to refer other materials (books) to prepare tasks that are different than those in school books. The other important thing is that the teacher might not connect and integrate the use of ideas and principles in one topic content (for example the concept of applied force from Newton's second law) to solve problems in different topics like in induction (when external force is applied on a coil placed around a current carrying conductor).

Land:

Land claimed that s/he addressed the ability differences of students in a class in the lessons s/he planned. Land explained that s/he planned tasks of different difficulty levels, for example, worksheets with easy, medium, and difficult tasks. Land argued that this provides opportunity for students to work on exercises that suit them best.

To get more rich data on the participants thinking about how they tailor lessons to individual student learning needs, the participant teachers were asked a question "Considering the differences of students in a class when planning a lesson can be subsumed under the keyword "adaptation" of the lesson to preconditions. Do you think that you considered the preconditions in your lesson plans?"

HAS:

HAS did not consider the preconditions when planning lessons. HAS's verbal expression indicated that the teacher does not think about the outer (or surface) preconditions like material collections for conducting an experiment but rather the teacher thinks about the inner (or deep) level preconditions like the how of integrating the experiment in the flow of instruction so that learners can build up knowledge that is insightful. In Land's own word, "*If I am honest I did not think about that.*" The teacher was presented with other question "So you did not have to think about precondition concerning the laboratory, because everything is supplied there?" The teacher replied to this question as follows: "*I do not have to look in the material collection, which I need for example for presenting. If I have a lesson in a normal classroom and want to experiment, I obviously have to think about, weather it is possible to conduct it. Ehhm… or should I present the experiment during the preceding lesson and let the pupils make notes and discuss these in the normal classroom.*"

Kaise:

Kaise did think about the inner (deep) level preconditions. That is, conditions related to the attributes of the students learning when planning lessons. The teacher explained this as follows:

> *"...for me the pre-conditions normally are the attributes of the students... I know what the attributes of my students are, because I had some of them in my class from the very beginning... They were in my class continuously from grade 8 to 10 so that I know exactly what we did in class and what we didn´t do... What I do consider are the pre-conditions like where are*

misunderstandings of the students because of misconceptions, terms that are assigned to different meanings or something like that…"

The teacher asked for more clarification about the preconditions the interviewer was talking about saying *"...I did not really know what this was supposed to mean... hahaha...*" The interviewer continued to explain the preconditions as follows: "the preconditions, so what you already mentioned for example. But also the pre-conditions just like the material in the laboratory. Did you consider these pre-conditions for your planning?" Kaise said that s/he have to take into account such preconditions when planning lessons. To plan lesson, in teachers own words "*...I have to know what student experiments there are, what I can actually implement with the students in the student experiments, what experiments I have in the physics collection. Because I have done it quite often I know what´s there.*" Kaise claimed that s/he does not make written planning for these preconditions, "*I know the preconditions in my mind, I don´t make written planning*". The implication is that the teacher knows from her/his experience what materials are there and needed; however, the teacher doesn't write the list of necessary materials when planning lessons. The teacher said that s/he doesn't also explicitly write preconditions related to students attributes; however, s/he implicitly considers those aspects usually through tasks.

Land:

Land witnessed that the planned lessons were not adapted to preconditions. The teacher explained the reason for this saying that by the time of planning with the help of the planning tool, "*everything had already reached a certain flow, that's why I did not need to consider something specific*." This might imply that there are specific times during the semester of the year where the teacher adaptively plans lessons to address the differences in students learning.

The analysis of the interview data clearly indicated that the participant teachers did not consider preconditions in the lessons they planned. This supports the findings from the quantitative analysis of the lessons. The verbal expressions of the participant teachers illustrated that all the participant teachers believe on the importance of taking into account the differences in students when planning lessons. Further analysis of the interview data showed that the participant teachers use the following different methods to account for variation of students in a class:

- Using tasks of different levels of difficulties to provide all students the opportunity to work on tasks that suits them best,
- Setting different levels of performance expectations to be acquired by students of different competency levels
- Selecting tasks and topics related to everyday life
- Selecting and using application problems
- Planning for variety of teaching and learning approaches to include all students learning preferences

It is important to note that these themes were not explicitly indicated in the lessons planned. It might be the case that the participant teachers plan implicitly these elements or techniques and convey more explicitly during instruction. It might be also the case that teachers thinking and action are incongruent.

5.4.3 Planning for students' engagement in high order cognitive thinking.

The quality of lesson plans can be judged with reference to its potential in substantially engaging students in cognitive thinking during instruction. The lesson plans developed by the participant teachers with the help of the planning tool were analyzed to explore whether the planning teacher had considered cognitive activation of students or not. The result of the analysis indicated that similar to adaptability, the planned lessons had limitations with regards to the cognitive activation of students. I wanted to learn and understand from the participant teachers' verbal expressions about how they plan for student engagement in high order cognitive activity when they sequence lessons. To triangulate and validate the findings from the analysis of the lesson plans with teacher's thoughts about whether they have considered cognitive activation of students, the participant teachers were asked on an interview the following questions:

(1) There is also a normative opinion that lessons should cognitively activate all students in a class. Do you agree? In your opinion, what should a lesson that is cognitively activating, contain?

(2) In light of this, how do you see the lesson plans you produced with the help of the planning tool? Did you consider the cognitive activation?

HAS:

HAS asked the interviewer, "*What do you exactly mean with cognitive activation?*" The interviewer explained to the teacher "cognitive activation is to induce the students to actively start thinking". The teacher explained student engagement in cognitive thinking linking with the interest and motivation of students. The teacher said that it is important to create interest by relating lessons to everyday life. HAS underscores the importance of students interest for their cognitive involvement in their learning. HAS expressed her/his worries about the difficulty of engaging students in cognitive activity as follows: *"... I also made experiences where somebody was not at all interested in the subject... very difficult to encourage uninterested kids to actively take part in the lesson*." When asked how the teacher can get students like these to participate, HAS mentioned that

> *"... Ehmm... it is difficult to get uninterested students participate in their learning....mostly when I do group work I try to put the enthusiastic students together with the less eager students... the enthusiastic students can somehow try to encourage the less eager students to take part...sometimes it works and sometimes not*."

To sum up, HAS believes that (1) lessons linked to students everyday life experiences arouses students interest and consequently students can actively engage in their learning, (2) grouping less eager students with enthusiastic students can encourage the less eager students for active participation. However, it important to note here a mere participation can't guarantee students engagement in cognitive activity.

Kaise:

According to Kaise, cognitively activating students is trying to get students think for themselves some time during the lesson. Kaise said that it is difficult to engage 10th graders in cognitive activity because many of these students wanted to drop physics after 10th grade. Kaise viewed students learning from the teacher own perspective. The verbal expression of Kaise revealed that the teacher decides what s/he believes that the students should learn and know, not what the students need to know and learn. On one hand, Kaise blamed that students had knowledge gaps, “they are already done with physics, they don’t show interest to learn”, but on the other hand the teacher does not consider students learning needs and does not think on student’s feet. The teacher just plans for imparting content that s/he believes is important for students. Hattie (2008) argued that “what teachers do matters” (Hattie, 2008, p.22), about students learning. Teachers seeing learning through the eyes of students and providing students with multiple opportunities and alternatives is a key to students learning progress (Hattie, 2008). There are research evidences that report that children start science learning with very high interest, and the way they experience science lessons in high schools erodes the interest of the learners ultimately resulting in dropping science course at the end of the school life. This is exactly implied by Kaise’s statement that most of her/his students are done with physics and are ready to drop on completion of secondary school.

Kaise believes that students emotional affect to certain physics topics influences their intellectual (cognitive) engagement and activity. Students have positive emotional affects with topics related to their lives and topics related to everyday life engage students in cognitive activity. Kaise explained the effect of topics related to students’ everyday life as follows:

> *"... that was the feedback I got. So I address the dangers of electricity for example. And then I have this experiment where I stand in the middle. I start an electric circuit between the heating, myself and the water conduit and put a high voltage machine in between…hahaha…and the lamp glows. And then they wonder “hu, why?” The first time was with an LED (light emitting diode) light that started to glow. Then I turned down the light and*

they were like "Hu, why is it glowing? The circle (circuit) is not closed. "So to have aha-moments (a moment of surprise and excitement) where they realize…ehm…right, so everything is conductive and that is how you can close the electric circuit. Things like that. That´s when I realize that I reached them cognitively because they are all sitting there like: "We don´t really understand that, we think this is strange"."

Because Kaise claimed that it is difficult to cognitively activate 10th graders who are at the end of their high school and are ready to drop physics, Kaise was asked whether s/he did consider cognitively activation of students in lower classes, and how did s/he activate students in lower classes. Kaise said that it is very hard to cognitively activate 10th grade students in physics lesson and consequently the teacher didn't think about cognitive activation when planning lessons. Kaise also explained the difficulty of engaging students in physics lessons relative to mathematics taking as an example her/his 8th grade mathematics and physics students as follows: *"...in grade 8 they deal with formula for the first time.... at the same time you have may be 4 or 3 unknown quantities in physics...in math class you only have one variable x, so that the students have a problem in physics...they can reorganize the equation with x but not with all these variables in physics...and when I have them in both classes I don´t get the impression that they are independent in physics.*" The implication is that students need more support and scaffolding in physics, they don't engage in cognitive thinking independently. This is in line with Vygotsky idea that students need to be supported and get scaffolding until they reach their zones of proximal development.

In general, to cognitively activate students, Kaise uses her/his experiences and the knowledge about the topics which students find difficult to learn and focusses on selecting and prioritizing topics that students could be able to learn and make use of it. Kaise selectively drops out topics that students find it difficult to learn to avoid the possibility of building a perception of "physics is not for me" by weaker students. However, if the topic is mandated by the curriculum and compulsory to teach it, Kaise said that s/he teaches it just to comply with the demand of the curriculum but believes that weaker students don't build on it. Kaise sometimes group tasks on the basis of level of difficulty and deliberately and implicitly assign tasks to students on the basis of their ability (the most difficult tasks for stronger students and the less difficult tasks for weaker students) without the recognition of such acts by the students. Students are not aware of which task is difficult and easy, but they work on tasks assigned to them and present to each other their work products. Kaise sometimes also sets a kind of multiple choice questions with four possible answers to engage students in learning. Kaise poses a question and puts the four possible alternatives at four corners, students chose a corner according to what they think is the correct answer. Each student explains why s/he is standing there and persuades others to change their corner. Such creative activities substantially engage students in their learning as they explain their reasons to convince others forming a learning community. However, Kaise also mentioned that such approach doesn’t always work because it demands the teacher to set a good question with good possible answers. Such approaches of course demands teachers to set distractors (alternative answers) taking into account possible misconceptions (alternative explanations) so that they potentially appear as close as the correct answer.

Planning for such approach is also useful for the teacher in identifying misconceptions from student's arguments for further improvement.

Land:

Land did believe that lessons should cognitively activate all students in a class. Land was asked, "What should a lesson that cognitively activates students contain?" Land explained that cognitively activating students is engaging them on a topic. According to Land, the moment student's start thinking about the experiment, they enter the cognitive processes. Land believed that materials related to everyday life or historical contexts provide students an opportunity to draw connections. Land pointed out that when students make the connections between the lesson and the historical and industrial developments, they engage in cognitive thinking. The teacher expressed that integrating theory and experiments requires thinking and is cognitively activating.

The participant teachers' were asked, "Did you address cognitive activation in your lesson plans?" The summary of the responses to this question indicated that (1) the participant teachers did not think about the cognitive activation of students while planning lessons, (2) however, all participant teachers believed that it is important to consider the cognitive activation of students while planning lessons.

Interviewer: In light of this, how do you see the lesson plans you produced with the help of the planning tool? Did you consider the cognitive activation?

HAS:

HAS confirmed that the cognitive activation of students was not considered in the lessons s/he planned with the help of the online planning tool. The teacher expressed her/his idea as follows:

“*...Ehmm… and I try …ehmm… this is not really emphasized in the lessons I sent you.....But normally I try to …ehmm… connect this with the everyday life of the students…As I said…connection to everyday life… is not really emphasized in the lessons I sent you.*”

Kaise:

When asked to explain whether s/he considered the cognitive activation of students in the lessons s/he planned with the help of the planning tool, Kaise said that s/he didn´t specifically think about how to cognitively activate her/his students in the lesson. The verbal expression of Kaise indicated that the teacher was more concerned with what to orchestrate in front of the class as an actor. The teacher also claimed that her/his students had little motivation. In Kaise’s own word:

"*...Well I didn´t specifically think about how to cognitively activate my students in the lesson. Of course I noticed that one or other students who are already done with physics need to be motivated to copy what is written on the blackboard... but... I sometimes realized that I was much more excited about the things that were going on in front of the class than my students. Which sometimes led to a discrepancy? For one thing I think that as a teacher you are also an actor. If you are not excited yourself by the matter you cannot motivate your students like that. But I have to say, I was disappointed with some of them because of how little they could recall just because there was no motivation left.*"

Land:

The verbal expression of Land demonstrated that the teacher didn't think about cognitive activation of students while planning lessons. The teacher expressed her/his idea as follows:

> "*... I don't think about whether I should be making a cognitive activation or not.... I activate myself cognitively and this I convey on to the students… if I don't cognitively activate myself I could never instruct this topic, because I would be bored... if I am bored this will also convey itself upon the pupils*."

The participant teachers witnessed that they did not consider the cognitive activation of students in the lessons they planned. This is consistent with the findings from the quantitative analysis of the lesson plans. However, the participant teachers believed that it is important to consider the cognitive activation of students while planning lessons. They suggested the following strategies to engage students in cognitive activity:

- Relating lesson topics and tasks to everyday life experiences of students
- Integrating theory with experiment for the lessons
- Relating lessons to its historical context, and technology (or industrial development)
- Selecting and prioritizing topics that are appropriate to student cognitive ability so that students learning can be appropriately progressing
- Deliberately and covertly assigning tasks of different levels of difficulties to students on the basis of their cognitive ability to provide an opportunity to engage all students in cognitive activity.

5.5 Teacher attributions

The intention of studying teacher attributions in this research was to assess the perceived responsibility of teachers for their students' achievement. In particular, I am interested to get insight into the kind of intervention strategies teachers propose against those factors they attribute to students failure. Exploring the intervention strategies teachers suggest is important to better understand teachers thinking about the use of externally generated feedback data to customize lessons to students learning needs. Teacher attributions were analyzed qualitatively.

Table 19 presents factors attributed to students' academic success and academic failure by Land. Table 19 indicates that Land attributed the same eight factors as reasons behind students' academic success and academic failure. These factors were student interest in physics, student work/study habits during the course of their study, quality of instruction, student academic ability, peer (other students) influence towards academic work, academic support from the family, difficulty of the content, and difficulty of the exam.

The participant teachers were asked, "Which of those causes (reasons) you selected for failure can you change/influence?" Land believed that s/he can change about three-fourths of those factors s/he attributed to students' academic failure. Those factors attributed to students' failure but seen as controllable by Land were quality of instruction, student interest in physics, student work/study habits during the course of their study, difficulty of the content, difficulty of the exam, and peer (other students) influence towards academic work. This large magnitude might indicate that Land is willing to shoulder the responsibility and accountability of improving the academic performance of failing students in the future. It also shows that the teacher has a good self-efficacy towards controlling those factors.

Teachers were also asked to describe how they can control or influence the factors attributed to students' academic failure but perceived controllable by the attributing teacher. Land held a belief that the quality of instruction could be improved by teaching through experiments. Put in Land's own words "make current references, think through the experiments in detail". Land was referring to the importance of experimentation for students learning. Instructional strategies that utilize the integration of laboratory activities could help in the development of students' science process abilities, skills and conceptual understanding of the contents. Research findings indicate that such approach can result in greater achievement in science, better retention of concepts, improved attitudes toward science and science learning, improved reasoning ability and process skills (Abraham & Renner, 1986; Renner, Abraham, & Birnie, 1985). Integrating and sequencing laboratory experiences with other forms of instruction resulted in improving mastery of subject matter, developing scientific reasoning, and cultivating interest in science (National Research Council, 2006).

Table 19

Factors attributed to student academic success and academic failure by Land.

Factors attributed to success	Factors attributed to failure	Factors perceived controllable	Proposed intervention strategy
Student interest in physics	Student interest in physics	Quality of instruction	Make current references, think through the experiments in detail.
Student work/study habits during the course of their study	Student work/study habits during the course of their study	Student interest in physics	Current references are motivational and close to real life.
Quality of instruction	Quality of instruction	Student work/study habits during the course of their study	Understandable tasks, transparency.
Student academic ability	Student academic ability	Difficulty of the content	Avoid over- and under exertion.
Academic support from the family	Peer influence towards academic work	Difficulty of the exam	Avoid over- and under exertion.
Peer influence towards academic work	Academic support from the family	Peer influence towards academic work	Avoid disturbances during lessons.
Difficulty of the content	Difficulty of the content		
Difficulty of the exam	Difficulty of the exam		

According to Land, student interest in physics is another reason for academic failure. Table 19 illustrates that the intervention proposed by Land to arouse students' interest was making the topic motivating by relating it to real life situations. In Land's own words, "current references are motivational and close to real life." This idea is consistent with the contemporary literature on the issue. Teachers can stimulate students' motivation to learn by providing real-world learning opportunities (Boekaerts, Pintrich, & Zeidner, 2000). Students can be motivated when they are given choices that are in line with their personal interests. Such experiences can provide students the opportunity to think creatively and deeply. However, the teacher did not mention how to integrate aspects of motivation into instructional sequences. Teachers can arouse and sustain students interest to learn by providing tasks and activities that call for optimal level of cognitive challenge and are interesting, engaging, and satisfying the needs of students; by clearly communicating learning objectives and desirable expectations; by promoting cooperative learning; by promoting self-regulated learning; by scaffolding students' learning efforts; and by using multiple criteria and methods to assess the progress of individualized student over assessment that target comparisons of individuals (e.g., Ames, 1990; Brophy, 2010; Hidi & Renninger, 2006; Keller, 1983; Wlodkowski, 1985).

Students' work/study habits during the course of their study (their effort) were another factor ascribed by Land as reason for students' academic failure. Table 19 demonstrates that inclusion of understandable and transparent tasks was suggested as an intervention strategy to improve student work/study habits during the course of their study. In line with this, Fullan and Langworthy (2014) explained the importance of designing clear and transparent deep learning tasks as follows:

> deep learning tasks (1) with clear and optimal challenging learning goals that are within a student's range of near-term cognitive development as per Vygotsky's zone of proximal development; (2) are negotiated between and accepted by both teachers and students; and allow for the integration of a learning task with a student's personal interests or aspirations, and (3) clearly spelt success indicators and ways of measuring progress brings greater transparency to learning progress, helping students to master the process of learning. (p. 28)

Fullan and Langworthy pointed out that the more transparent the teacher makes the learning goals, the more likely the student is to engage in the work needed to meet the goal. Furthermore, the authors stressed that the more the student is aware of the criteria of success, the more the student can see and appreciate the specific actions that are needed to attain these criteria.

Table 19 depicts that Land ascribed difficulty of the content and difficulty of the exam as reasons behind students' academic failure. As an intervention against these factors the participant mentioned "avoid over- and under exertion." This might be referring to the importance of appropriateness of the content with the skills and abilities necessary to comprehend the learning material at hand, and the importance of tailoring tasks (exams/tests) appropriate to the reasonable level of what students have learned. For example, tasks can be provided that they are suitable to the person's own ability, and a student may experience successful outcomes with such tasks and experiences which in turn can help the student raise confidence in his or her own ability. Attribution of failure to the difficulty of the content to be learned might be implicitly referring to poor academic readiness (lack of required abilities and skills) of the students were upon entering the class to comprehend the new learning.

Land also believed that s/he can change or control the influence of peers towards academic work and achievement. The participant was referring this particular factor within the context of classroom management during instruction. In Land's words, "avoid disturbances during lessons". However, the teacher did not mention how to avoid disruptive behavior that distracts students' learning. In line with this, Landau (2009) discusses two approaches of teacher's classroom management:

If teachers believe that students serve as vessels waiting to be filled with content knowledge, then their approach to classroom management …and their ultimate goal will be to have quiet, obedient students who listen to lectures and perform tasks as instructed. And… other teachers who believe learning is a shared process of discovery…their approach to classroom management … and their ultimate goal is to use problem solving and reflective thinking both as processes that support a well-managed classroom and processes that support effective content acquisition. The first approach is commonly referred to as behaviorist and the second as constructivist or democratic. (p. 740)

Landau (2009) emphasized that the constructivist approach to classroom management treats all individual needs and can support the academic achievement of all students. Some techniques suggested by The Center for Effective Discipline (2006), quoted in Landau (2009), to avoid disruptive behavior in a classroom includes among others "planning lessons that provide realistic opportunities for success for all students…. planning for providing help to students who are having difficulty and supplemental tasks to students who finish work early" (p. 748).

Table 20 presents factors attributed to students' academic success and academic failure by Kaise. Table 20 shows that Kaise attributed ten factors as reasons behind students' academic success and also ten factors as reasons behind students' academic failure. The factors responsible for students' academic success were student academic ability, student work/study habits during the course of their study, student interest in physics, the effort a teacher makes to help each student in their learning, teachers' knowledge of how to teach physics, difficulty of the exam, student academic background (entry abilities and skills), the quality of instruction, difficulty of the content, and academic support from the family. Kaise attributed the following factors as reasons for students' academic failure: teacher teaching ability, the effort a teacher puts into teaching, teachers' knowledge of the subject, quality of instruction, difficulty of the material/content, student work/study habits during the course of their study, mood/luck on exam date, excitement and lack of concentration on exam, and peer influence both towards academic work and leisure.

Kaise believed that all factors attributed to students' academic failure could be controllable. This demonstrates that the teacher had a greater self-efficacy. This might indicate that the teacher held a perception that s/he is responsible and accountable to students' academic performance. This might also mean that the teacher didn't dismiss the possibility of improving the future success of failing students. A teacher having such kind of thinking can exert a maximum effort to optimize students' learning. The strategies suggested by Kaise against factors attributed to students' academic failure were: seeing teaching as an enjoyment, finding out students mistakes, engaging individual students, involving didactics, always questioning the topic at hand, involving weaker students during instruction, using exercises that are feasible and relevant to everyday life situations, praising and encouraging students, knowing different difficulties in the lesson topics, and considering personal situations of each student.

Teachers' affective behavior towards their profession influences the effort they put into teaching which in turn influences students learning outcomes. Kaise proposed that teachers should view teaching as an enjoyment, and such perception may increase the effort they put into teaching. Kaise had a belief that to help each student in their learning the teacher must find out what students mistakes are, and engage individual students in their learning. The former could highlight the importance of diagnosing (assessing) individual student mistakes including misconceptions and learning difficulties. The later, engaging individual students could mean that teachers should provide inclusive and equitable instruction, should design appropriate level of cognitive activation for all students, and should create a learning environment that provides students the opportunity to share the responsibility of their learning. These are very important in supporting, engaging and empowering individual learners as “learners” as per their learning needs.

Substantive student engagement occurs when students are provided an opportunity to reflectively involve in deep understanding, to genuinely value what they are doing, and to actively participate in classroom activities (Fredricks, Blumenfield, & Paris, 2004). The authors argued that to engage students in their learning teachers must provide opportunities for the students to share their thoughts and feelings about their learning with each other and with the teacher. They suggested that involving students in such processes that emphasize and encourage the sharing of the classroom pedagogic spaces provides students the opportunities to reflect on what and how they are learning, what they are achieving, their view of themselves as learners, and the say they have over the direction and evaluation of their learning. Fredricks et al. (2004) pointed out that linking student engagement, classroom pedagogies, and student learning experiences could result in high performance learning.

Table 20

Factors attributed to students' academic success and academic failure by Kaise.

Factors attributed to success	Factors attributed to failure	Factors perceived controllable	Intervention strategy
Student academic ability	Teacher teaching ability	Effort teacher put into teaching	The instruction should be fun for the teacher
Student work/study habits during the course of their study	Student work/study habits during the course of their study	Effort teacher make to help each student in their learning	Engage individual pupils, try and find out what their mistakes are.
Student interest in physics	Mood/luck on exam date	Teacher knowledge of the subject	Don't leave out interesting pages due to time pressure (example: rainbow, aurora borealis or similar).
Effort teacher make to help each student in their learning	Excitement and lack of concentration on exam	Teacher knowledge of how to teach physics	Involve didactics.
Teacher knowledge of how to teach physics	Effort teacher put into teaching	Quality of instruction	Good basic knowledge, always question the topic.
Difficulty of the exam	Teacher knowledge of the subject	Student academic ability	Involve weaker students during the instruction.
Student academic background (entry knowledge and skill)	Difficulty of the content	Student interest in physics	Exercises for pupils, which are feasible and relevant to everyday live situations.
Quality of instruction	Peer influence towards academic work	Student effort during exam	Praise and encourage pupils.
Difficulty of the content	Peer influence towards leisure	Difficulty of the content	Knowing different difficulties in topics. Implement a few short tests not only in difficult topics.
Academic support from the family	Quality of instruction	Mood/luck on exam date	Regard the personal situation of each student. Either talk to the pupils or get your information from the class teacher. Be careful with pupils, which are in difficult situations (family, personal). Allow and search for individual solutions.

Table 20 demonstrates that not only the effort dimension of the teacher but also both teachers' knowledge of the subject and their knowledge of how to teach the subject could be influenced or controlled. Kaise's proposition as a strategy to reduce the effect of teachers' knowledge of the subject on student failure implied that teachers should not leave out interesting topics due to time pressure to cover content. The implication is that a teacher who has the knowledge of the subject s/he is teaching selects contents that interests and motivates students to learn. Kaise was directly referring to the importance of catching students' interest with the prior inclusion of topics that interest students as a remedy to improve the learning of a failing student. Kaise stated that the teacher knowledge of how to teach physics can be improved by involving didactics. The implication is that using alternative teaching and learning methods can improve failing students' learning and academic performance.

Kaise suggested that it is important to always question the topic at hand as a strategy to improve quality of instruction. This might imply the importance the teacher attaches to updating oneself on the "what", "why", and "how" of instructional decision. I also believe that a teacher who always questions the topic at hand before instruction might get involved in answering the following important questions while planning instruction: Why it is important for students to learn this content? What are the expected learning outcomes? What abilities and skills (pre-requisites) are required for the learning of the new material? How to link the current material with the previous lesson and with the lesson to come next? What method of teaching and learning to use? How to use multiple representations to accommodate diverse styles of students learning? What level of cognitive engagement is required? What kind of tasks/exercises to use for such cognitive engagement? What aspects of students learning to assess? How to assess students learning? Such proactive reflective processes are crucial to plan a meaningful learning experience for students.

Kaise suggested the inclusion of exercises/tasks which are feasible, relevant and applicable to everyday life situations of the learners as a strategy to stimulate students' interest in physics. Kaise also placed importance on praise and encouragement as a strategy to increase student effort during exam. The teacher also ascribed difficulty of the content as casual factor of students' failure. The teacher held a perception that this factor is controllable. The teacher implied that the need to know the level of difficulties of each topic and the inclusion of different levels of difficulties in tests. In teachers' own word "knowing different difficulties in topics. Implement a few short tests not only in difficult topics". In the former case, the teacher is referring to teachers' knowledge of the level of difficulties of a topic when setting exams; the latter refers to teachers' knowledge of methods of assessment particularly in using a combination of questions that measures both low level and high level cognitive domains. The teacher also believed that communicating with students and treating their problems could better improve the learnings of failing students.

Table 21 presents factors attributed to students' academic success and academic failure by HAS. Table 21 shows that HAS attributed ten factors as reasons behind students' academic success and also ten factors as reasons behind students' academic failure. Table 21 demonstrates that factors attributed to students' academic success were student interest in physics, student work/study habits during the course of their study, student academic ability, excitement and lack of concentration on exam, teacher teaching ability, effort a teacher makes to help each student in her/his learning, effort teacher put into teaching, teacher knowledge of the subject, quality of instruction, and peer influence towards academic work. Factors attributed to students' academic failure by HAS were student work/study habits during the course of their study, student academic ability, student interest in physics, student academic background (entry knowledge and skills), excitement and lack of concentration on exam, mood/luck on exam date, quality of instruction, teacher teaching ability, difficulty of the exam, and peer influence towards academic work.

HAS held a belief that some teacher related factors (such as teaching ability, quality of instruction, difficulty of the exam) and student's related factors (student interest in physics, and excitement and lack of concentration on exam) could be controlled. As an intervention strategy HAS suggested the importance of getting advanced training as well as establishing a culture of exchanging and sharing idea with colleagues to improve teacher teaching ability, evaluating and comparing teachers teaching abilities and using feedback from students as a method of improving quality of instruction.

HAS suggested that to minimize the effect of task difficulty on academic failure teachers should make a better preparation, choose tasks thoroughly and communicate with students the expectations. The teacher suggested that students' interest could be stimulated by integrating experiments within the flow of instruction, preparing excursions programs, and using everyday life references in the teaching learning processes. HAS also pointed that creating a calming and pleasant atmosphere during exams would help control students lack of concentration on exam. One can infer from table 21 that teacher related factors including effort a teacher makes to help each student in her/his learning, effort teacher put into teaching and teacher knowledge of the subject were attributed as reason for students' academic success where as these factors were not attributed to academic failure. The implication is that the teacher was showing willingness to sharing the responsibility of academic success while rejecting to take the responsibility for academic failure. On the other hand, student entry knowledge and skills (academic background) was attributed to students' academic failure; however, the factor was not attributed to students' academic success. What is the implication? Failing students are blamed to have poor entry background. However, the question is, do teachers consider this poor entry background they sensed while planning and sequencing lessons to bring the students up to the level required?

Table 21

Factors attributed to students' academic success and academic failure by HAS.

Factors attributed to success	Factors attributed to failure	Factors perceived controllable	Intervention strategy
Student interest in physics	Student work/study habits during the course of their study	Teacher teaching ability	Advanced education, exchange with colleagues.
Student work/study habits during the course of their study	Peer influence towards academic work	Quality of instruction	Compare teaching abilities, feedback from pupils.
Quality of instruction	Difficulty of the exam	Student interest in physics	Targeted motivation (for example: experiments, excursions, everyday life references,…).
Teacher teaching ability	Excitement and lack of concentration on exam	Difficulty of the exam	Better preparation, choose tasks thoroughly, better communication with pupils.
Effort teacher make to help each student in their learning	Quality of instruction	Excitement and lack of concentration on exam	Creating a calming and pleasant atmosphere during exams get rid of the fears from pupils.
Excitement and lack of concentration on exam	Student interest in physics		
Peer influence towards academic work	Student academic background		
Student academic ability	Mood/luck on exam date		
Effort teacher put into teaching	Student academic ability		
Teacher knowledge of the subject	Teacher teaching ability		

In the previous sections, we have seen that the lessons produced by HAS, and others, were not adapted to preconditions. Preconditions includes considering students learning needs. It is important to raise one issue: on one hand, teachers blame students for their low interest, poor ability, low effort, and on the other hand, teachers don't consider those elements while planning and sequencing instruction. By not considering these preconditions in instructional decisions, teachers are unconsciously increasing the intensity of the problem.

Table 22 presents factors attributed to students' academic success and academic failure by Main. Table 22 shows that Main attributed ten factors as reasons behind students' academic success and ten factors as reasons behind students' academic failure. The factors attributed to students' academic success were student academic ability, student work/study habits during the course of their study, student interest in physics, effort teacher put into teaching, teacher teaching ability, teacher knowledge of how to teach physics, quality of instruction, effort a teacher makes to help each student in her/his learning, difficulty of the content, and peer influence towards academic work.

Table 22 illustrates that Main attributed the following factors to students' academic failure: student academic ability, student work/study habits during the course of their study, student interest in physics, excitement and lack of concentration on exam, teacher knowledge of how to teach physics, quality of instruction, difficulty of the content, difficulty of the exam, effort teacher put into teaching, and teacher teaching ability. Main had a perception that s/he can change (or influence) some of the factors s/he attributed to students' academic failure. Table 22 depicts that those factors attributed to students' failure but seen as controllable by the teacher were teacher teaching ability, effort teacher put into teaching, effort a teacher makes to help each student in her/his learning, quality of instruction, student academic ability, student work/study habits during the course of their study, difficulty of the exam, and excitement and lack of concentration on exam.

Table 22

Factors attributed to students' academic success and academic failure by Main.

Factors attributed to success	Factors attributed to failure	Factors perceived controllable	Intervention strategy
Student work/study habits during the course of their study	Student academic ability	Teacher teaching ability	Work on professional qualities.
Student interest in physics	Student work/study habits during the course of their study	Effort teacher put into teaching	Restrict your biography.
Effort teacher put into teaching	Teacher knowledge of how to teach physics	Effort teacher make to help each student in their learning	Look from rooms and take different rooms into your planning, for example "free work"
Teacher teaching ability	Quality of instruction	Quality of instruction	Master category!
Student academic ability	Difficulty of the content	Student academic ability	In long term and as a member of an instruction team it can be worked on motivation and learning strategies.
Quality of instruction	Excitement and lack of concentration on exam	Student work/study habits during the course of their study	In long term and as a member of an instruction team it can be worked on motivation and learning strategies.
Teacher knowledge of how to teach physics	Difficulty of the exam	Difficulty of the exam	Influenceable
Peer influence towards academic work	Effort teacher put into teaching	Peer influence towards academic work	Influenceable
Effort teacher make to help each student in their learning	Student interest in physics	Peer influence towards leisure	influenceable
Difficulty of the content	Teacher teaching ability	Excitement and lack of concentration on exam	Create a fear free atmosphere during exams.

In addition to the qualitative descriptions made above, the proportions of student related, teacher related and other people related factors attributed to student academic success and academic failure were analyzed. Figure 18 indicates the percentage proportions of factors attributed to students' academic success. Figure 18 illustrates that the large portion of the factors attributed to students' academic success by both Main and Kaise were teacher related. This might imply that these teachers credited themselves for students' academic success.

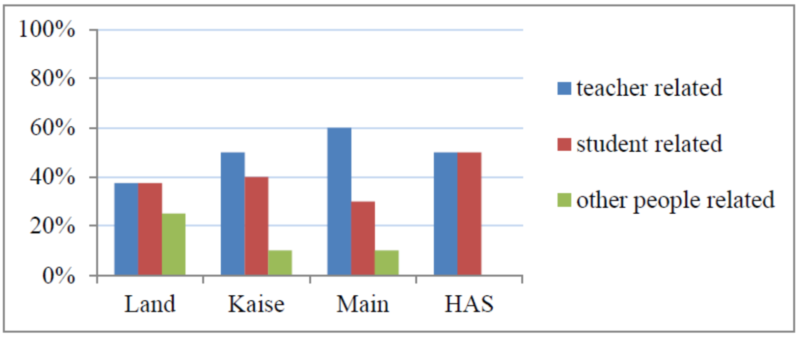

Figure 18. Proportion of factors attributed to academic success.

Figure 19 presents the percentage proportion of factors attributed to students' academic failure. Figure 19 demonstrates that the large portion of the factors attributed to students' academic failure by both Main and Kaise were teacher related. However, the large portion of the factors attributed to students' academic failure by HAS was student related. The large proportion of teacher related factors ascribed as reasons behind students' academic failure by Main and Kaise imply their willingness to share more accountability and responsibility for students' academic failure. Whereas the large proportion of student related factors attributed as reasons behind students' academic failure by HAS might imply that the teacher was attaching more responsibility to students for their poor academic performance.

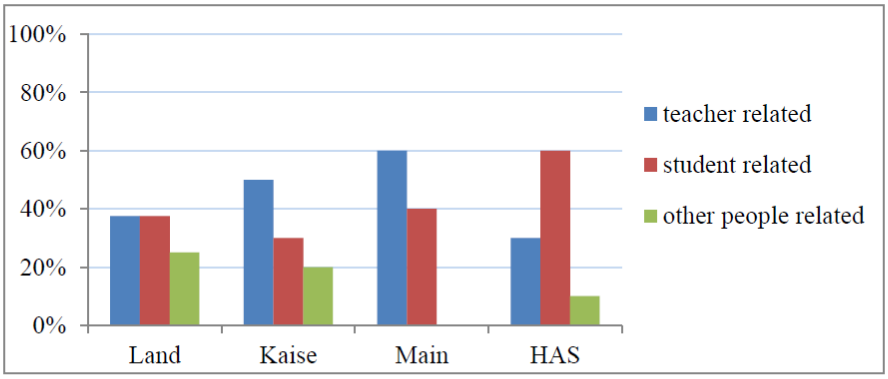

Figure 19. Proportion of factors attributed to academic failure.

The commonality (or agreement) of the attributed factors by the participant teachers were analyzed to identify the most serious and critical factor behind student academic success and academic failure. The analysis indicated that the most critical factors responsible for both students' academic failure and academic success were student academic ability, student work/study habits during the course of their study, student interest in physics, difficulty of the exam, and quality of instruction.

5.6 Interview on feedback data

Georgiou et al. (2002) pointed out that teacher's interpretation of an academic performance is important because the way the teacher sees student's academic performance activates certain kind of instruction the students receive. Nurmi et al. (2012) found that students' academic performance had an impact on how teachers instruct. The authors claimed that teachers adapted their instruction according to the previous academic performance of a particular student. However, this result was based on teachers' self-report. There is no research study that examined teachers thinking about how they can use student's performance data to adaptively plan lessons. However, I believe that such study is worthwhile in the era of greater accountability pressures on teachers to improve students' academic achievement. With this intention, the participant teachers of this study were provided externally generated feedback data on their students' performance.

The feedback data consisted of aggregate level, category level and item level. The feedback data provided to the participant teachers are presented in appendices. Teachers were interviewed to explore their thinking and explanation of their student's performance feedback data, and the kind of strategy they bring to floor to remedy the underperformance implied by the feedback data. Teachers participated in 37 to 64 - minute interviews with two interviewers. HAS participated in a 38- minute interview. Approximately 24 minutes of the interview time were spent on feedback data that the teacher received and how the teacher can adapt lessons on the basis of the feedback data. Land participated in a 55-minute interview. Approximately 25 minutes were used on questions concerning the feedback data and its use in adapting lessons. Kaise participated in a 64-minute interview. Approximately 31 minutes were devoted on questions concerning the feedback data and its use in adapting lessons. Analysis of teachers' responses to the interview questions provided insights into the way teachers' reasoned student performance feedback data.

5.6.1 Participant teachers' general opinions on the feedback data.

To elicit teachers' feelings about the feedback data they received teachers were asked, "We sent you some feedback data. What was going through your mind when you were looking at the feedback data you received?" HAS pointed that s/he was overwhelmed by the diagrams and numbers and it took her/him time to intensively read and understand the feedback. HAS looked at item level results of the first part of the feedback data and was surprised by her/his class's performance. The teacher claimed that more of the test items were not instructed, and the teacher didn't know how students performed well. The teacher stressed that students might have answered either by transferring knowledge, or guessing. The verbal description made by HAS suggested that her/his students had difficulties with items that measure low competence levels. The teacher concluded that her/his students were better on tasks that were higher in complexity than on tasks that were lower in complexity. The teacher said that s/he can't explain why her/his class performed better on high complex tasks than on less complex tasks. Land pointed out that the tested class was a poor performer, and the feedback data reflected her/his expectations. The teacher ascribed the reason for her/his class's poor performance in terms of students' poor academic ability. The teacher expressed that s/he was happy to see that some questions were solved correctly and even in some parts better than the reference group.

Apart from students' poor academic ability, Land claimed and criticized that the content of her/his lesson plans was only partly reflected by the questions of the test. The teacher ascribed her/his students' poor performance to task difficulty, and/or validity of the test items in terms of content coverage. The verbal descriptions suggested that the teacher doesn't wonder why the students could not answer items that were not the content of instruction by the time of testing. The teacher said that s/he "could not do anything with table 2 (see appendix D), because it was not possible to allocate individual students answer to individual items". Kaise appreciated the opportunity to look at the tasks of the first part of the test. The teacher underscored that having the tasks the teacher could make sense out of the feedback data. The teacher wished to have items of the second part of the test and pointed out that s/he didn't know what tasks it contained and had difficulty to make meaning out of it. The verbal descriptions from Kaise suggested that the teacher checked areas of weakness and strength both at item level and subscale level. Kaise expressed that s/he made little sense from the second part of the feedback data because the teacher didn't understand the meanings of some terms like reproducing, organizing and integrating.

Interviewer: We sent you some feedback data. What was going through your mind when you were looking at the feedback data you received?

HAS: *...So first I opened the document and quickly went through the pages. At first the diagrams and numbers overwhelmed me… it takes time to …ehmm… intensively read through the document. What surprised me looking at the results is ….the kids have not worked with the term "energy" so far. I have the opinion, that the only exercises they could have solved from part one of this test where the questions regarding "work". This was covered during the lessons. Everything else could only be answered by transferring knowledge.*

Interviewer: So exercise 1 or which exercise haven't you addressed?

HAS: *I actually haven't addressed 1, 2, 3, 4, because we only introduced the term "system" with the law of conservation of energy. Not 5, this also includes the term "energy", 6 this we discussed. We also did not discuss 7….*

Interviewer: So basically no exercise?

HAS: *That's why the results are surprising me. I did not teach it in such a way, that it would allow the students to easily answer the questions. That's why I don't know if there was … a lot of guessing. Or, I can't say, I don't know. This was the first thing, which surprised me.*

Interviewer: It was actually planned, that these questions – that these topics had been taught in your class already.

HAS: *This was not the case.*

Interviewer: Then we must have made a mistake.

HAS: *But still I have to say, if I look at the results…*

Interviewer: If you look at the results,

HAS: *The result indicates the high competency of this class. And the second thing which surprised me, is that the higher the complexity level became, the better the pupils were. I cannot explain this to myself. What I found out in other grades, also in higher grades is this thing with reproducing and selecting. This is unbelievable, normally you think as a teacher, when you give exercises that the easiest thing is to reproduce. But everyone has difficulties with this. This is surprising for me. But this is an experience I also do in other grades also other colleagues make these.*

Interviewer: We sent you some feedback data. What was going through your mind when you were looking at the feedback data you received?

Land: *Firstly I looked at the overall solved tasks. This class is not a high performer. My colleagues and me rated this class as a poor performer. This has been emphasized by the results… these results really reflect what I expected of them. … I was happy to see that some questions were solved correctly and that even in some parts my class was better than the average. Of course there were also some below average. The questions had not been subject of my instructions at that point of time. I could not do anything with table 2. Then I also saw the questions. I criticised* *this earlier without the microphone. I criticised that the content of my lesson plans was only partly reflected by the questions of the test. The content of some questions were not yet discussed. Like …question 2 had not been discussed prior to the test. That content was only due in the first or second lesson after the test. This explains ….ehm… the poor competency. Let's see here …thermodynamic equilibrium was not discussed. This obviously in connection with thermo system's had not been discussed. Then I don't wonder why the pupils could not answer these….*

Interviewer: We sent you some feedback data. What was going through your mind when you were looking at the feedback data you received?

Kaise: *Ehm... so for one thing I appreciated that I received the test eventually….had a chance to look at the tasks again carefully... because with the help of this I could make sense out of the feedback data. Whereas the unspecific part was missing and therefore I don´t really know what tasks it contained. Ehm... Of course I was glad, that my class scored above the reference group. And then I checked where they had done particularly well and where they performed poorly. Ehm... but basically I could make little sense of it because…I couldn´t quite catch the meaning of those terms. Well that´s what I thought on reproduction…selection probably stands for how much basic knowledge they have, what you should know.... but what about organizing and integrating. Integrating may be like transfer. And*

...ehm... because I didn´t receive the questions I just checked… well at the one below they are not that bad, there they are a little bit better, there they are a little bit better, I guess it was okay. But I couldn´t do more….

Teachers were asked, "How did you proceed when looking at the feedback data?" HAS first skimmed through the feedback data to get a general overview. The teacher then looked at how each question in the first part of the feedback was solved. HAS then continued to the second part of the feedback. The teacher emphasized that s/he had to think to remember about the contents of the second part of the feedback data but was quite difficult to remember it. The verbal expressions of the teacher suggested that the teacher had difficulty to understand table 2 (see appendix C). HAS said that s/he was unable to draw a conclusion out of the table. Land read the feedback data from the beginning to the end without difficulty. Land said that the feedback data was progressively differentiated spanning from general statistics through the statistics of individual tasks to evaluations regarding competence levels. Kaise said that s/he went through the data from the beginning to the end. Kaise tried to make sense out of the feedback data contrasting her/his class with the reference group.

Interviewer: How did you proceed when looking at the feedback data?

HAS: *First I made myself a general overview… then this big table.. I left out…then I looked at each question. How they were solved.... Then I looked at the second part of the test, where I had to think back and try to remember what this part was about. It was quite difficult to remember the contents of the second part....I continued to the table in part 2, which I systematically read from* *top to bottom. Because I could not start anything with the table I moved right to the front, because somewhere there is an explanation for the individual levels, which are displayed on the last page. At the end I tried to find out if there could be any systematic mistakes in the table, as this was addressed in the interpretation possibilities. However, I could not really come to a conclusion….*

Land: *Eh... I just read through it from the beginning to the end*

Interviewer: Ok. So you did not really have a structure when looking at it?

Land: *Eh … the structure is already given. First there is a general statistics then statistics regarding the individual tasks. This is progressive differentiation. At the end you find evaluations from the tester regarding the competencies…*

Interviewer: How did you proceed when looking at the feedback data?

Kaise: *I was going through it from the beginning to the end and I always checked: can I make a sense of this description and how does my group compare to the others.*

5.6.2 Teachers' interpretation and explanation of the feedback data.

Teachers were asked, "Were there parts of the feedback data you didn´t understand (immediately)? If yes, which parts were those and how do you understand them now?" One teacher's verbal descriptions suggested that s/he had difficulties to understand the data presented in tables. This teacher also expressed that s/he had difficulties with the technical terms used in subscale feedback data related to measures of different levels of competence. Teachers also pointed out that it was difficult to remember the contents of the second part of the test and expressed a desire to see the items. Teachers' verbal expressions shed light on the difficulty of making sense out of the feedback data, for example from bar graphs, if additional information like the test items is not provided. One teacher expressed the difficulty of understanding why her/his students performed poorly in subscale levels, for example in complexity 2, by looking at the bars. The implication is the teacher needs to know what complexity 2 is, and which items measured this level. The teacher expressed a desire to see for example items that measured model application. In addition to this, the teacher wished to have individual student level feedback data on each of the complexity levels (study design, applications of models, developing a question, a problem and/or a hypothesis, analyzing data) to know and understand which student was at which level. This seems reasonable especially to adapt instruction to individual student learning needs. One teacher compared the size of her/his class with the size of the reference group to see if there were mistakes or measurement errors in the feedback data. Teachers compared individual students' performance with their experience about the students. One teacher pointed out that s/he didn't understand the second part of the feedback data because some information like the total numbers of levels of competence, the total number of tasks in part 2 of the test, and the overall result of her/his class were missing.

Interviewer: Were there parts of the feedback data you didn´t understand (immediately)? If yes, which parts were those and how do you understand them now?

HAS: *I could not start anything with the table I moved right to the* *front, because somewhere there is an explanation for the individual levels…. it was quite difficult to remember the contents of the second part.*

Interviewer: You did not quite understand the last table?

HAS: *Not at the first glance. But now I do.*

Interviewer: Okay. Was this the only illustration or content, which you did not understand?

HAS: *No, I had difficulties with all these technical terms. I have never heard the term "to select". "To reproduce" I knew that. I had to intensively read to find out what is exactly meant by this. I did not really have problems in understanding the diagrams during the first glance.*

Interviewer: Have you understood everything now?

HAS: *Yes*

Interviewer: Were there parts of the feedback data you didn´t understand (immediately)? If yes, which parts were those and how do you understand them now?

Land: *No. I compared this with the pupils and my experience with their performance. Then I realised there had to be a mistake at one or two points. Eh… when I compare this with my knowledge about the performance of the pupils. Eh … but that is not important for the statistical part…*

Interviewer: So you understand all the other illustrations? Or were there some problems with the understanding?

Land: No. ... *let me see, if I add … the number of pupils… I just summed up the number of pupils. The class you did the comparison with, is that as big as my ninth class? 12, 24 it seems to be larger or? Slightly? … No they are the same size. All right. Correct.*

Interviewer: Were there parts of the feedback data you didn´t understand (immediately)? If yes, which parts were those and how do you understand them now?

Kaise: *... to begin with I don´t understand why my students performed poorly at complexity 2 and better at all the others, if complexity two is supposed to be the lowest one. So things like that go through my mind, because you can´t really understand it when you´re looking at the bars…for example I would have really liked to maybe see the questions on model application... If there has been a given model and they had to use it or if they had to apply a model they had learned in the lesson. Like, in what way did this relate to my lesson? Another question I had was…ehm…the competence levels reached are all well and good. Now I know who the best ones are. But how many levels of competence are there? Are there 8, 7, 6? What was the overall result of my class? I thought to myself, I´ve been tested on how well I can understand statistics... and I realize, that there is some information missing….for example how many tasks were there in* *total. I know that the highest number of answers was 20, but how many were there?*

Interviewer: So how do you understand the feedback data? Because of the difficulties you encountered, how do you understand it now?

Kaise: *Ehm... I would have wished, after in the beginning it was all about the students giving me their numbers. I didn´t get an individual feedback. So I cannot say for example, that student 1 is very good at applying models, because this feedback was not included. I just did…altogether…well it is…basically I just need it to know who is really good. I had copied it on a foil and then I had the first twelve numbers. And then I asked who the other five were because they, because they had done extremely well. Which was not a surprise, that it was them. But there was one surprise. There was one student who usually has grades around 4 and she reached competence level 5. She was really proud of course….*

Teachers were asked, "What conclusions can you draw from the feedback data?" The teachers explained the item level and scale (category) level data over the aggregate level data. This indicates the importance of providing disaggregate level feedback data so that the teachers can extract useful information. The teachers stressed that some of the items included in the test did not reflect the contents they planned and taught. However, one of the teachers said that the feedback data reflects the abilities of her/his students. The teachers pointed out that students performed better on items that were related to the contents discussed in the class. They expressed a feeling of proudness on their students' performance on some tasks and the teachers attributed such performance to their teaching and appreciated the presence of such tasks. However, they attributed poor performance on some task to the validity of items in terms of their coverage and representativeness of contents they did instruct in the class. In such cases the teachers didn't see poor performance as negative but expressed their anger on the presence of such test items. There seems also that teachers misinterpreted data and drew out wrong conclusion. Two teachers, for example, noted that their students had weaknesses on low level cognitive thinking like reproducing. They came to such conclusion only by referring their classes relative standing compared to the reference group rather than comparing their students' performance on the different levels of cognitive thinking.

Interviewer: What conclusions can you draw from the feedback data?

HAS: *Ehmm…That there were certain drawbacks regarding reproduction…this was clear feedback for me I will try and work on that because there is still a lot of potential... it is difficult to interpret the frequently picked answer alternative* $E = mc^2$ *as we have not done this before....*

Land: *... Well as expected the competence …ehmm… Thermal energy = heat; has not yet been implemented. It has not been discussed yet…. Looking at the entire class the feedback reflects the classes' abilities…. Task 3, 4 had poorer results. 5, 6, 7 were better and one (task 8) was equal compared to the results of the other group. Why these …ehm… I just want read the tasks. Where are they? Where did I put them? Here they are! … let's look at task 5, twice as cold, half as cold. If you look at this with the model of absolute temperature, it is clear, that it cannot be twice as cold and half as cold. We discussed this. We also talked about the particle model and* *kinetic energy. Further on I also gave them homework were they had to draw the relationship between the Celsius and …ehm… Kelvin scale. This was also discussed afterwards. Thank God that they remembered this… these were already subject of my lessons.*

Kaise: *Can I draw conclusions? ...hahaha... Well, when I look at the specific test of the test I was really proud that 18 compared to 6… Actually that was ...ehm... that was my goal, because that was like the basis, and then I looked and saw that on tasks they could not do, like task 6, I am under the impression, that if they had done the Lenz's rule…had known it, they could´ve managed this task but not like this, because it would´ve contained to many steps. And therefore I thought to myself: I don´t think this is negative, that the performance on task 6 was so bad. And there were two more questions based on the Lenz's rule. This irritated me a little because I thought you knew what I did and you saw that I didn´t do Lenz's rule… And concerning task 1 …I have addressed it. So I think it makes sense and I was happy that you set such tasks because I approve of them.*

5.6.3 How teachers use the feedback data?.

Teachers Attributions

Teachers were asked, "What factors do you think are responsible for low scores on the test?" The teachers' ascribed different factors including test item content coverage, lack of ability, lack of interest and motivation, and physiological processes (feeling good or bad) as reasons for their students' low score. HAS claimed that the main reason responsible for low scores in the test is that the topics of the test had not been discussed in her/his lessons. The teacher was attaching student failure to the validity of the test in terms of coverage and representativeness. The teacher also added that the students might not have been really interested doing the test. Land stressed that the tested class was poor performer. The teacher ascribed failure to lack of ability. Land also ascribed the validity of test in terms of coverage and representativeness as the causes of poor performance. The teacher said that most of the questions included in the test hadn't been discussed by the time the test was administered. Kaise attributed physiological processes (feeling bad or well) as reason behind students low score. The teacher also emphasized that her/his students were not motivated to take the exam. Kaise added that contents related to some of the test items were not addressed in the class.

Interviewer: What factors do you think are responsible for low scores on the test?

HAS: *The main reason is, as I said that the topics have not been discussed in my lessons. The term "energy" had not been contents of my instruction. If you would have asked the questions last week the pupils should have been able to answer them correctly. The test was conducted a bit early. I think these are the reasons. Another thing came to my attention when I was sitting next to the students and filling in my questionnaire, is that the students were doing drawings. Some pupils must have just guessed the answers, as they might not have been really interested. These are my main explanations.*

Land: *This class is not a high performer. My colleagues and I rated this class as a poor performer. This has been emphasized by the results. The questions had not been subject of my instructions at that point of time. I criticised that the content of my lesson plans was only partly reflected by the questions of the test. The content of some questions were not yet discussed. Like the question …what did I say? Question 2 had not been discussed prior to the test. That content was only due in the first or second lesson after the test. This explains ….ehm… the poor competency. The mixing calculation in question 2 was not suitable at that point of time. If this question was answered correctly then only because of luck or it was known from other sources. They did not know this from my instruction*

Kaise: *Yes ...ehm... and the usual factors, that the person was not feeling bad...ehm ...not well. That it´s a 10th grade and they are not that motivated anymore. I kind of forced them to do the test…. This for example was something I had left out. For me it was important that they know about transformers and know how transformers work… than Lenz's rule.*

What intervention strategy do teachers suggest to help low achiever?

Teachers were asked, "Which measures will you take to help those low scoring students?" The teachers outlined different strategies for helping students who scored low in the test. The teachers said that they would provide students tasks differentiated by difficulty levels, and involve less competent students in a class. One teacher said that s/he arranged exercises of a worksheet into different difficulty levels. However, one teacher mentioned that the idea of differentiation and how to do it are lacking in physics. The other teacher also said that s/he would give those low scoring students the opportunities to re-work on the test. One teacher thought helping low achievers in terms of the value s/he added to students learning with reference to where they were initially. This teacher said that s/he would not aim at bringing low achievers to the level of high achievers.

Interviewer: Which measures will you take to help those low scoring students?

HAS: *One measure is going to be, that when I write tests and hand back the corrected version. I want each pupil to revise the entire test again…. I give the kids an opportunity to get involved with the matter and rethink it…. Ehmm… I …Ehmm… have arranged exercises of a worksheet into different difficulty levels. The kids could choose which exercise they want to complete first. I haven't done this in this specific class, but in others. Ehmm… instinctively the less competent students select the easier exercise. Thus even these pupils gain a sense of achievement. If basic interest towards the subject prevails you can motivate the pupils through that, I think. Subsequently less competent pupils are supported.*

Land: *I knew before the test "who" are low scoring students because I teach them. My goal is to find out at what level of competency I take over these pupils at the beginning and how far I can get them...it is not my goal to get the low scoring pupils to the position of the high scoring ones. At the same time the high* *scoring pupils need to be nurtured as well. However, I will try and get these pupils as far as possible. I explained this earlier …ehm… with the different requirements (different levels of performance)…*

Kaise: *So this idea of differentiation…I think this is lacking in physics. Ehm... I could imagine for example...ehm... to differentiate more with tasks…. Ehm... So what I already do is that of course I know in every lesson which questions are easier and which are more difficult. And then for an easier question I compel the weaker students to say something. So that at the end of the lesson they have the feeling "Ah at least I said something".*

Teachers thinking on adapting lessons based on the feedback data

Teachers were asked, "You already sent us some planning's about the topic of the first part of the test. Would you change one of those plans now that you received the feedback data? If yes, which one? And why?" HAS explained that to re-plan a lesson using the feedback data the teacher had to refer her/his earlier plans and think about what s/he did exactly in the planned lesson and how the planned lesson was instructed. The teacher concluded that this process is very difficult. The teacher also claimed that s/he had no time to adapt lesson based on the feedback data. Land explained the difficulty of adapting lessons on the basis of students' data from time point of view. The teacher also implied that it is not possible to plan lesson by referring to the contents of the test, it is necessary to follow certain sequence to get students somewhere, in the order of the requisite knowledge and skills s required to progress student learning. The verbal descriptions of Land suggested that, had the teacher had the test items before planning, s/he wouldn't have adapted the lessons to the contents of the test as it results in shortening the other parts of the content and then students would have gotten bad results in the shortened parts of the result. Kaise said that s/he wouldn't change (adapt) the lessons based on the feedback data. The teacher was just satisfied with her/his students score compared to the reference group. The implication is that teacher's feeling of satisfaction or dissatisfaction on her/his students' performance depends on the relative position of the class compared to the reference group. Kaise pointed out that s/he doesn´t feel guilty just because s/he didn´t teach the questions on which her class performed relatively lower than the reference group.

Interviewer: You already sent us some planning's about the topic of the first part of the test. Would you change one of those plans now that you received the feedback data? If yes, which one and why?

HAS: *I already sent you one lesson plan… last night. This I have already changed. I would pretty surly do that with the other lesson plans as well…how could I do this? Looking at the short time…. I did not get to that. But I always think about that, every time I finish a lesson I think about what was good and what did not work out that well.*

Interviewer: Could you work out some factors looking specifically at the feedback data to find out where the lesson should be changed?

HAS: *Yes*.

Interviewer: So the feedback data was helpful for you?

HAS: *Yes definitely*.

Interviewer: The time gap between the test and the feedback data is quite large. However if the feedback data would have been there in time, let's say maybe one day after the test or like that. Would it then have influence on your future instruction?

HAS: *Yes, of course. It would have been much easier, because yesterday evening I had to think back and take out my notes. What did you do exactly back then? Ehmm… How did you proceed? And this is very difficult. When I know that there are problems with reproduction, I can take this into account within the next lesson. Yes, that would have been easier.*

Interviewer: What changes, just for the audio recorder, did you make while revising the lesson plan?

HAS: *It was about the golden rule of mechanics. I tried to change it in such a way as to activate the pupils to think and do problem solving by themselves. To do this I will give them the golden rule as a text.*

Interviewer: You already sent us some planning's about the topic of the first part of the test. Would you change one of those plans now that you received the feedback data? If yes, which one and why?

Land: *All right if I would have known which questions were going to be asked… it would have been a burden... How did I do it? Eh … you can't do anything faster, it just takes too long. If I try to do something faster I don't manage to do anything at all.*

Interviewer: If you had known the questions beforehand would you have

Adapted your lessons to those?

Land: *No I would have … then I would have had to shorten other parts and then these would have gotten bad results.*

Interviewer: So you wouldn't change your lessons?

Land: *Further on you need a certain sequence to actually get somewhere. Firstly I need the term "energy" … heat as a form of energy before I can start thinking about systems of different energy's…*

Interviewer: So these results don't leave you to want to change your lesson plans somehow?

Land: *Ehmm…not really. I don't know. Maybe I remember some kind of aspect from the feedback data the next time I teach thermodynamics.*

Interviewer: You said earlier that the feedback data arrived after you had already completed this topic. That's why it was impossible for you to use the feedback to plan further lessons.

Land: *No, not entirely. Actually while you were still evaluating the tests I was already working on those deficits in my lessons. The same deficits you addressed in your feedback data later….*

Interviewer: You already sent us some planning's about the topic of the first part of the test. Would you change one of those plans now that you received the feedback data? If yes, which one and why?

Kaise: *Principally, no…*

Interviewer: Well, if you had known which test it was going to be, would you have changed your planning accordingly?

Kaise: *No, I was just happy that I had done it, because I didn´t know that it would come up…*

Interviewer: But you wouldn´t necessarily change your planning?

Kaise: *Actually not, no. Well I don´t feel guilty just because I didn´t teach the last question on purpose and that are the questions that didn´t turn out so well. I can stand by that. I mean, if I knew now that in the reference group there are only from a lower school then this would give me a cause for concern, but I don´t think that´s the matter.*

5.6.4 Teachers' reflection on the use feedback data.

Teachers were asked, "You already know that in our project we want to find out about how external feedback on performance measurement can be used for lesson planning. Now we would like to know, how you would evaluate this idea. Does the feedback data have an influence on how you are going to plan further lessons in the class we tested? If yes, in what way? If not, why?" Teachers believed that the feedback data has an influence and is applicable. However, teachers had difficulty to understand what aspect of the lesson plan to change using the feedback data as well as how to change it. Teacher needs detailed information on the contexts behind each data. For example, Kaise wanted detailed information about complexity II and examples of questions that measure such complexity. Participant teachers did not identify learning needs from the performance feedback data. However, identification of learning needs from the feedback data is the most important step to adaptively plan a lesson. Kaise said that s/he differentiates lesson based on the feedback data when s/he realizes from the data what s/he should change. The implication is that feedback data doesn't inform action or direction for action. Properly adapting lessons based on feedback data demands reading beyond the data, linking data with the context of the data, asking questions about students learning from the performance data, identifying learning needs, generating hypothesis about the data and the context of the data, anticipating possible causes for underperformance, converting the learning needs to learning objectives, and designing an intervention strategy to satisfy the learning needs. This process requires teachers to become teacher-researchers where they research and reflect on their own practices and their students learning. That is, teachers' knowledge and skills about action research must be considered when planning for using feedback data as a means of optimizing every students learning and performance.

Interviewer: You already know that in our project we want to find out about how external feedback on performance measurement can be used for lesson planning. Now we would like to know, how you would evaluate this idea. Does the feedback data have an influence on how you are going to plan further lessons in the class we tested? If yes, in what way? If not, why?

HAS: *Of course, this has a general influence. Yes if, I know that there are certain deficits in different areas…. I will try and focus on them so that I can support the students in these areas.*

Land: *Well this is a hypothetical question, as the school year has come to an end and I don't know if I will teach this class again.*

Interviewer: That's a good argument.

Land: *Ehmm… yes it has influence. Every test even my old tests give me* *insight and also the feedback is ok. The feedback is applicable, I would say.*

Interviewer: You already know that in our project we want to find out about how external feedback on performance measurement can be used for lesson planning. Now we would like to know, how you would evaluate this idea. Does the feedback data have an influence on how you are going to plan further lessons in the class we tested? If yes, in what way? If not, why?

Kaise: *No...if now for example I saw that complexity 2 needs improvement…I don´t really know… should I add more easy tasks?... So that they are prepared better for easier tasks, because they performed poorly on that….But what was complexity 2? I have no examples for that to make sense out of it. Apart from that, I had similar results everywhere …What I´m missing is where I should be maybe… so what was the intention… should all the bars have about the same length? I mean they all are about the same length…. So what is the actual goal? … I cannot understand this from that. If for example for model application, if I had a 10 instead of 56 I would have worried about that and would think… apparently I don´t impart models good enough…but it doesn´t deviate strikingly*

Interviewer: So because your class performed rather well…ehm... you wouldn´t change anything?

Kaise: *I don´t know exactly what I should change. Differentiation is* *something you realized you want to change. Well I am very open. If somebody tells me that here and there I could work on something I would be responsive to that.*

Teachers were asked, “What difficulties do you see, when you want/have to plan a lesson using the feedback data?” HAS expressed her/his doubt about the generalizability and transferability of feedback data. The teacher mentioned the difficulty to use student result on particular topics to adaptively plan lessons on other topics. Kaise stressed the difficulty (or challenge) in using feedback data to adapt lessons. The verbal expression of the teacher suggested that s/he needs help on how to improve lessons based on the feedback data. However, Land said that s/he doesn't see any difficulties when s/he wants to plan a lesson using the feedback data. Kaise said that the teacher teaches to the best of her/his belief about teaching and learning. Kaise added that if this belief is not helping students learning, the teacher needs help to change the belief. Kaise desired to have training on how to use feedback data for differentiation of lessons. In teacher own word, "I never found an advanced training on differentiation in physics." Contrasting with mathematics books the teacher claimed that in physics books the pool of tasks are very limited and they are not differentiated according to the difficulties. The teacher also added that creating different levels of task from a single task calls for a lot of effort and creativity on the part of the teacher.

Interviewer: What difficulties do you see, when you want/have to plan a lesson using the feedback data?

HAS: *I would have problems with … ehm … This test is restricted to a* *small topic area. Ehm…I don't know if this result is transferable to different lessons or different classes. I would have problems to convey the results on to other classes. That would be difficult for me.*

Land: *I don't see any difficulties when I want to plan a lesson using the feedback data. The feedback data says what competencies; possible false concepts associated with questions…there are no difficulties… I can use the feedback data to plan a lesson the way it is.*

Kaise: *The problems that I see ...ehm... if you do it like that and maybe keep making a mistake you don´t do it good enough…ehm... that you usually teach to the best of your belief and then it would be good to get help to change that.*

Interviewer: So your difficulty with the feedback data is that it´s just paper with data and numbers and there is nobody who is going to explain it?

Kaise*:* *Exactly! No help on how you could improve it. It only says: You didn´t do well on that, in case you got a bad result at a certain point.*

Teachers were asked," What comments or feedback could you give us on the project?" HAS point out that the feedback was an interesting and educational experience. The teacher pointed out that s/he has never received feedback over her/his own class except when the principal is there for evaluation purpose. The teacher further stressed that s/he is quite interested to participate in similar studies. The teacher expressed also the difficulties of planning a lesson with the planning tool. Land worried about the security of data exchange and transfer. The teacher clearly stated that such results are devastating as there is delicate evaluation in the system which can have a negative or positive effect on the teacher depending on the information. Researchers working in schools should know such sensible points. Land also expressed her/his concern about the items included in the second part of the test saying that s/he doesn't believe that the questions are general. The teacher added that some of the questions belong to topics that are taught in grade 10. Students cannot answer such questions from general knowledge. Kaise desired feedback on the lessons s/he planned with the help of the planning tool. The teacher pointed out that s/he expected collective and integrated feedback of the lessons s/he planned and students result.

Kaise wished to have feedback that could inform how s/he could improve the lessons. The teacher expressed her/his feeling that s/he expected more detailed feedback that clearly indicates students learning areas that must be improved, areas of students weakness including whether they lack basic knowledge, creativity, or in applying and transferring their basic knowledge instead of giving feedback just by classifying points. The teacher expected such detail feedback for students instead of feedback like a usual grade students have been receiving in school from summative assessments which doesn't inform them about the level of learning. Kaise implied that s/he would find it interesting if the feedback data could tell which student has which shortcomings and how the teacher could support them individually. That is, the teacher sought detail feedback on "who" has "what" shorting comings and how the teacher could support "this" and "that" student individually. There is also one danger in interpreting the feedback data. Kaise had a student who wanted to join advanced physics courses. The teacher said that this student reached only competence level 3, and came to the conclusion that physics is not adequate for the student. Such kind of interpretation influences the expectancies of future performance on physics. This can negatively affect the effort the teacher puts to help the student and the effort the student exerts to learn physics. Kaise considered the score of the student on this test as an absolute measure of the ability of the student in physics.

Interviewer: What comments or feedback could you give us on the project?

HAS: *I believe this was seriously an interesting experience…I see difficulties in planning a lesson using the planning tool…It was an interesting and educational experience. I have never received feedback over my own class except from the seminar supervisor or when the principal is there for evaluation purpose.*

Land: *…you should rigorously respect, that …eh… agreements about secure data exchange and transfer of information. If you want to do …eh… experiments with schools and are aided by teachers you should be aware that a delicate system of evaluation exists…These evaluations can result positively or negatively depending on the information…if you are a young teacher and still have an entire career in front of you these results can be devastating.*

Kaise: *…well I expected something different. I thought I´d use this planning tool, get the results and you are going to tell me more about it. Like ...ehm... well maybe you put the focus too much on that during the lesson and...ehm... maybe you could, in combination with the test results, pay more attention to that…. Because by evaluation I* *understand something like ideas on how you can improve your lessons.*

Interviewer: OK. And other points?

Kaise: *I think it´s a little bit disappointing for my class… they couldn´t really make sense of the results… are they creative, do they lack basic knowledge, instead of just this classification by points... One student for example wanted to pick the advanced course in physics but only scored 3 points on the test….this is frustrating for him because it was like a slap in the face…. it´s going to be difficult for him in the advanced physics course.*

Interviewer: So that the students, that they get individual feedback?

Kaise: *Exactly. And not just a grade like they already get in everyday life and which they cannot make sense of….*

Interviewer: So of course you would find it interesting if we could tell you which student has which shortcomings and how you could support them individually?

Kaise: *Yes. This would be great of course! If there were suggestions like that….*

5.7 Discussion

This section discusses and summarizes the findings of the study from concept maps, lesson plans, attributions, and interviews. To assess the participant teachers' cognitive structure on lesson planning processes, teachers were asked to plan a lesson on a topic force with the help of the concept mapping tool software. The participant's concept maps showed similarities and differences.

One of the most important and significant similarity was that all but Kaise placed at the top of the hierarchy of the concept maps a kind of activity or task to diagnose and identify students' prior knowledge about force. This approach is in line with what David Ausubel (1968) said; "If I had to reduce all of educational psychology to just one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (Novak & Gowin, 1984, p.40). Learning is a cognitive process and occurs by construction of knowledge in the mind of the learner (Bodner, 1986), and student's prior knowledge influences this process (Resnick, 1983; Sanger & Greenbowe, 1997). Moreover, Novak and Gowin (1984) explained the importance of prior knowledge by explaining the difference between learning and meaning sharing.

> Learning the meaning of a piece of knowledge requires dialog, exchange, sharing, and sometimes compromise.
>
> Learning is an activity that cannot be shared; it is rather a matter of individual responsibility. Meanings, on the other hand, can be shared, discussed, negotiated, and agreed upon. (p.20)

Novak and Gowin (1984) emphasized that "students always bring something of their own to the negotiation; they are not a blank tablet to be written on or an empty container to be filled" (p.21).

The other important similarity was that all participant teachers valued the importance of experiment and integrated experiments within the flow of the planned lesson. Integrating laboratory activities with other forms of instruction increases students' understanding of the content, the science processes skill, and interest in science (NRC, 2006). According to Bell (2004), sequencing learner-centered scientific investigations along with other forms of instruction resulted in simultaneous outcomes including the understanding of the science contents and the science process skills.

The analysis of the mapped concepts indicated that there are differences among the participants in their approaches. In Land's approach, students use the pictorial representation from school textbook and explain their understanding about force and its effects in words. This approach has at least three advantages. The first one is that it develops the ability of students in transforming one form of representation of a physical phenomenon to another form (in this case, from picture to word). Second, it helps the teacher to know students' prior knowledge about force. Third, it also exposes possible misconceptions students might have about force. The teacher planned to collect and write students' idea on a board which could serve as a discussion point. Through this discussion the teacher and the students can share the correct physical meaning of force. Even though Land has integrated laboratory activities within the planned lesson, the details of the experiment, the expected level of student involvement and engagement were not articulated.

Kaise planned to introduce the concept force by first defining momentum and conservation of momentum. Though implicit, Kaise also used the analogy of the relationship between work done and power. Teaching by providing a concrete analogy which is intelligible (understandable by learners), plausible (the learner can meaningfully reconcile and relate the analogy with the main concern of the topic), and fruitful (the learner can transfer and use the analogy in new situations) are being used in the processes of conceptual change by science educators and researchers (Mayer, 2004).

During the discussion on a workshop, Kaise explained why s/he used momentum to introduce force as follows:

> "*It was difficult for me to implement the term force. I am used to introduce the term "force" with the term momentum. When you start with momentum, the difference between "force" and "mass" is clearer. The term force is difficult to implement, because pupils tend to mistake force with mass. "Inertia" is easier to introduce with momentum than with the term "force". Introducing the term "force" is always very difficult*."

Kaise integrated experiments within the flow of the planned lesson both for the purpose of teaching the concept force as well as to help students transfer and apply their knowledge to a new situation. Main started sequencing the lesson by a question which asks students to list and to describe the forces they knew. This approach could inform the teacher about her/his student's prior knowledge. In this approach, possible misconceptions can be confronted in the form of discussion when the teacher comments on students' idea. Main integrated experiments in the flow of planned lesson with clearly delineated student roles, and details of the experimental processes. These include experimental setups, what variables to measure, how to present the data, and what variable to determine. The planned lesson calls for high level of student's engagement in the learning processes if actualized as per the intention.

When we see the approach of HAS, collecting student's idea about force from everyday life experiences was placed at the top of the hierarchy of the concepts mapped. HAS planned to compare and contrast student's everyday language about force with the physical meaning of force. This could help the teacher to recognize and confront student's misconceptions. Students enter classrooms with their own mental models of what a force is which might be inconsistent with the correct physical meaning of force. Such incorrect conceptions or mental models impede students' understanding of new learnings unless otherwise the anomalies between their thinking and the correct physical meaning is recognized and confronted to bear a new thinking. To change student's incorrect conceptions and thinking, teachers need to design teaching and learning approaches that creates cognitive conflict and dissonance with their old thinking. Questioning techniques and integration of laboratory activities along with discussions can serve this purpose. In line with this, HAS stated variety of approaches so that students can learn both the content and the science process skills.

In summary, the participant teachers clearly delineated the important concepts involved under the topic force hierarchically. Compared to the lessons the teachers planned with the help of the online lesson planning tool, the lessons planned with the concept mapping tool were more informative and more structured. In science, the use of concept mapping for lesson planning resulted in a high quality lesson plans (Martin, 1994) which is hierarchically arranged, integrated, and conceptually driven (Starr & Krajcik, 1990) and which can be used as an advance organizer guiding teachers in how to show the relationships between important ideas and his/her lesson plans (Willerman & Mac Harg, 1991). The mental model of the participant teachers on lesson planning can be categorized as a three step process that includes planning for diagnosing and identifying students pre-existing ideas on the topic, planning for teaching the correct physical meanings, concepts, and its applications, and planning for consolidating and deepening students' learning through laboratory activities.

The analysis of the planned lessons showed that the sequences of teacher decisions on the lesson planning areas vary from lesson to lesson. To understand the criteria the participant teachers do use in sequencing the chain of lessons, teachers were interviewed. The analysis of the interview data showed that the participant teachers had no scheme or blueprint to follow in sequencing lessons. However, the verbal expressions of the participants indicated that implicitly or explicitly they follow the content specified in the curriculum to sequence lessons.

The other important finding from the analysis of the lesson plans is that in most of the planned lessons, the participant teachers didn't start sequencing the lessons by first defining learning objectives. However, researchers reported that defining learning objectives is the first key step to plan a lesson customized to students' learning needs. In other words, delineating learning objectives was considered the first and most important step in the processes of lesson planning. For example, in the research based lesson planning model by Eylon and Bango (2006), the first stage of their model was to identify and define the learning objectives based on content analysis and diagnosis of students learning needs. Similarly, in the standards based lesson planning model by Carpinelli et al. (2008) identification of learning objectives was considered as a key process of lesson planning. According to this model, learning objectives govern the contents and activities to be included in the lesson, and are bases to evaluate learning outcomes.

The first stage in Panasuk's four stage lesson planning strategy was also defining learning objectives. According to this model, clearly defined learning objectives guide the lesson planning processes including the development of evaluation and assessment strategies. Lesson planning involves analyzing the learning needs of learners, delineating learning objectives, designing sequence of activities to promote cognitive development of learners as well as planning to evaluate and reflect on the outcomes of learning and teaching (Jalongo, Rieg, & Helterbran, 2007; Oser & Baeriswyl, 2001; Panasuk & Todd, 2005). Hiebert, Morris, Berk, and Jansen (2007) proposed a framework for analyzing teaching. Specifying learning goals was the first skill in their framework and the authors wrote that:

> Without explicit learning goals, it is difficult to know what counts as evidence of students' learning, how students' learning can be linked to particular instructional activities, and how to revise instruction to facilitate students' learning more effectively in future lessons. Formulating clear, explicit learning goals sets the stage for everything else. (p.51)

The analysis of the lessons planned by the participant teachers with the help of vignettes showed that participant teachers didn't consider preconditions in the planned lessons to accommodate the diversity of students pre-existing knowledge and skills. I thought that the possible reasons for this could be (1) the vignettes and the planning situation teachers were provided to work with was not related to the context of their actual classroom experience, and consequently the teachers had no idea about what preconditions to consider, (2) teachers did consider adapting lessons to preconditions only during actual instruction, and (3) the participants have an orientations towards "one fits all" model of teaching. My expectation was that when the teachers plan lessons for their ongoing classes they would consider preconditions to accommodate students' learning differences. However, the analysis of the lessons planned by the participant teachers for their ongoing teaching practices showed similar results. The planned lessons were not adapted to preconditions. The participant teachers did not differentiate lessons to accommodate the diversity of students' pre-existing knowledge and skills. There was no sign on how to support students with learning difficulties, and how to challenge students who are progressing in their learning.

To explore the participant teachers' thinking about adapting lessons, teachers were interviewed. The verbal expressions of the participant teachers clearly demonstrated that these teachers do not think about differentiating lessons to address individual student learning needs. All the participant teachers also confessed that the lessons they planned with the help of the planning tool were not adapted to preconditions. This supports the findings from the quantitative analysis of the lessons.

The analysis of the interview data on differentiation of lessons to individual students yielded very interesting findings. The first finding is that all the participant teachers believe on the importance of taking into account the differences in students while planning lessons. The second finding is that the participant teachers view adapting lessons to preconditions as addressing attributes related to students' learning like learning differences, competence levels, learning difficulties, and misconceptions. Such preconditions related to students' learning are termed as inner (deep) level preconditions. The participant teachers do think for such inner (deep) level preconditions but they do not make explicit written planning for it. To say it in another way, the participant teachers have a mental model of deep level differentiation but they do not spell out their mental structure about it while planning lessons.

A planned lesson could lead to better learning outcomes if the sequence of activities accommodates individual student pre-existing knowledge and skills, and are tailored towards the learning needs and characteristics of individual learners. The planning teacher needs to take into account both the outer preconditions (like the accessible material, laboratory facilities, available time) and inner preconditions (attributes of students learning like pre-requisites required for learning the material, the skills, abilities, and the learning preferences of students) to provide all students a meaningful learning experiences. Both the analysis of the interview data and the planned lessons clearly indicated that the participant teachers did not consider both the outer and inner preconditions. However, researchers underscored the importance of differentiating lessons to accommodate the differences in students in a class (Corno, 2008; Haynes, 2007; Liyanage & Bartlett, 2010; Panasuk & Todd, 2005; Stender, 2014; Vogt & Rogalla, 2009).

Teachers can differentiate lessons to suit the diverse needs and characteristics of the learners by planning how to modify the task, by planning different tasks, by planning for different levels of outcomes for individual students on the same task, and by planning different kinds and levels of support (Haynes, 2007).Teachers can also differentiate the curriculum materials to meet the needs, interests, and experiences of their specific classroom (Barab & Luehmann, 2003; Brown, 2009; Enyedy & Goldberg, 2004; Pint´o, 2004; Squire et al., 2003). Teachers can also plan for various approaches to teaching to accommodate the needs of a range of learners, and to adjust teaching for different conditions (Corno, 2008). However, such elements of differentiation were not evident in the lessons planned by the participant teachers.

The other important findings from this study is that the lessons planned with the help of the planning tool lack deep learning tasks that are cognitively challenging and enabling students in constructing and applying knowledge. That is, the participant teachers did not consider the cognitive activation of students. One of the most important aspects that define the quality of lesson plan is how thoroughly deep learning tasks are sequenced to engage all students in a high level cognitive thinking. Deep learning tasks enable “students in creating knowledge through the integration of their prior knowledge with ideas, information and concepts, into a wholly new product and apply the new knowledge in real contexts” (Fullan & Langworthy, 2014, p.23). Cognitively activating tasks stimulates insightful learning. Insightful learning is “an active individual construction process which involves modification of knowledge structures, dependent on learners’ individual cognitive characteristics (domain-specific prior knowledge), and controllable by motivational and metacognitive processes” (Baumert et al., 2013, p.3). Teachers need to plan such insightful learning experiences to challenge and promote the cognitive development of students. The type of tasks and the way the tasks are integrated and embedded within the flow of instruction influences the level of cognitive challenge (Baumert et al., 2010).

In general, the planned lessons lack deep learning tasks that call for students’ substantial engagement in deep learning process. The analysis of the interview data revealed that the participant teachers normally do not consider about the cognitive activation of students while planning and sequencing lessons. All participant teachers witnessed that they did not consider the cognitive activation of students in the lessons they planned. This is consistent with the findings from the quantitative analysis of the lesson plans. However, the participant teachers believed that it is important to consider the cognitive activation of students and suggested the following strategies to engage students in cognitive activity:

- Relating topics and tasks to everyday life experiences of students
- Integrating theory with experiment
- Relating lessons to its historical context, and technology (or industrial development)

- Selecting and prioritizing topics that are appropriate to student cognitive ability so that students' learning can be appropriately progressing
- Deliberately and covertly assigning tasks of different levels of difficulties to students on the basis of their cognitive ability to provide an opportunity to engage all students in cognitive activity.

A closer look at the participants' verbal expressions indicated that the participant teachers view student's engagement in cognitive activity as a mere participation, or surface engagement. Planning for such surface engagement cannot ensure that there is cognitive change and progressive development in the student. In their meta-analysis of research into student engagement, Fredricks, Blumenfield, and Paris (2004) explained student engagement as a multidimensional construct involving the cognitive, emotional and behavioral components where students are simultaneously reflectively involved in deep understanding, genuinely valuing what they are doing, and actively participating in classroom activities. To engage all students in a high level cognitive thinking, teachers need to design and integrate deep learning tasks that build on students' prior knowledge with optimum cognitive challenge (Baumert et al., 2010; Baumert et al., 2013; Fullan & Langworthy, 2014; Neubrand et al., 2013). Bereiter (2002) quoted in Haitte (2008) discusses three worlds to students learning in school: the physical world, the subjective or mental world, and the world of ideas. Haitte (2008) argued that

> these three worlds have major parallels with the three worlds of students' learning and achievement: surface knowledge of the physical world, the thinking strategies and deeper understanding of the subjective world, and the ways in which students construct knowledge and reality for themselves. (p.26)

According to Haitte (2008), the third world (knowledge creation/construction of realities) is “often forgotten in the passion for teaching facts and thinking skills” (p.26). The author explained about the importance of the third worlds as follows:

> Students often come to lessons with already constructed realities (third worlds), which, if we as teachers do not understand them before we start to teach, can become the stumbling blocks for future learning. If we are successful, then the students’ constructed realities (based on their surface and deep knowing) and keenness to explore these worlds are the major legacy of teaching. (p.26)

The implication is that teachers need to identify students’ prior knowledge both to provide students with multiple opportunities and alternatives and to ensure progressive cognitive change in the student. Therefore, careful design of deep learning tasks that are cognitively challenging and build upon students prior knowledge enabling students to use their surface and deep knowledge and understanding to construct new knowledge, and apply the new knowledge in real context (or in new situation) is what define the quality of a lesson. Teachers should design tasks and questions that call for relational and elaborative thinking, cognitively more challenging and involve student in deep learning processes (Haitte, 2008). The findings from the analysis of the lesson plans and the findings from teachers’ interview also indicated some kind of incongruence between what the participant teachers claimed to follow and what was actually included in the planned lessons. Haitte (2008) also argued that teachers claim to prefer a deep view of learning while at the same time they emphasize surface methods of teaching. This implies that teachers exposed theories (their thought) and their theories in use (their action) are different. This will be discussed later in detail.

The other finding is that the approach used to integrate laboratory activities in the sequence of the lessons varies from teacher to teacher ranging from complete absence of laboratory activities in the planned lessons through the demonstrative to the investigative approach. In the demonstrative approach the participant teachers integrated a laboratory experience to deepen students' understanding of a concept previously discussed in a class. In the investigative approach, the focus is on the process of scientific discovery where students conduct an experiment about a physical phenomenon and draw conclusion from the laboratory observations before the teacher introduces the content. There are reports that support the investigative approach. Laboratory investigations should be learning experiences where students "actively participate in scientific investigations, and …use the cognitive and manipulative skills associated with the formulation of scientific explanations" (NRC, 1996, p. 173). Instructional strategies that utilize the integration of laboratory activities and to apply the concept with an instructional environment that accommodates both individual and social constructivist view of learning could help in the development of students' science process abilities, skills and conceptual understanding of the contents. Such sequences of instruction that emphasize learner centered laboratory experiences can engage students in meaning making processes. According to Bell (2004),

> learner-centered scientific investigations of the natural world involve (1) engaging students systematically in meaning making processes (2) in conjunction with sustained scientific investigation of natural phenomena (3) through the scaffolding of individual and social learning mechanisms (4) in ways that result in an improved understanding of subject matter, inquiry processes, the nature of science, and the role of science in society. (pp. 6-7)

Bell explains the importance of the first essential element that is, engaging students in meaning making processes from constructivist view of learning. Quoting other researchers (e.g., Brown & Campione, 1998; Bruner, 1996; Linn, 1995) Bell argued that instructional sequences that values both individualistic and social constructivist accounts of knowledge and knowing provides students an opportunity to articulate, deliberate, and refine their understanding and to develop a deeper understanding of a subject. Bell (2004) pointed out that sequencing instruction by focusing on engaging students in sustained scientific investigation of the physical phenomena help students on learning the more difficult concepts.

The third essential element of learner centered laboratory investigation is in accord with the "Vygotskian view of individual development through social processes in a cultural context" (p. 9), to support and to guide both individual and social learning. The fourth essential element recognizes the importance of sequencing learner-centered scientific investigations along with other forms of instruction so that students gain simultaneous outcomes including the learning of scientific concepts and principles, the processes of scientific inquiry, and the nature of science (Bell, 2004). The National Research Council (2006) pointed out that sequencing laboratory experiences "with other types of science learning activities, including lectures, reading, and discussion…increase students' ability to understand and apply science subject matter, improve their scientific reasoning, interest in science, and understanding of the nature of science" (pp. 4-5).

In general, the lessons planned with the help of the online planning tool were poor in quality. This is because the lessons were neither adapted to the diversity of students pre-existing knowledge and skills nor included deep learning tasks that engages all students in high level cognitive activity. This was also supported by the interview data. Therefore, the answer to the research question, “Do physics teachers plan high quality lessons?” is NO. However, it is important to note that the participant teachers were asked to plan lessons with highly structured online lesson planning tool. The participant teachers commented that the lesson planning tool does not reflect the complex processes of lesson planning. This could be one reason for the poor quality of the lessons. There were some differences between the participant teachers thinking about lesson planning (what they said during interview) and their action (what was evident from the planned lessons). The findings from the interview data illustrated that the participant teachers believe in and claim that they use the following in making instructional decisions:

- Considering students variations or differences in class is essential and important.
- Adapting lessons to preconditions is the reason why planning is needed.
- Teachers’ instructional decisions are guided not only by students level of knowledge and understanding but also by their motivation and learning preferences.
- Learning objectives guides other subsequent teacher decisions.
- Level of students’ knowledge dictates teachers’ decisions.
- Setting tasks with different levels of difficulties to address the variation in students and to provide all students the opportunity to work on tasks that suits them best.
- Setting different levels of performance expectations to be acquired by students of different competency levels.
- Linking lessons with its historical and industrial (technology) developments.

- Planning for variety of teaching and learning approaches to include all students learning preferences.

These themes which emerged from the analysis of the interview data indicate that the participant teachers (1) do adapt lessons to preconditions related to student attributes; (2) do consider students' cognitive activation. However, analysis of the planned lessons indicated that these teachers did not consider these two aspects. The implication is that there existed incongruence between the participants' espoused theory and their theory in use.

One of my research questions was, what attributions do teachers hold for students' performance? Through this research question I wanted to investigate teachers' causual expalnations for their students' achievement, and the kind of intervention strategies they propose to intervene against the supposed causes of failure. Throughout their teaching experience, teachers acquire knowledge about classroom management, instructional strategies and pedagogical content knowledge. From their ongoing experience teachers also construct knowledge and beliefs about individual student learning. Teachers' beliefs like academic attributions influence teacher instructional decisions. The most common factor attributed by the participant teachers to both students' academic failure and academic success were student academic ability, student work/study habits during the course of their study, students' interest in physics, difficulty of the exam, and quality of instruction. However, with reference to the feedback data teachers received on their students' performance, the participant teachers ascribed task difficulty, test item validity in terms of representativenes, students ability, and students motivation as reasons for low score.

The intervention strategy the participant teachers proposed to improve the academic achievement of failing students were finding out students' mistakes, using contents and tasks appropriate to students' cognitive level, approaching instruction through experiments, using variety of instructional strategies, making contents motivating and close to real life, using exercises that are understandable, transparent, feasible and relevant to everyday life situations of students, taking into account students' motivation and learning strategies, involving weaker students during the instruction, taking into account the personal situation of each student, praising and encouraging students, collecting and using feedback from students, establishing better communication with students, and establishing a good classroom management and conducive atmosphere.

The strategies the participant teachers proposed can arouse and sustain student's interest, increase student's effort, engage students substantially in their learning, and increase the performance of students if they are properly utilized. However, the participant teachers did not clearly spell out how these ideas could be integrated in everyday instruction. Some of the techniques suggested by researchers on how to integrate some of these intervention strategies were discussed in the qualitative description of teacher's attributions, and in the review of literature at large.

The primary focus of this study was to explore how teachers might use externally generated student performance feedback data to adapt lessons to students' learning needs. To better understand how the participant teachers used the feedback data, teachers' verbal expressions was coded for the presence or absence of the following elements: attributions, item analysis, between group analysis, within group analysis, knowledge of students, test validity, interpretation, data use for adaptive planning (differentiation of instruction), instructional intervention strategies, lack of knowledge or understanding, and drawing conclusion. Table 23 presents the definitions of these codes and the corresponding examples from teachers' verbal expressions.

The table 23 illustrates that the participant teachers did not use the feedback data on students' performance to identify areas of students' weaknesses (or students learning needs). The table illustrates that the participant teachers tried to analyze individual test items or expressed a desire to get test items (questions) to judge student performance. The teachers attempted to look at individual items in which students had demonstrated poor performance. Table 23 demonstrates that teachers used item level or subscale data to compare her/his class performance with the reference group. They compared whether the magnitude of the score of their class was greater than or lower than the reference group. They did not examine whether this difference was significant or not. In the previous section I have discussed that the participant teachers came to wrong conclusion about their students' performance only by looking at the relative standing of the size of the score of their students in relation to that of the reference group. The participant teachers did not make meaningful comparisons within her/his own students' performance variations. However, making meaningful comparison of their own students' performance on item level or category level is the only way to identify areas of weakness and strengths of individual students. This way they can identify learning gap, and can propose strategies to bridge the gap.

Table 23 depicts that the participant teachers explained the reason for their students' performance in terms of task difficulty, test item validity in terms of coverage and representativenes, students' ability, students' motivation and interest. Teachers expressed their worries that the contents of their lessons were not reflected by the test items. They also added that students were not motivated to work the test. The table shows that teachers have questioned the validity of the test items in particular its representatives of the content coverage.

Moreover, table 23 demonstrates that the participant teachers did not make any meaningful interpretation, or did not draw meaning from the feedback data. Therefore, no meaningful description was found from the verbal expressions of the teachers in relation to using the feedback data for identifying areas of learning needs, delineating learning objectives from learning gaps, and proposing intervention strategies to remedy the learning gap revealed by the feedback data. It is only by addressing these elements of feedback data use that teachers can adaptively plan lessons based on the performance data. However, the findings in this study implied that the use of students' performance feedback data by teachers to differentiate lessons is not a straight forward and is ambiguous.

Teachers have their own way of seeing their teaching, students learning and students' performance. This influences the effective utilization of feedback data to customize lessons to students learning needs. Performance feedback data is useful for adapting lessons if teachers bring "concepts, criteria, theories of action, and interpretive frames of reference to the task of making sense of the data" (Knapp et al., 2006, p.10). The participant teachers looked at the performance data on surface level where they only compared the size of the students score relative to reference group. They did not look deeply beyond the size of the data to identify areas of students learning difficulties. The research team in Untied States of America reported that teachers had the most difficulty with data interpretation, and data query when they worked with assessment data (U.S. Department of Education, 2011). In addition, Vanhoof et al. (2011) claimed that teachers lack the knowledge and skills needed to interpret data and generate meaningful information that leads to action.

The verbal expressions of the participant teachers indicated that there existed a mixed idea on how to use the feedback data to differentiate lessons. One teacher said that s/he can use the feedback data to adapt lessons. One teacher said that s/he would have a problem to use the feedback data because the feedback data is restricted to a small topic area. This teacher was referring to the generalizability of the performance feedback data use in adaptively planning lessons in other content areas. The other teacher said that s/he did not know what to change. The teacher said that differentiation is something that you realized from the feedback data that you want to change. This supports what I discussed above that the participant teachers did not identify areas of learning needs and consequently they did not know what to change. The teacher desired to have training on how to adapt lessons based on the feedback data. Earlier researchers pointed out that teachers lack of know-how on making use of the information they generate from data is one barrier to the effective use of performance feedback (Kerr et al., 2006; Williams & Coles, 2007). The participant teachers' verbal expressions indicated that it was difficult for them to use the feedback data to differentiate instruction. The examples described, from teachers verbal expressions, in table 23 indicates the difficulty of adapting lessons based on the feedback data.

Table 23 clearly revealed that the participant teachers lack basic knowledge in interpreting the data, identifying learning needs, in drawing meaningful information from the data for adapting (or differentiating) lessons. This is consistent with existent research reports on data use. Schildkamp and Kuiper (2010) reported that teachers had difficulty both to analyze data and to apply outcomes of analyses to innovate teaching.

Furthermore, research reports indicated that teachers need support and training to use feedback data for instructional decisions (Schildkamp & Kuiper, 2010; Vanhoof et al., 2011; Visscher, 2009).

Table 23

Codes, definitions and examples from teachers' verbal expressions.

Code	Definition	Examples from teachers verbal expressions
Between group analysis	Makes comparisons of her/his class performance with the reference group	"…in some parts my class was better than the average…there were also some below average. I was glad, that my class scored above the reference group… there they are a little bit better, when I look at the specific test, I was really proud that 18 compared to 6… I don´t understand why my students performed poorly at complexity 2 and better at all the others, if complexity two is supposed to be the lowest one; Tasks…were better compared to the results of the other group."
Within group analysis	Makes comparisons within her/his own students' performance variations	No meaningful within group analysis
Item analysis	analyzes individual test items or expresses desire to get test items (questions) to judge student performance on individual test items; looks at particular items in which students had demonstrated poor performance as a guide to what to emphasize in instruction	"I have the opinion, that the only exercises they could have solved from part one of this test where the questions regarding work; I was happy to see that some questions were solved correctly… there were also some below average…. The content of some questions like …question 2 had not been discussed ... I had a chance to look at the tasks again carefully….because with the help of this I could make sense out of the feedback data…whereas the unspecific part was missing and therefore I don´t really know what tasks it contained,.. I didn´t receive the questions for part 2 of the test, I looked at each question ...,how they were solved, … I would have really liked to maybe see the questions on model application…. I cannot say for example, that student 1 is very good at applying models, because this feedback was not included.."

Code	Definition	Examples from teachers verbal expressions
Knowledge of students	Associates student performance revealed by the feedback data with her/his knowledge about the student	I compared this with the pupils and my experience with their performance. There was one student who usually has grades around 4 and she reached competence level 5.
Attributions	Explains the reasons behind poor performance	"contents of the questions had not been subject of my instructions; the content of my lesson plans was only partly reflected by the questions of the test; this class is not a high performer; they are not that motivated to take the test…I… forced them to do the test.."
Test validity	Express ideas about the quality of tests including content coverage	"contents of the questions had not been subject of my instructions; the content of my lesson plans was only partly reflected by the questions of the test; this test is restricted to a small topic area…I don't know if this result is transferable to different lessons or different classes"
Interpretations	Draws meaning from the feedback data by integrating data and context like identifying areas of learning gaps (or areas of learning needs)	No meaningful interpretations of the feedback data
Data use	Identifies learning gaps, delineates learning objectives from learning gaps, and identifies intervention strategies to remedy the learning gap revealed by the feedback data	No meaningful description was found from the verbal expressions of the teachers

Code	Definition	Examples from teachers verbal expressions
Adaptive planning (differentiation of instruction)	Describes use of the feedback data for differentiated instruction; suggests group or individualized instruction or support based on the data; looks at particular items or competencies where students had weakness to priorities and adapt instruction. Or describes the difficulty to adapt lessons based on the feedback data.	"All right if I would have known which questions were going to be asked … it would have been a burden...… you can't do anything faster, it just takes too long…Further more you need a certain sequence to actually get somewhere…I don´t know exactly what I should change. Differentiation is something you realized you want to change, No help on how you could improve it... It only says ..you didn´t do well on that…in case you got a bad result, I would have problems with (adapting lesson based on feedback data)… This test is restricted to a small topic area...I don't know if this result is transferable to different lessons or different classes...That would be difficult for me, I don't see any difficulties when I want to plan a lesson using the feedback data.…there are no difficulties… I can use the feedback data to plan a lesson the way it is…"
Instructional intervention strategies	Describes or suggests intervention strategies for improving student learning and achievement	"…arranging exercises of a worksheet into different difficulty levels...the less competent students select the easier exercise… Thus these pupils gain a sense of achievement; …with the different requirements (different levels of performance)…, I could imagine for example.... to differentiate more with tasks… for an easier question I compel the weaker students to say something…"

Code	Definition	Examples from teachers verbal expressions
Lack of knowledge	Evidence that the teacher lacks basic knowledge in describing the data or interpreting the data, identifying learning needs, adapting (or differentiating) instruction.	"…I cannot explain this to myself. I could not do anything with table 2… basically I could make little sense of it because…I couldn´t quite catch the meaning of those terms… It was quite difficult to remember the contents of the second part… I had difficulties with all these technical terms…I did not really have problems in understanding the diagrams…you can´t really understand it when you´re looking at the bars… I don´t know exactly what I should change. Differentiation is something you realized you want to change."
Conclusion	Draws valid, reliable information from the feedback data	The participant teachers did not draw meaningful conclusions from the feedback data. I could not really come to a conclusion….
Generalizability	Expresses the idea that the students score on this results can be used for planning lessons in other areas or indicates the sensitivity of using the feedback data to other classes or to other content areas	This test is restricted to a small topic area…I don't know if this result is transferable to different lessons or different classes

With the believe that item-level data provides information that teachers can use to plan individualized instruction for students, the participant teachers were provided item level data along with the tasks and the correct answers. However, the finding from the interview showed that the participant teachers had difficulty to plan differentiated lesson based on the feedback data. The teachers attempted to use the item level and subscale data only to compare the relative position of their class with the reference group. They did not read beyond the data like identifying their students learning needs and planning for differentiated instruction based on individual student performance.

The participant teachers did not draw meaningful conclusions from the feedback data. Teachers were asked to describe how they might use student data to adaptively plan lesson particularly to help low achieving students. Teachers suggested using tasks of differing difficulty levels, setting different levels of performance criteria on a similar task, and involving less competent students during instruction as intervention strategies to improving the low scoring students learning and achievement.

5.8 Conclusions

This section concludes the answers to my research questions and discusses the limitations of the study. The answer to the research question, "Do physics teachers plan high quality lessons?" is NO. This is because the lessons planned were neither included deep learning tasks that engages all students in high level cognitive activity nor adapted to the diversity of students pre-existing knowledge and skills. This was also supported by the interview data. However, it is important to note that the participant teachers were asked to plan lessons with highly structured online lesson planning tool. Teachers suggested that the lesson planning tool does not reflect the complex processes of lesson planning. This could be one reason for the poor quality of the lessons. Further research that involve analysis of actual lesson plans that teachers normally develop for their ongoing practices along with observation of the implementation of the planned lessons need to be carried out to understand how teachers account for the variation in their students learning. The participant teachers attributed the reason for their students' poor performance in terms of task difficulty, the validity of test items in terms of content coverage, students' ability, students' motivation and interest. All the participant teachers implied that the contents of the test items did not reflect the content of their instruction. The answer to the research question, "How do physics teachers use performance feedback data?” is that the participant teachers attempted to use the item level and subscale data feedback data only to compare the relative position of their class with the reference group. The participant teachers did not identify individual students learning needs from the feedback data to plan differentiated lessons. Some of the participants desired to have training on how to adaptively plan lessons based on students results. The implication is that teachers need to be supported and trained on how to identify learning gaps from student data, and on how to adaptively plan to bridge the learning gap revealed by the feedback data.

This study had some limitations. The first limitation arises from the accidental change of the initial design of the research. The initial design of the research was to use both quantitative and qualitative approaches at least on 25 physics teachers teaching the same physics content, mechanics, for grade 9 classes. The initial intention of the design was to analyze the relationship between the quality of teacher’s lesson plans and students’ achievement, the effect of teacher competencies like pedagogical content knowledge, data literacy, self-efficacy, and belief on teacher’s use of performance feedback data and adaptive planning. I also wanted to investigate the variation in teacher’s attributions on students’ academic success and academic failure and how these variations are also revealed in their interpretation of feedback data and adaptive planning. However, of 413 physics teachers contacted from 120 schools only 4 teachers volunteered to take part in the study. This event forced me to accidentally change the design to a qualitative study with the four participants. Therefore, the low number of participants is the second limitation in this study. Even one of the four participants withdrew from the study during the interview. The third limitation of this study is that the participants were teaching different grade levels and different contents. Consequently, they received different performance feedback data. It was, therefore, not possible to make meaningful comparisons of the quality of the lesson plans, teacher's explanations and interpretations of feedback data. The fourth limitation was that the online lesson planning tool is very structured and failed to cater for the complexity of lesson planning processes. The other deficiency of this online planning tool was that it asks teachers only teaching intentions, and overlooks learning intentions. This could be one possible reason as to why the lessons planned with the planning tool were of poor quality. The participant teachers clearly criticized the planning tool. The fifth limitation was the time gap between test administration and feedback delivery. Due to this time gap, the participant teachers were not interested to adaptively re-plan one of the lessons they already planned and taught based on the feedback data on student performance. The implication is that any attempt to use student performance feedback data for adaptive planning needs to consider the issue of timing of feedback data as well as the extra working time it adds to the teachers. As this area of research is at a very infant stage, despite these limitations, the researcher strongly believes that the study will serve as a starting point for those interested in researching on how to optimize students learning using student performance data.

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Appendices

Appendix A List of Tables

Appendix B List of Figures

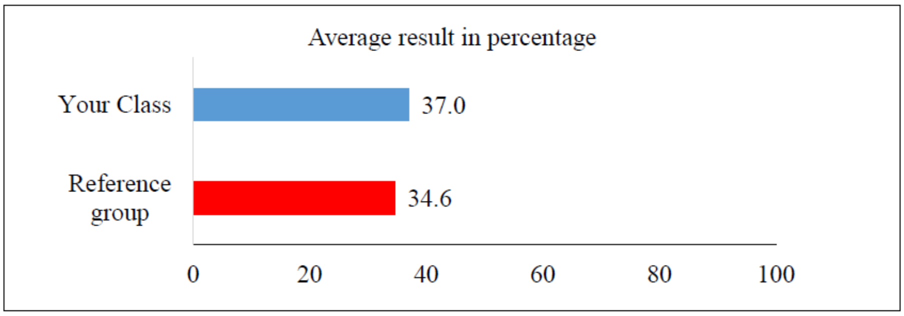
Appendix C Feedback data provided to HAS

Dear Mr/Mrs. HAS,

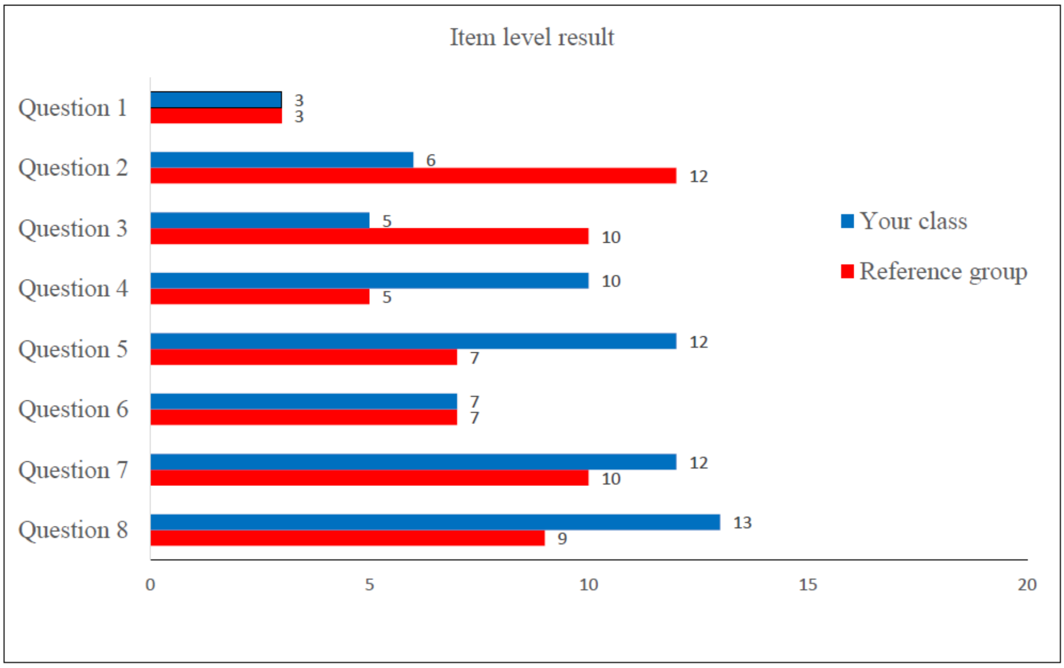
On ----------------,2014 we conducted a test in your class. The test consisted of two parts. In the first part we used an established test to assess the knowledge about the content you had already taught in class. In the second part we measured competence in the area of knowledge acquisition with the help of items from the national comparative study of the institute of quality management in the educational system (IQB). The following information can be useful for you to compare the results of your class with the respective peer group, to conduct an analysis of causes specific to the tasks or the individuals and compare the results with your own evaluation. Please consider that all reported mean values underlie measurement errors which will not be reported for reasons of clarity.

Part 1: Specific part of the test

This test has been used with 128 German students of year 10 in a different study. We used those students as a respective peer group for your class (see graph. 1 and 2). Surely, not all of the concepts and contents of the test have been taught in the same way, so that some of the tasks require reproducing whereas others require transfer thinking. This may have an impact on the difficulty of the tasks (compare with graph 2). The tasks in this test contain typical ideas of students (misconceptions) as possible wrong answers so that you may draw conclusions about possible ideas of the students from the answers (compare with table 1).



Graph 1. Comparison of the average correctly answered percentage of the tasks between your class and the respective peer group.



Graph 2. Description of the expected and actual number of students that answered the questions. The expected value is determined on the basis of the frequency of solutions in the respective peer group and the number of students in your class.

Table 1. Overview of which student chose the right (1) or wrong (2) answer for what question as well as the total number of correct answers. Wrong answers that are marked red or orange display answer alternatives which have been chosen frequently and which possibly indicate the existence of misconceptions.

Student ID	Question(item) No. 1	2	3	4	5	6	7	8	Number of solved tasks
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	1	0	0	1	0	1	1	1	5
4	0	0	0	0	1	1	0	0	2
5	0	0	0	0	1	0	0	0	1
6	0	1	1	0	0	1	0	0	3
7	0	0	0	1	1	0	1	1	4
8	1	0	1	0	1	1	0	1	5
9	0	0	1	0	1	1	1	0	4
10	1	0	0	1	1	0	1	1	5
11	0	1	0	1	0	0	0	1	3
12	0	1	0	1	0	0	0	0	2
13	0	0	0	0	1	1	1	1	4
14	0	1	1	0	0	1	1	1	5
15	0	0	0	1	0	0	0	0	1
16	0	0	0	1	1	0	1	1	4
17	0	0	0	1	1	0	1	1	4
18	0	0	0	1	1	0	1	1	4
19	0	1	0	0	0	0	0	1	2
20	0	1	1	0	1	0	0	0	3
21	0	0	0	0	0	0	1	0	1
22	0	0	0	0	0	0	1	1	2
23	0	0	0	1	1	0	1	1	4

Explanation of the color coding:

Question number 1: Red: answer option 2; orange: answer option 4.

Question number 2: Red: answer option 5; orange: answer option 2.

Question number 3: Red: answer option 4.

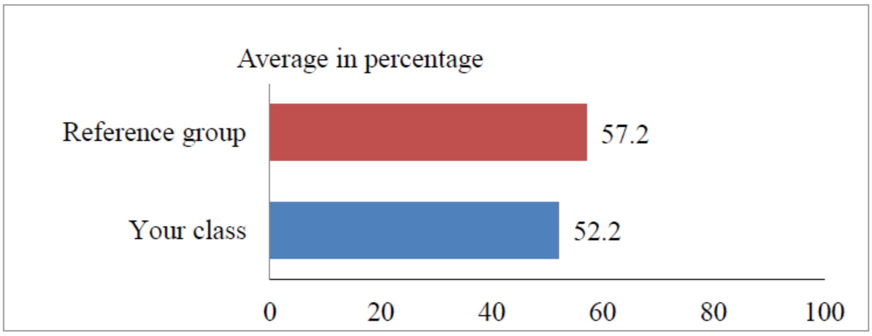
Question number 4: Red: answer option 2.

Question number 5: Red: answer option 1.

Question number 6: Red: answer option 2.

Part 2: Unspecific part of the test (IQB)

The tasks in this part of the test have been developed after certain criteria to measure how well students are familiar with methods of scientific knowledge (experimenting and modelling).Tasks with different levels of complexity have been developed and connected with certain (general) cognitive requirements (for explanation see graphs 4,5 and 6). As reference group for your class we used the standardization sample from the IQB which includes students in grade 9 from all over Germany (graph 3). Based on this the IQB generated certain levels of competence. Competence level 3 equals the so-called baseline competency which should be reached by the end of secondary education I (medium educational qualification) (compare table 2).



Graph 3. Comparison of the average correct answers in your class and the respective peer group.

In the following part the tasks will be divided into different sub-groups which measure different aspects of competence. Firstly it will be explained how the aspects are defined and secondly the results of your class will be shown in comparison to the respective peer group.

The students can…

Reproduce and select:

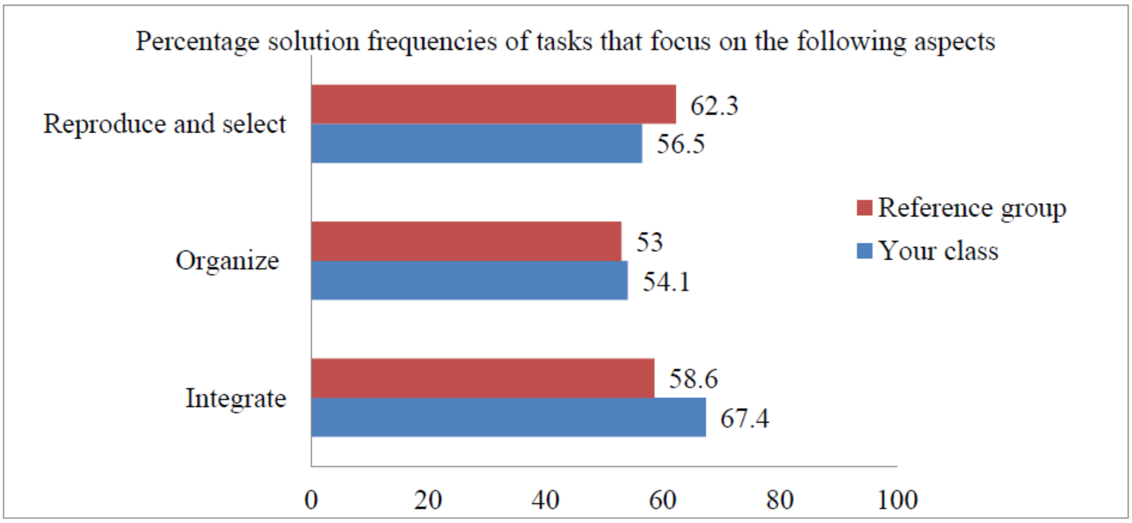
- extract relevant information suitable for the problem from physical descriptions.

Organize (in addition to reproducing and selecting):

- restructure and arrange the given information about physical systems so that a solution process for the problem results.

Integrate (in addition to organizing):

- make conclusions from the given information which are physically adequate and integrate them to be able to solve the problem.



Graph 4. Comparison of the mean of correctly answered questions of your class and the respective peer group. The questions refer to different aspects of task solving.

The students are …

Complexity I (this level has not been used in the tasks, since it is appropriate for weaker students):

- being able to name a single term, quality, physical factor or unit regarding a physical system or to use it for problem-solving.

Complexity II

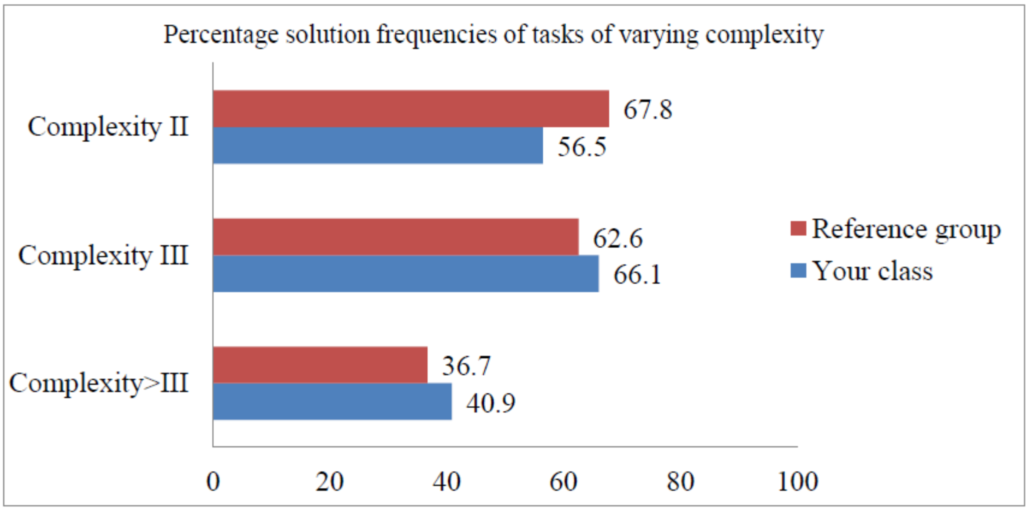
- being able to name two or more terms, qualities, physical factors or units regarding a physical system or to use them for problem-solving.

Complexity III

- being able to name a functional connection, an impact or effect of a physical system correctly, to postulate it or to use it for problem-solving.

Complexity >III

- being able to name event chains, interactions, circuits, etc. in a physical system, postulate them or use them for problem-solving. They are capable of establishing a connection with basic concepts and main ideas of physics and its´ methods.



Graph 5. Comparison of the mean of correctly answered questions with different levels of complexity of your class and the respective peer group.

The students can…

Aspect "study design":

- plan a scientific study based on given hypotheses and describe its´ implementation.

Aspect "application of models":

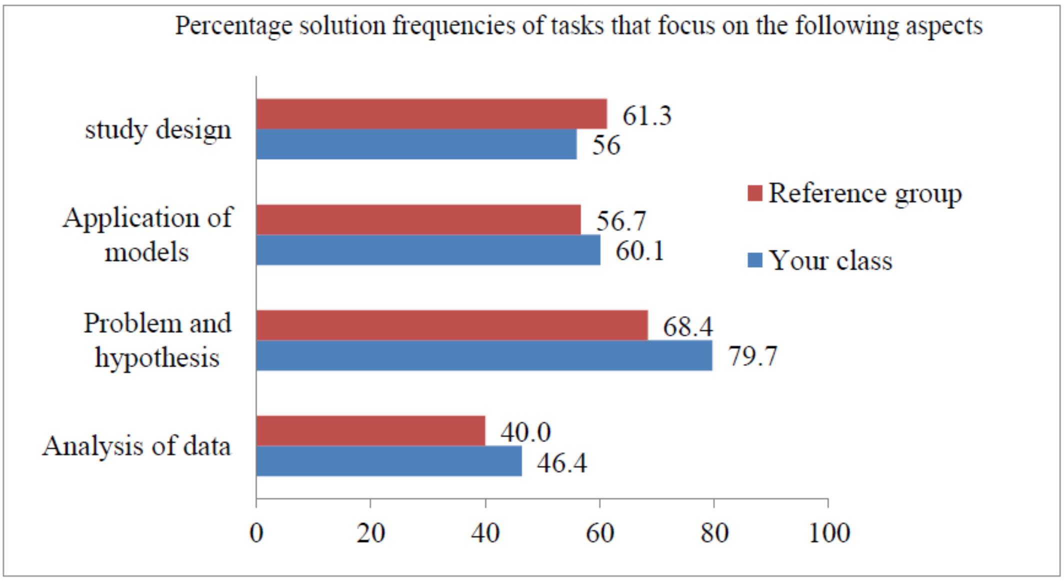
- grasp the meaning of models in the research process and describe its' validation.

Aspect "problem and hypothesis":

- develop a scientific question, problem or study design or make theoretical or exemplary assumptions about a given scientific question or study design.

Aspect „analysis of data"(both methods):

- analyze and interpret given results of a study with regard to the hypotheses and possible errors.



Graph 6. Comparison of the mean of correctly answered questions of your class and the respective peer group. The questions refer to different aspects of tasks.

Table 2. Overview on how many tasks the students answered correctly and the level of competence for each student.

Student ID	Number of tasks solved	Level of competence reached
1	5	2
2	6	2
3	13	4
4	12	3
5	11	3
6	18	5
7	16	4
8	20	5
9	18	5
10	15	4
11	15	4
12	9	3
13	16	4
14	14	4
15	12	3
16	14	4
17	14	4
18	13	4
19	9	3
20	12	3
21	16	4
22	8	3
23	15	4

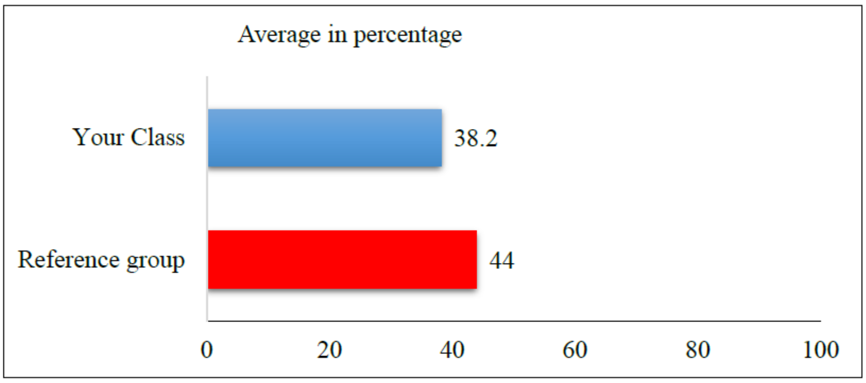
Appendix D Feedback data provided to Land

Dear Mr/Mrs. Land,

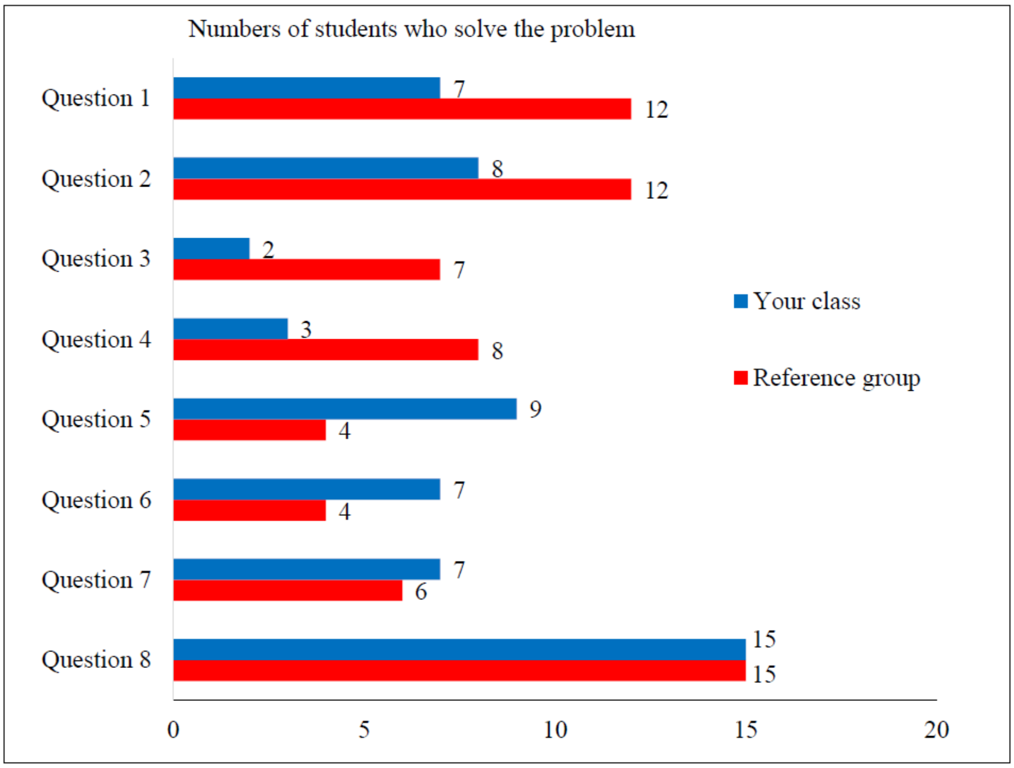
On --------------, 2014 we conducted a test in your class. The test consisted of two parts. In the first part we used an established test to assess the knowledge about the content you had already taught in class. In the second part we measured competence in the area of knowledge acquisition with the help of items from the national comparative study of the institute of quality management in the educational system (IQB). The following information can be useful for you to compare the results of your class with the respective peer group, to conduct an analysis of causes specific to the tasks or the individuals and compare the results with your own evaluation. Please consider that all reported mean values underlie measurement errors which will not be reported for reasons of clarity.

Part 1: Specific part of the test

As testing material we used a German version of the Thermal Concept Evaluation (Yeo & Zadnik, 2001). This test has been used with students of year 10 in a different study. We used those students as a respective peer group for your class (see graph. 1 and 2). Surely, not all of the concepts and contents of the test have been taught in the same way, so that some of the tasks require reproducing whereas others require transfer thinking. This may have an impact on the difficulty of the tasks (compare with graph 2). The tasks in this test contain typical ideas of students (misconceptions) as possible wrong answers so that you may draw conclusions about possible ideas of the students from the answers (compare with table 1).



Graph 1. Comparison of the average correctly answered percentage of the tasks between your class and the respective peer group.



Graph 2. Description of the expected and actual number of students that answered the questions. The expected value is determined on the basis of the frequency of solutions in the respective peer group and the number of students in your class.

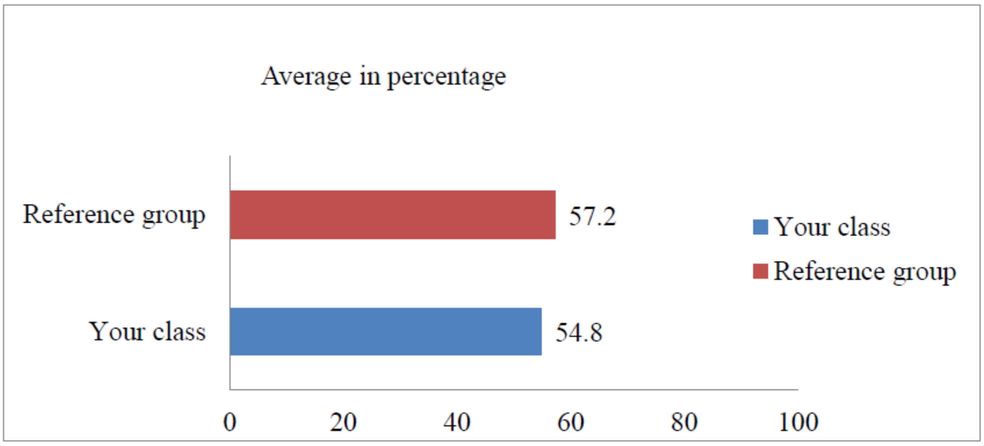
Table 1. Overview of which student chose the right (1) or wrong (2) answer for what question as well as the total number of correct answers. Wrong answers that are marked red or orange display answer alternatives which have been chosen frequently and which possibly indicate the existence of misconceptions.

	Question No.								Number of solved tasks
Student-Nr.	1	2	3	4	5	6	7	8	
2	1	0	0	0	0	0	0	1	2
3	1	0	0	0	1	0	0	1	3
4	1	1	0	0	0	0	1	0	3
5	1	0	0	0	0	1	0	1	3
6	0	0	0	1	0	0	1	1	3
7	0	0	0	0	1	1	1	1	4
8	0	0	1	0	0	0	0	0	1
9	0	0	0	0	1	0	0	1	2
10	1	0	0	0	1	1	0	1	4
11	0	1	0	1	1	1	1	1	6
12	1	1	0	0	0	0	1	1	4
13	0	0	1	0	1	0	0	1	3
14	0	0	0	0	0	1	0	1	2
15	0	1	0	0	0	1	1	0	3
16	0	1	0	0	1	0	0	1	3
17	1	1	0	0	1	1	0	0	4
19	0	0	0	0	1	0	0	1	2
20	0	1	0	0	0	0	0	1	2
21	0	1	0	1	0	0	1	1	4

	Explanation of the color coding
Task 1	Red: answer option 2; possible misconception: “There is no concept of thermal equilibrium. The students don´t understand that objects exchange thermal energy with their environment and that this process causes that the object and the environment have the same temperature”.
Task 2	Red: answer option 2; possible misconception: “Heat and temperature are proportional to each other”.
Task 3	Red: answer option 4; possible misconception: “There is no concept of thermal equilibrium. The students don´t understand that objects exchange thermal energy with their environment and that this process causes that the object and the environment have the same temperature.” as well as “Temperature is a quality of a material or object (e.g. iron is cold)”.
	Orange: answer option 5; possible misconception: “The temperature of an object depends on its size/volume”.
Task 4	Red: answer option 1; possible misconception: “Heat and cold are different dimensions.”as well as “A cold body contains no heat (meaning thermal energy).”
Task 5	Red: answer option 3; possible misconception: “Heat and temperature are proportional to each other”.
Task 6	Red: answer option 3; possible misconception: “Certain materials (e.g. wool) can warm objects.” as well as “There is no concept of thermal equilibrium. The students don´t understand that objects exchange thermal energy with their environment and that this process causes that the object and the environment have the same temperature”.
Task 7	Red: answer option 3; possible misconception: “Water always/generally boils at 100° C”.

Part 2: Unspecific part of the test (IQB)

The tasks in this part of the test have been developed after certain criteria to measure how well students are familiar with methods of scientific knowledge (experimenting and modelling).Tasks with different levels of complexity have been developed and connected with certain (general) cognitive requirements (for explanation see graphs 4,5 and 6). As reference group for your class we used the standardization sample from the IQB which includes students in grade 9 from all over Germany (graph 3). Based on this the IQB generated certain levels of competence. Competence level 3 equals the so-called baseline competency which should be reached by the end of secondary education I (medium educational qualification) (compare table 2).



Graph 3. Comparison of the average correct answers in your class and the respective peer group.

In the following part the tasks will be divided into different sub-groups which measure different aspects of competence. Firstly it will be explained how the aspects are defined and secondly the results of your class will be shown in comparison to the respective peer group.

The students can…

Reproduce and select:

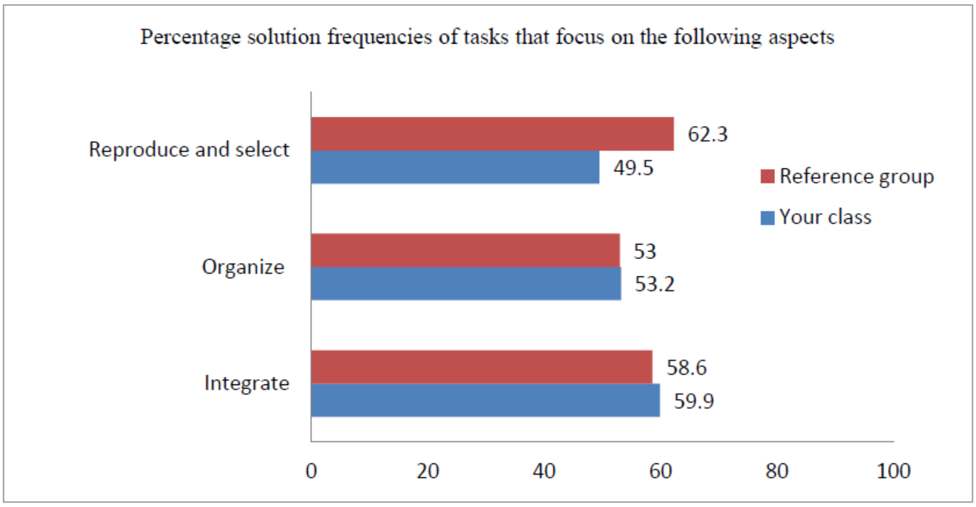
- extract relevant information suitable for the problem from physical descriptions.

Organize (in addition to reproducing and selecting):

- restructure and arrange the given information about physical systems so that a solution process for the problem results.

Integrate (in addition to organizing):

- make conclusions from the given information which are physically adequate and integrate them to be able to solve the problem.



Graph 4. Comparison of the mean of correctly answered questions of your class and the respective peer group. The questions refer to different aspects of task solving.

The students are …

Complexity I (this level has not been used in the tasks, since it is appropriate for weaker students):

- being able to name a single term, quality, physical factor or unit regarding a physical system or to use it for problem-solving.

Complexity II

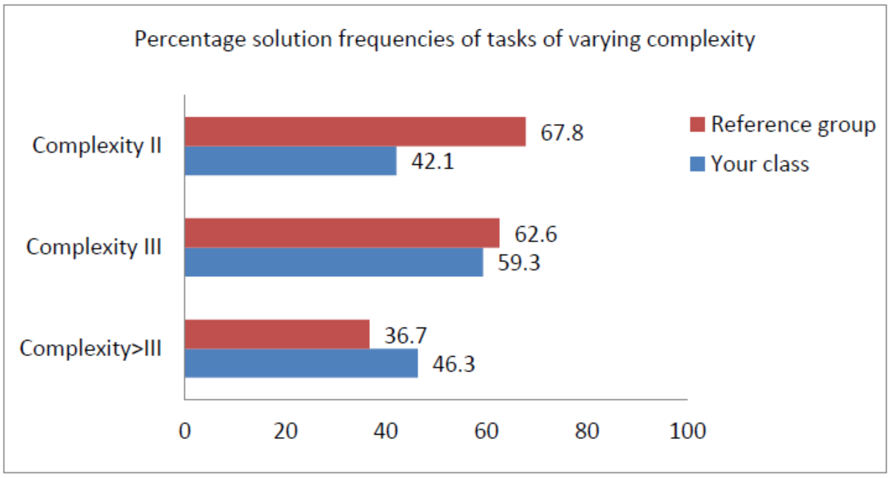
- being able to name two or more terms, qualities, physical factors or units regarding a physical system or to use them for problem-solving.

Complexity III

- being able to name a functional connection, an impact or effect of a physical system correctly, to postulate it or to use it for problem-solving.

Complexity >III

- being able to name event chains, interactions, circuits, etc. in a physical system, postulate them or use them for problem-solving. They are capable of establishing a connection with basic concepts and main ideas of physics and its´ methods.



Graph 5. Comparison of the mean of correctly answered questions with different levels of complexity of your class and the respective peer group.

The students can…

Aspect “study design”:

- plan a scientific study based on given hypotheses and describe its´ implementation.

Aspect “application of models”:

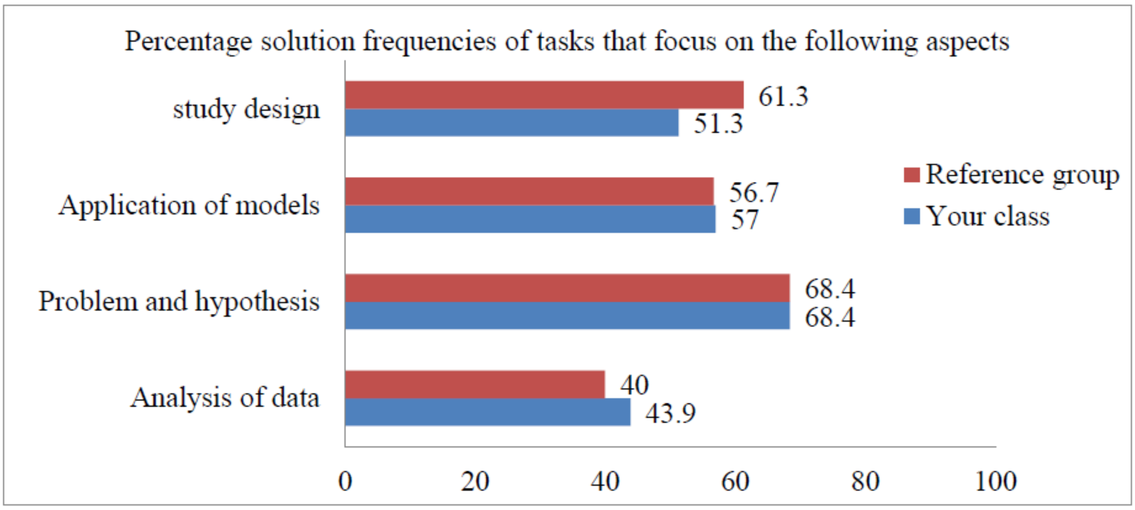
- grasp the meaning of models in the research process and describe its’ validation.

Aspect “problem and hypothesis”:

- develop a scientific question, problem or study design or make theoretical or exemplary assumptions about a given scientific question or study design.

Aspect „analysis of data“(both methods):

- analyze and interpret given results of a study with regard to the hypotheses and possible errors.



Graph 6. Comparison of the mean of correctly answered questions of your class and the respective peer group. The questions refer to different aspects of tasks.

Table 2. Overview on how many tasks the students answered correctly and the level of competence for each student.

Student-ID	Number of tasks solved	Level of competence reached
2	10	3
3	14	4
4	12	3
5	18	5
6	19	5
7	12	3
8	7	3
9	9	3
10	8	3
11	16	4
12	16	4
13	12	3
14	7	3
15	13	4
16	13	4
17	13	4
19	13	4
20	10	3
21	7	3

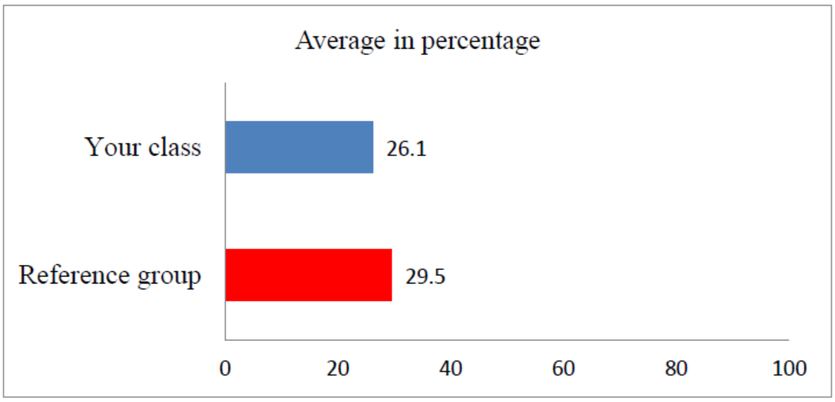
Appendix E Feedback data provided to Kaise

Dear Mr/Mrs. Kaise,

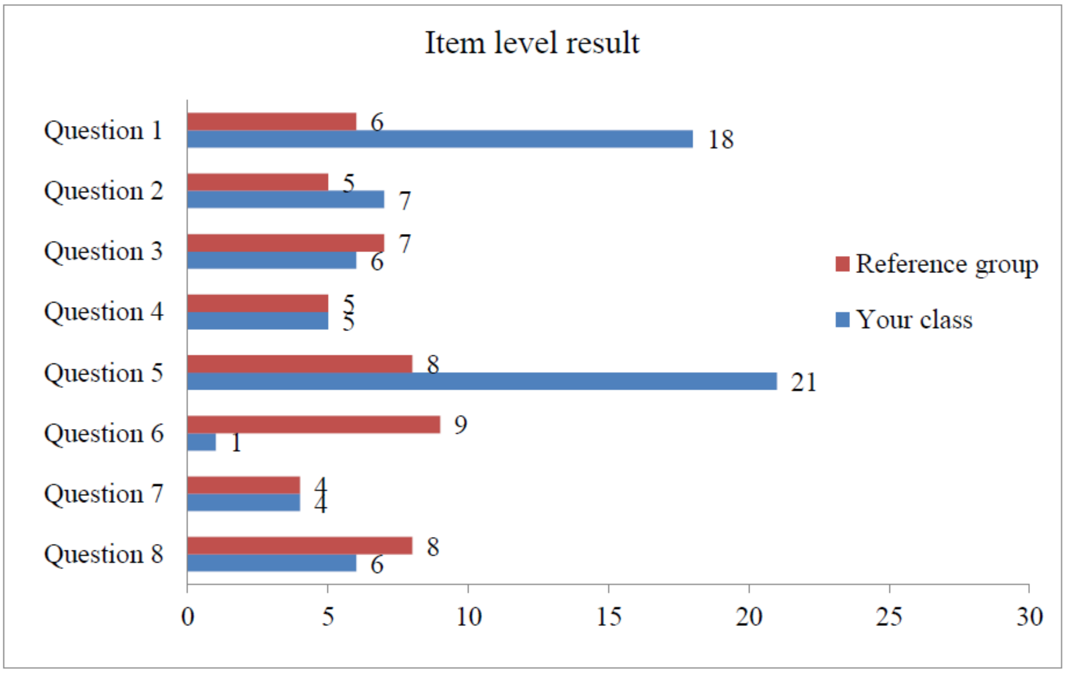
On -------------- ,2014 we conducted a test in your class. The test consisted of two parts. In the first part we used an established test to assess the knowledge about the content you had already taught in class. In the second part we measured competence in the area of knowledge acquisition with the help of items from the national comparative study of the institute of quality management in the educational system (IQB). The following information can be useful for you to compare the results of your class with the respective peer group, to conduct an analysis of causes specific to the tasks or the individuals and compare the results with your own evaluation. Please consider that all reported mean values underlie measurement errors which will not be reported for reasons of clarity.

Part 1: Specific part of the test

This test has been used with 128 German students of year 10 in a different study. We used those students as a respective peer group for your class (see graph. 1 and 2). Surely, not all of the concepts and contents of the test have been taught in the same way, so that some of the tasks require reproducing whereas others require transfer thinking. This may have an impact on the difficulty of the tasks (compare with graph 2). The tasks in this test contain typical ideas of students (misconceptions) as possible wrong answers so that you may draw conclusions about possible ideas of the students from the answers (compare with table 1).



Graph 1. Comparison of the average correctly answered percentage of the tasks between your class and the respective peer group.



Graph 2. Description of the expected and actual number of students that answered the questions. The expected value is determined on the basis of the frequency of solutions in the respective peer group and the number of students in your class.

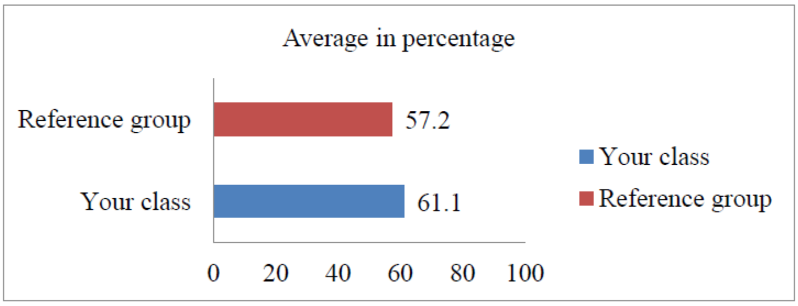
Table 1. Overview of which student chose the right (1) or wrong (2) answer for what question as well as the total number of correct answers. Wrong answers that are marked red or orange display answer alternatives which have been chosen frequently and which possibly indicate the existence of misconceptions.

	Question No.								Number of solved tasks
Student ID	1	2	3	4	5	6	7	8	
1	0	0	0	1	1	0	0	0	2
2	1	1	0	0	1	0	0	1	4
3	1	0	1	0	1	0	1	0	4
4	1	0	0	1	0	0	0	0	2
5	1	0	0	0	0	0	0	0	1
6	1	1	1	1	0	0	0	0	4
7	1	1	0	0	0	0	0	0	2
8	1	0	1	0	1	0	0	0	3
9	1	0	0	0	1	0	0	1	3
10	1	0	1	0	0	0	0	0	2
11	1	1	0	0	1	0	0	0	3
12	1	0	0	0	0	0	0	0	1
13	1	0	0	1	1	0	0	1	4
14	1	1	0	0	0	0	0	0	2
15	1	0	0	0	1	0	0	0	2
17	1	0	0	0	1	0	0	0	2
18	1	0	0	0	1	0	0	1	3
19	0	0	1	0	0	1	1	0	3
21	0	0	0	0	0	0	0	1	1
22	0	0	0	0	1	0	1	0	2
23	0	1	0	0	1	0	0	0	2
24	1	0	0	0	0	0	0	1	2
25	1	0	0	1	0	0	0	0	2
26	0	1	0	0	0	0	1	0	2
27	0	0	1	0	0	0	0	0	1

Explanation of the color coding:
Question number 2: red: answer option 4.
Question number 3: red: answer option 3.
Question number 4: red: answer option 3; orange: answer option 2.
Question number 6: red: answer option 4; orange: answer option 3.
Question number 7: red: answer option 4; orange: answer option 1.
Question number 8: red: answer option 3.

Part 2: Unspecific part of the test (IQB)

The tasks in this part of the test have been developed after certain criteria to measure how well students are familiar with methods of scientific knowledge (experimenting and modelling).Tasks with different levels of complexity have been developed and connected with certain (general) cognitive requirements (for explanation see graphs 4,5 and 6). As reference group for your class we used the standardization sample from the IQB which includes students in grade 9 from all over Germany (graph 3). Based on this the IQB generated certain levels of competence. Competence level 3 equals the so-called baseline competency which should be reached by the end of secondary education I (medium educational qualification) (compare table 2).



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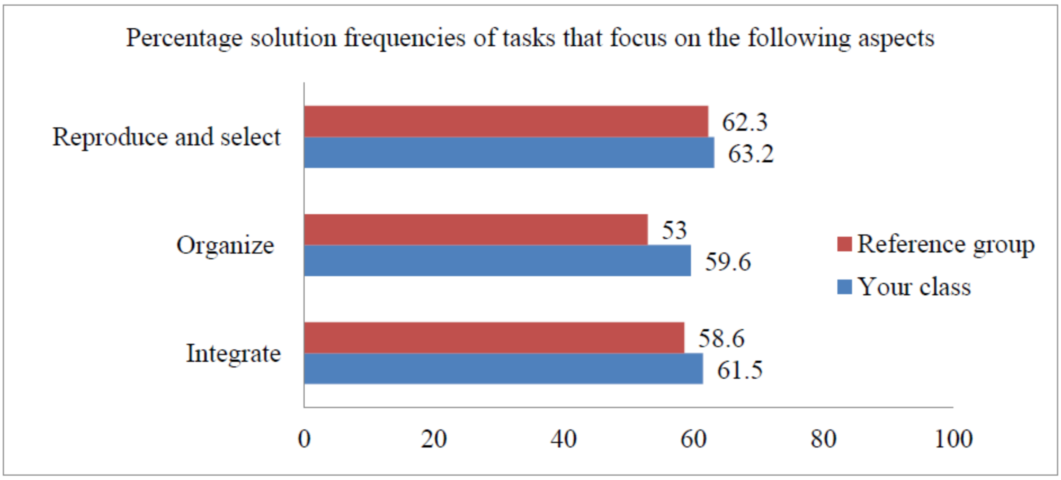

Graph 4. Comparison of the mean of correctly answered questions of your class and the respective peer group. The questions refer to different aspects of task solving.

The students are …

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Complexity II

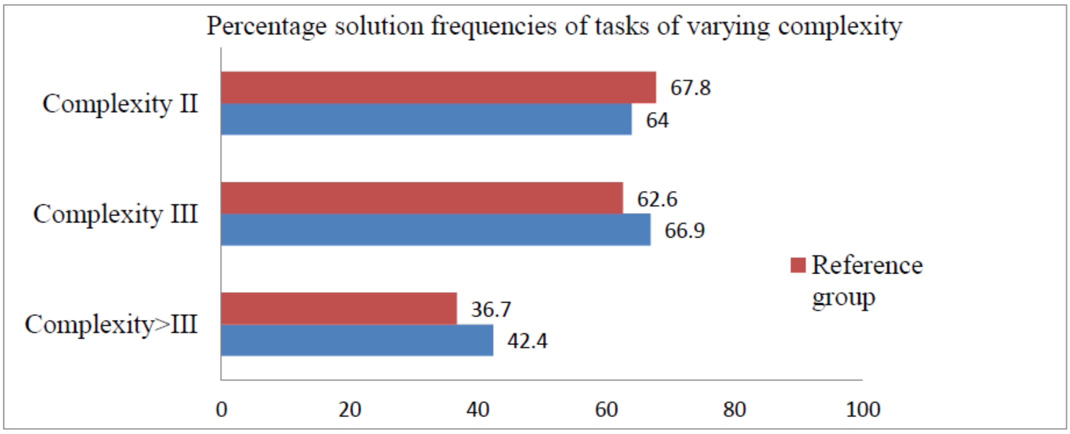
- being able to name two or more terms, qualities, physical factors or units regarding a physical system or to use them for problem-solving.

Complexity III

- being able to name a functional connection, an impact or effect of a physical system correctly, to postulate it or to use it for problem-solving.

Complexity >III

- being able to name event chains, interactions, circuits, etc. in a physical system, postulate them or use them for problem-solving. They are capable of establishing a connection with basic concepts and main ideas of physics and its´ methods.



Graph 5. Comparison of the mean of correctly answered questions with different levels of complexity of your class and the respective peer group.

The students can…

Aspect “study design”:

- plan a scientific study based on given hypotheses and describe its´ implementation.

Aspect “application of models”:

- grasp the meaning of models in the research process and describe its’ validation.

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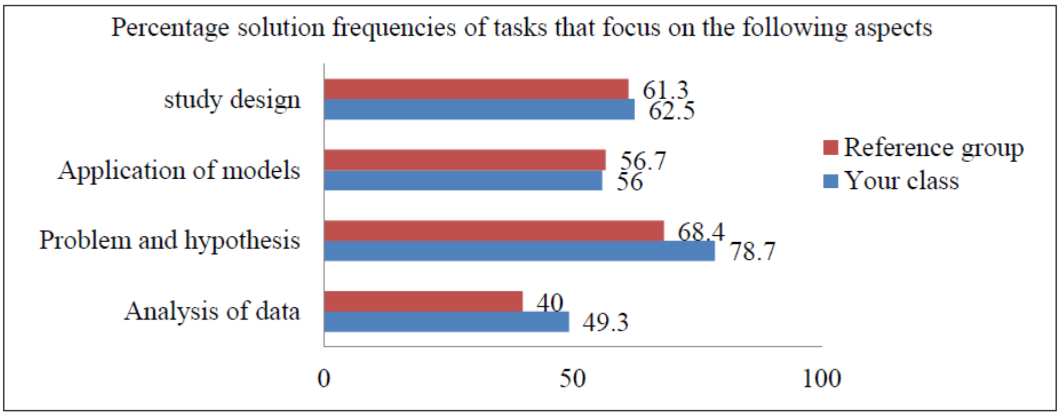


Graph 6. Comparison of the mean of correctly answered questions of your class and the respective peer group. The questions refer to different aspects of tasks.

Table 2. Overview on how many tasks the students answered correctly and the level of competence for each student.

Student ID	Number of tasks solved	Competence level reached
1	17	5
2	18	5
3	3	2
4	20	5
5	19	5
6	19	5
7	5	2
8	14	4
9	14	4
10	15	4
11	15	4
12	7	3
13	17	5
14	10	3
15	13	4
17	12	3
18	10	3
19	16	4
21	11	3
22	6	2
23	9	3
24	20	5
25	19	5
26	16	4
27	11	3

Appendix F Semi-Structured Interview Protocol[1]

Date: _______________

Interviewee:________________Interviewer________________

Place________________________ Time: Start___________

End___________________

Part I: Interview questions on the processes of lesson planning

Thank you for taking time to take part in this interview. We would like to separate the interview in two parts. In the first part we would like to talk about lesson planning and in the second part about the feedback we sent you. If you are ready we would like to begin with the first part now.

Start Interview: Now I am going to ask you a few questions on the processes of lesson planning. Thankfully you documented your lesson planning with the help of the online tool for us and the first question is related to these plannings.

1. Interview questions on teachers' decision areas and decision sequence

- What were your criteria when making the first decision in the areas of lesson planning?
- What were your criteria when making the next decision in the areas of lesson planning?
- We found from your three lesson plans that you most frequently made decision in the area of "methods" whereas you made decisions on the areas

[1] The first part of the interview particularly question number 1 was prepared based on the analysis of the planned lessons, and therefore this part is different for different teachers.

"experiment" and "exercise" only in one lesson plan. One could interpret this that you think that this area is more important than others. Is that correct? If yes, why do you consider it more important? If not, why is it as important as other areas? Why did you choose it more often?

- We found also, that the sequences of your decision areas are varying from lesson to lesson. What underlying criteria did you use in sequencing these decisions?

  Point of interest: The interest here is to see if there are any underlying regularities for the planning and if yes, what are they?

2. Interview questions on features of lesson plan (adaptability & cognitive activation)

- There is the normative opinion that a teacher should consider the variations in students in a class when planning a lesson. Do you agree or disagree? Please explain why you agree or why you disagree.
- In light of this, how you see the lesson plan you produced with the help of the planning tool?
- This can be subsumed under the keyword "adaption of the class to preconditions. Do you think, that you considered the preconditions in your lesson plans? Please explain your answer in detail.
- There is also a normative opinion that lessons should cognitively activate all students in a class. What should a lesson that cognitively activates students contain?
- In light of this, how do you see the lesson plans you produced with the help of the planning tool?

Point of interest: In which way do considerations of cognitive activation and of adaption of the lessons to the specific preconditions of a class play a role in your lesson planning?

Last question of this part: Is there anything concerning the planning that you consider important and that we didn´t talk about already?

Part II: Interview questions on feedback data and adaptive planning

Start Interview: Now we are going to ask you a few questions about the feedback data you received as well as how you adapt lesson based on the feedback data.

1. **Questions to elicit teachers' general opinions/ideas/thinking on and preferences of the feedback data**
   - We sent you some feedback data. What was going through your mind when you were looking at the feedback data you received?
   - How did you proceed when looking at the feedback data?
2. **Questions to elicit teachers' understanding, interpretation and explanation of the feedback data**
   - Were there parts of the feedback data you didn´t understand (immediately)? If yes, which parts were those and how do you understand them now?
   - What conclusions can you draw from the feedback data?
3. **Questions to elicit information on how teachers' use the feedback data**
   - What factors do you think are responsible for low scores on the test?
   - Which measures will you take to help those low scoring students?
   - You already sent us some planning's about the topic of the first part of the test (in this case Mechanical work and mechanical energy). Would you change one of those plannings now that you received the feedback data? If yes, which

one and why? (Interviewer has to take the printed plannings and show them to the teacher if necessary)

4. **Interview questions to assess teachers' reflection about the use feedback data**

You already know that in our project we want to find out about how external feedback on performance measurement can be used for lesson planning. Now we would like to know, how you would evaluate this idea.

- Does the feedback data have an influence on how you are going to plan further lessons in the class we tested? If yes, in what way? If not, why?
- What difficulties do you see, when you want/have to plan a lesson using the feedback data?
- What comments or feedback could you give us on the project?

Appendix G Test items used for the purpose of generating feedback data (thermodynamics)

Tiel 1

1. Was ist die wahrscheinlichste Temperatur von Eiswürfeln, die im Gefrierfach eines Kühlschrankes gelagert sind?
   - ☐ -10 °C
   - ☐ 0 °C
   - ☐ 5 °C
   - ☐ Das ist abhängig von der Größe der Eiswürfel.

2. Thorben nimmt zwei Tassen mit Wasser, deren Temperatur 40 °C beträgt und mixt diese mit einer Tasse voll Wasser mit einer Temperatur von 10 °C. Wie hoch wird die Temperatur dieses Gemisches am ehesten sein?
   - ☐ 20 °C
   - ☐ 25 °C
   - ☐ 30 °C
   - ☐ 50 °C

3. Bodo nimmt eine Dose Cola und eine Plastikflasche Cola aus dem Kühlschrank, wo er sie die ganze Nacht über gelassen hatte. Schnell steckt er ein Thermometer in die Cola in der Dose. Die Temperatur beträgt 7 °C. Welche Temperaturen werden die *Plastikflasche* und die *Cola*, die in ihr enthalten ist am wahrscheinlichsten haben?
   - ☐ Beide haben weniger als 7 °C
   - ☐ Beide haben eine Temperatur von 7 °C.
   - ☐ Beide haben eine größere Temperatur als 7 °C.
   - ☐ Die Cola hat 7 °C, aber die Flasche ist wärmer als 7 °C.
   - ☐ Das ist abhängig von der Menge der Cola und/oder der Größe der Flasche.

4. Einige Minuten später nimmt Karsten die Coladose hoch und erzählt jedem, dass sich die Arbeitsfläche unter der Dose kälter anfühlt, als der Rest der Fläche.
   - ☐ Anna sagt: “Die Kälte wurde von der Cola auf die Arbeitsfläche übertragen.”
   - ☐ Marc sagt: “In der Fläche unter der Dose ist keine Energie übrig geblieben.”
   - ☐ Nora sagt: “Etwas Wärme wurde von der Arbeitsfläche auf die Cola übertragen.”
   - ☐ Sven: “Die Dose bringt die Wärme unter sich dazu, durch die Arbeitsfläche weg zu gehen.”

   Wessen Erklärung ist Deiner Meinung nach die beste?

5. Eine Gruppe hört eine Wettervorhersage im Radio. Sie hören: „...heute Nacht wird es kühle 5°C, also kälter als die 10 °C die wir die letzte Nacht hatten...“.
   - ☐ Pia sagt: “Das bedeutet, dass es doppelt so kalt wird wie letzte Nacht.”
   - ☐ Theo sagt: “Das stimmt nicht. 5 °C sind nicht doppelt so kalt wie 10 °C.”
   - ☐ Sarah meint: “Es ist zum Teil richtig, aber sie hätte sagen müssen, dass 10 °C doppelt so warm sind wie 5 °C.
   - ☐ Paul sagt: “Es ist zum Teil richtig, aber sie hätte sagen müssen, dass 5 °C halb so kalt sind wie 10 °C.

   Wessen Aussage stimmst Du am meisten zu?

6. Amelie nahm sich zwei Glasflaschen mit Wasser von 20 °C und wickelte diese in Frotteewaschlappen. Einer der Waschlappen war nass, der andere trocken. Zwanzig Minuten später hat sie in jeder Glasflasche die Wassertemperatur gemessen. Das Wasser in der Flasche mit dem nassen Waschlappen betrug nun 18°C, das Wasser in der Flasche mit dem trockenen Waschlappen war bei 22°C. Die Raumtemperatur während des Versuches lag am wahrscheinlichsten bei:
   - ☐ 26°C
   - ☐ 21°C
   - ☐ 20°C
   - ☐ 18°C

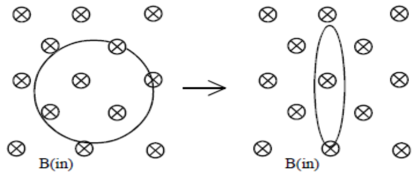
7. Simon sagt, dass seine Mutter Suppe in einem Dampfkochtopf kocht, weil sie darin schneller kocht als in einem normalen Topf, aber er weiß nicht warum. [Dampfkochtöpfe haben einen dichtschließenden Deckel, so dass der Druck innen weit über den atmosphärischen Druck steigt].
   - ☐ Emil meint: "Das geschieht, weil der Druck das Wasser auf über 100 °C sieden lässt."
   - ☐ Jan sagt: "Das geschieht, weil der hohe Druck zusätzliche Wärme erzeugt."
   - ☐ Mira sagt: "Das geschieht, weil der Dampf eine höhere Temperatur hat als die siedende Suppe."
   - ☐ Tom meint: "Das geschieht, weil Schnellkochtöpfe die Wärme gleichmäßiger im Essen verteilen."

   Welcher Person stimmst Du am meisten zu?

8. Wenn Rafael eine Fahrradpumpe benutzt, um die Reifen seines Mountainbikes aufzupumpen, bemerkt er, dass die Pumpe ziemlich heiß wird. Welche der folgenden Erklärungen scheint die Beste zu sein?
   - ☐ Auf die Pumpe ist Energie übertragen worden.
   - ☐ Auf die Pumpe ist Temperatur übertragen worden.
   - ☐ Wärme fließt von seinen Händen zur Pumpe.
   - ☐ Das Metall in der Pumpe bewirkt, dass die Temperatur steigt.

Appendix H Test items used for the purpose of generating feedback data (electromagnetic induction)

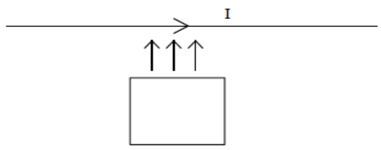
1. Ein Drahtring befindet sich in einem homogenen Magnetfeld (linke Abb.). Nun wird der kreisförmige Ring zu einem ovalen Ring zusammen gedrückt (rechte Abb.).



   Welche der Aussagen ist richtig?

   - ☐ Bevor der Ring zusammengedrückt wird, fließt in ihm ein Strom.
   - ☐ Während der Ring zusammengedrückt wird, fließt in ihm ein Strom.
   - ☐ Nachdem der Ring zusammengedrückt wurde, fließt in ihm ein Storm.
   - ☐ Vor, während und nach dem Zusammendrücken fließt im Ring ein konstanter Strom.

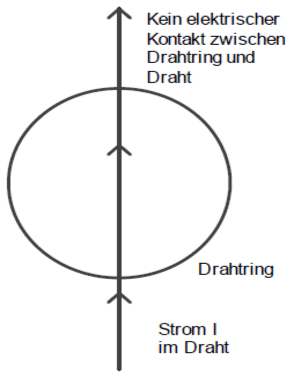
2. Ein Drahtring wird in die Nähe eines langen und geraden Drahtes gebracht. Durch den geraden Draht fließt der Strom I in Pfeilrichtung. Im Drahtring fließt daraufhin ein Induktionsstrom.



   Welcher Effekt kann beobachtet werden?

   - ☐ Der Drahtring lässt sich schwerer in die Richtung des geraden Drahtes hin bewegen.
   - ☐ Der Drahtring wird sich während der Bewegung verformen.
   - ☐ Der Drahtring beginnt um die zum geraden Draht senkrechte Achse zu rotieren.
   - ☐ Der Drahtring wird vom geraden Draht angezogen.

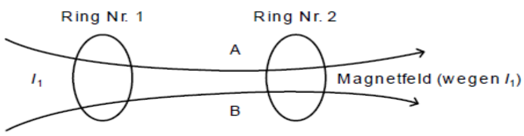
3. Ein langer gerader Draht durchläuft die Mitte eines Drahtringes. Durch den geraden Draht fließt ein Strom mit steigender Stromstärke *I*. Es besteht kein elektrischer Kontakt zwischen den beiden Drähten.



   Der induzierte Stromfluss…

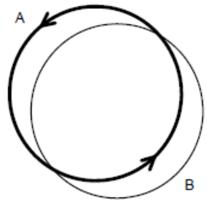
   - ☐ ist null.
   - ☐ fließt gegen den Uhrzeigersinn.
   - ☐ fließt mit dem Uhrzeigersinn.
   - ☐ geht gegen unendlich (Kurzschluss).

4. Ring Nr. 1 hat einen gleichmäßigen Stromfluss I_1. Was passiert in Ring Nr. 2?



   - ☐ Der Strom fließt in Richtung A.
   - ☐ Der Strom fließt in Richtung B.
   - ☐ Der Strom teilt sich und fließt zur Hälfte in Richtung A und zur Hälfte in Richtung B.
   - ☐ Es wird kein Strom in Ring Nr. 2 induziert.

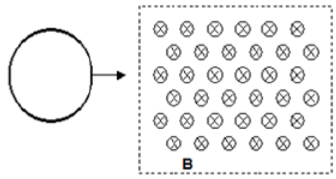
5. Zwei Drahtringe A und B werden nebeneinander platziert. Am Drahtring A wird ein starker Strom angeschlossen.
Dies verursacht einen im Drahtring B induzierten Stromfluss, der …



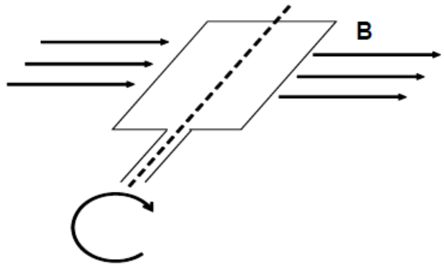
- ☐ eine Abstoßungskraft zwischen den beiden Ringen verursacht.
- ☐ eine Anziehungskraft zwischen den beiden Ringen verursacht.
- ☐ die Fläche des zweiten Rings verkleinert (den Ring verformt)
- ☐ keine Auswirkung auf den anderen Ring hat.

6. Ein Drahtring bewegt sich von links nach rechts. Dabei durchquert der Ring ein homogenes Magnetfeld. Die Magnetfeldlinien zeigen in das Papier.
Wenn der Drahtring in das Magnetfeld eintritt, zeigt die resultierende Kraft nach …

- ☐ rechts →
- ☐ ← links
- ☐ oben ↑
- ☐ ↓ unten



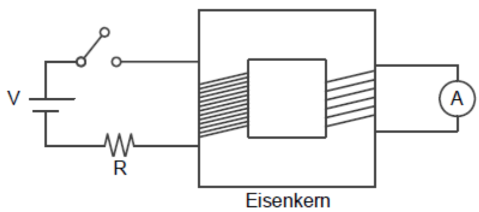
7. Ein handgekurbelter elektrischer Generator rotiert mit dem Uhrzeigersinn in einem konstanten homogenen Magnetfeld. Die Magnetfeldlinien zeigen nach rechts.
Was kann man über den momentanen magnetischen Fluss im Generator (s. Abb.) aussagen?



- ☐ Er ist in diesem Moment maximal.
- ☐ Er ist in diesem Moment null.
- ☐ Er ist halb so groß wie das Maximum.
- ☐ Er hat keinen definierten Wert.

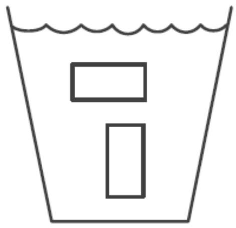
8. Die Primärspule eines Transformators ist an eine Batterie, einem Widerstand und einem Schalter verbunden. An die Sekundärspule ist ein Amperemeter angeschlossen.
Wenn der Schalter geschlossen ist, zeigt das Amperemeter …

- ☐ den Wert null an.
- ☐ kurzfristig einen Wert an, der ungleich null ist.
- ☐ einen konstanten Wert ungleich null an.
- ☐ einen zunehmend ansteigenden Wert an.



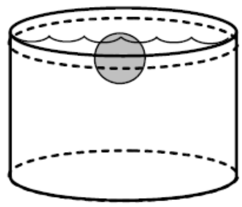
Appendix I Test items used for the purpose of generating feedback data (fluid mechanics)

1. Zwei identische Ziegelsteine mit den Kantenlängen 10 cm, 10 cm und 20 cm werden, in einem Eimer unter Wasser gehalten (s. Abb.). Die auftreibende Kraft des unteren Ziegelsteins ist im Vergleich zum oberen Ziegelstein ...



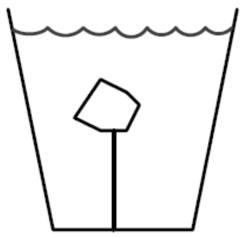
   - ☐ größer
   - ☐ genau so groß
   - ☐ genau halb so groß
   - ☐ sehr viel kleiner

2. Eine Plastikkugel der Masse *m* schwimmt bewegungslos in einem Eimer Wasser.
   Vergleiche die Auftriebskraft mit der Gewichtskraft.



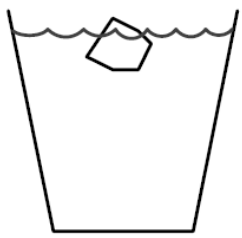
   - ☐ Die Auftriebskraft ist größer als die Gewichtskraft.
   - ☐ Die Auftriebskraft ist kleiner als die Gewichtskraft.
   - ☐ Die Auftriebskraft ist gleich der Gewichtskraft.
   - ☐ Die Auftriebskraft ist an der Unterseite der Kugel größer und an der Oberseite kleiner als die Gewichtskraft.

3. Ein Plastikkörper mit dem Volumen V und der Dichte $\rho_{Plastik}$ würde normalerweise an der Oberfläche des Wassers (Dichte des Wassers ρ_{Wasser}) schwimmen. Der Plastikkörper ist aber mit einer Schnur am Boden des Wassereimers befestigt.
   Bestimme die auf den Plastikkörper wirkende Kraft F.



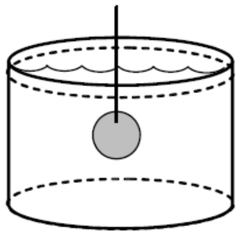
   - ☐ $F = 0$
   - ☐ $F = \rho_{Plastik} \cdot m \cdot V$
   - ☐ $F = \rho_{Wasser} \cdot V \cdot g$
   - ☐ $F = \rho_{Plastik} \cdot V \cdot g$

4. Ein Plastikkörper mit dem Volumen V und der Dichte $\rho_{Plastik}$ schwimmt an der Oberfläche eines Wassereimers. Die Dichte von Wasser wird mit ρ_{Wasser} bezeichnet.
   Bestimme die auf den Plastikkörper wirkende Auftriebskraft F.



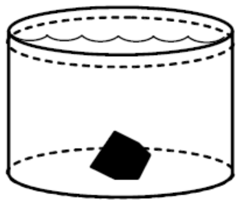
   - ☐ $F = 0$
   - ☐ $F = \rho_{Plastik} \cdot m \cdot V$
   - ☐ $F = \rho_{Wasser} \cdot V \cdot g$
   - ☐ $F = \rho_{Plastik} \cdot V \cdot g$

5. Eine Kupferkugel der Masse *m* und des Volumens *V* wird mit einer Schnur in einen Behälter mit dem Volumen V_B unter Wasser gehangen.
Wovon hängt die Zugkraft auf die Schnur ab?



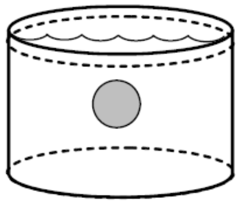
- ☐ Eintauchtiefe *h* und Dichte ($\rho = {}^{m}/_{V}$) der Kugel
- ☐ Masse *m* und Volumen *V* der Kugel
- ☐ Volumen des Wassersbehälters V_B und äußerer Luftdruck *p*
- ☐ Volumen *V* der Kugel und Volumen V_B des Wasserbehälters

6. Ein Stein der Masse *m* liegt auf dem Boden, eines mit Wasser gefüllten Eimers.
Welche Kraft ist betragsmäßig mindestens notwendig, um den Stein anzuheben?



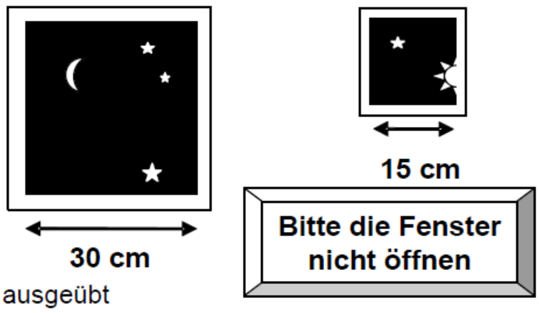
- ☐ Gewichtskraft des Steins
- ☐ Auftriebskraft minus Gewichtskraft
- ☐ Gewichtskraft minus Auftriebskraft
- ☐ Gewichtskraft plus Auftriebskraft

7. Eine speziell angefertigte Kugel schwebt im Wasser, ohne sich zu bewegen.
Warum bewegt sich die Kugel nicht nach oben oder unten?



- ☐ Weil sich Auftriebskraft und Gewichtskraft ausgleichen
- ☐ Weil die Dichte des Wasser unter der Kugel größer ist
- ☐ Weil die notwendige Wasserverdrängung zu groß wäre
- ☐ Weil der Druck von oben und unten gleich groß ist

8. Der Luftdruck in der Raumstation beträgt 1000 hpa. In der Raumstation gibt es zwei quadratische Fenster, ein großes und ein kleines. Das große Fenster hat eine Kantenlänge von 30 cm und das kleine 15 cm. Vergleiche den auf das große Fenster wirkenden Druck mit dem auf das kleine Fenster wirkenden Druck!



- ☐ Auf das große Fenster wird doppelt so viel Druck ausgeübt
- ☐ Auf das große Fenster wird vier mal so viel Druck ausgeübt
- ☐ Auf das große Fenster wird neun mal so viel Druck ausgeübt
- ☐ Es herrscht der gleiche Druck auf beide Fenster

Appendix J Sample of first round invitation letter and consent form

Graduiertenkolleg
Unterrichtsprozesse

UPGRADE
DFG gefördert

Hannah-Arendt-Gymnasium Haßloch
Viroflayer Str. 20
67454 Haßloch

Graduiertenkolleg
Unterrichtsprozesse UPGrade
Universität Koblenz-Landau
Campus Landau
Thomas-Nast-Str. 44, 76829 Landau

Tesfaye Getinet
Doktorand

Tel. 06341 / 280 – 33511
Fax 06341 / 280 – 33 260
E-mail: getinet@uni-landau.de
http://www.upgrade.uni-landau.de/

Landau, den 12.02.2014

Workshop für Physiklehrerinnen und Lehrer an der Universität Koblenz-Landau am Campus Landau

Sehr geehrte Damen und Herren,

als Physiklehrerin oder Physiklehrer brauchen Sie Informationen darüber wie gut Ihre Schülerinnen und Schüler sind, um Ihren weiteren Unterricht darauf abstimmen zu können. Eine Quelle für diese Informationen sind schriftliche Tests, die Sie selbst stellen, oder zentrale oder standardisierte Tests, die im Rahmen von Forschungsstudien erhoben werden. Es ist bislang kaum untersucht, wie solche Informationen systematisch bei der Planung von Unterricht berücksichtigt werden können. In Ihrer Ausbildung haben Sie gelernt, Unterricht auf eine Weise systematisch zu planen, die im Alltag kaum durchzuhalten ist und auch mit ausreichender Erfahrung nicht mehr benötigt wird. Im Rahmen eines Forschungsprojekts hat Frau Stender vom Leibnizinstitut für die Pädagogik der Naturwissenschaften (IPN) in Kiel ein effizientes Verfahren entwickelt, um auf der Grundlage von Erfahrungen und eigenem Vorbereitungsstil systematisch Unterricht zu planen.

Unser Ziel ist es, mit Ihnen ein Verfahren zu finden, wie Testergebnisse mit diesem Planungsinstrument zusammen genutzt werden können. Dazu möchten wir mit Ihnen gemeinsam Erfahrungen sammeln über die Eignung des Planungs-Tools im Alltag und lernen, wie Sie Testdaten, die wir gezielt in Ihrer Klasse (nach Möglichkeit Jahrgangsstufe 9 oder 10) erheben, im Rahmen des Tools und Ihrer Planung nutzen. Ihre Teilnahme an dieser Studie erfordert keine Änderungen der Lerninhalte.

Der Ablauf der Studie wird wie folgt aussehen:

1. Sie nehmen an einem Workshop an der Universität am Freitag, den 07.03.2014, von 09:30 bis 14:30 Uhr teil. Dort erhalten Sie eine Einführung in das Planungs-Tool, die

Nutzung von Daten aus vergleichenden Studien und die Gelegenheit zu kollegialem Austausch.

2. Sie nutzen das Planungs-Tool für die fünf darauf folgenden Physikstunden in einer Ihrer Klassen.
3. In der letzten Stunde vor den Osterferien führen wir in Ihrer Klasse einen Test durch, dessen Ergebnis wir ca. 4-5 Wochen später an Sie schriftlich zurückmelden.
4. Zusammen mit der Rückmeldung zu Ihrer Klasse senden wir Ihnen eine Reihe Fragen, verbunden mit der Bitte, diese innerhalb von etwa 2 Wochen zu beantworten.
5. Danach werden wir Sie für ein umfassendes Gespräch über die Rückmeldung, mögliche Konsequenzen für Ihren Unterricht und Ihre Erfahrungen mit dem Planungs-Tool und dem Test besuchen (ca. 90 Minuten).

Im Rahmen der Untersuchung benötigen wir zur wissenschaftlichen Beantwortung der obigen Fragen weitere Informationen von Ihnen, die wir standardisiert in Form von Fragebögen erfragen, die teilweise auf Papier, teilweise am Rechner ausgefüllt werden. Darin wird es

a. um Ihre Berufserfahrung,
b. Ihr Wissen über empirische Daten und
c. Ihre Reaktion auf typische Unterrichtssituationen gehen.

Die Gespräche mit Ihnen möchten wir mit Hilfe digitaler Audiorekorder aufzeichnen.

Alle datenschutzrechtlichen Bestimmungen werden eingehalten. Für dieses Projekt gelten die hohen wissenschaftlichen Standards der Deutschen Forschungsgemeinschaft (DFG), durch die dieses Projekt im Rahmen des Graduiertenkollegs „Unterrichtsprozesse“ gefördert wird. Insbesondere sind Ihre Angaben in der Öffentlichkeit nicht identifizierbar, da wir zum Schutz Ihrer Daten bei der Speicherung und Verarbeitung der Daten Pseudonyme für alle teilnehmenden Lehrkräfte verwenden.

Wir bitten Sie daher, an dieser Studie teilzunehmen. Bitte füllen Sie dazu die beigefügte Einverständniserklärung aus. Über Ihre Teilnahme erhalten Sie ein Zertifikat und im Anschluss an die Studie bedanken wir uns bei Ihnen mit einer kleinen Aufmerksamkeit. Ihre Aufwendungen zur Anreise zum Workshop werden im Rahmen des Landesreisekostengesetzes erstattet.

Wir sind jederzeit für Fragen, Anregungen oder Kommentare erreichbar unter: getinet@uni-landau.de oder telefonisch unter 06341-280-31-356 oder 06341-280-32-165.

Mit freundlichen Grüßen,

Prof. Dr. Alexander Kauertz, Prof. Dr. Ingmar Hosenfeld, Tesfaye Getinet

Gefördert durch die Deutsche Forschungsgemeinschaft DFG UNIVERSITÄT KOBLENZ · LANDAU

Einverständniserklärung

Hiermit erkläre ich mich dazu bereit, an der Studie mit dem Titel, „Auswirkungen von Feedback externer Evaluierungen über Schülerleistungen auf die Unterrichtsplanung von Lehrern" teilzunehmen. Tesfaye Getinet oder ein autorisierter Vertreter haben den Zweck und die Anlage der Studie erläutert und erklärt, welche Verfahren eingesetzt und welche Mitwirkung von den Studienteilnehmern erwartet werden. Mögliche Vorteile der Studie wurden mir aufgezeigt.

Die Einwilligung kann ich jederzeit widerrufen und ohne jeden Nachteil meine Teilnahme an der Studie beenden. Die Einverständniserklärung habe ich vollständig gelesen und verstanden.

Datum: _______________ Unterschrift: ___________________________

(Teilnehmende Lehrkraft)

Appendix K Sample of second round invitation letter and consent form

Graduiertenkolleg
Unterrichtsprozesse

UPGRADE DFG gefördert

Ketteler-Kolleg und -Abendgymnasium
Rektor-Plum-Weg 10
55122 Mainz

Graduiertenkolleg
Unterrichtsprozesse UPGrade
Universität Koblenz-Landau
Campus Landau
Thomas-Nast-Str. 44, 76829 Landau

Tesfaye Getinet
Doktorand

Tel. 06341 / 280 – 33511
Fax 06341 / 280 – 33 260
E-mail: getinet@uni-landau.de
http://www.upgrade.uni-landau.de/

Landau, den 18.03.2014

Workshop für Physiklehrerinnen und Lehrer an der Universität Koblenz-Landau am Campus Landau

Sehr geehrte Damen und Herren,

als Physiklehrerin oder Physiklehrer brauchen Sie Informationen darüber wie gut Ihre Schülerinnen und Schüler sind, um Ihren weiteren Unterricht darauf abstimmen zu können. Eine Quelle für diese Informationen sind schriftliche Tests, die Sie selbst stellen, oder zentrale oder standardisierte Tests, die im Rahmen von Forschungsstudien erhoben werden. Es ist bislang kaum untersucht, wie solche Informationen systematisch bei der Planung von Unterricht berücksichtigt werden können. In Ihrer Ausbildung haben Sie gelernt, Unterricht auf eine Weise systematisch zu planen, die im Alltag kaum durchzuhalten ist und auch mit ausreichender Erfahrung nicht mehr benötigt wird. Im Rahmen eines Forschungsprojekts hat Frau Stender vom Leibnizinstitut für die Pädagogik der Naturwissenschaften (IPN) in Kiel ein effizientes Verfahren entwickelt, um auf der Grundlage von Erfahrungen und eigenem Vorbereitungsstil systematisch Unterricht zu planen.

Unser Ziel ist es, mit Ihnen ein Verfahren zu finden, wie Testergebnisse mit diesem Planungsinstrument zusammen genutzt werden können. Dazu möchten wir mit Ihnen gemeinsam Erfahrungen sammeln über die Eignung des Planungs-Tools im Alltag und lernen, wie Sie Testdaten, die wir gezielt in Ihrer Klasse (nach Möglichkeit Jahrgangsstufe 9 oder 10) erheben, im Rahmen des Tools und Ihrer Planung nutzen. Ihre Teilnahme an dieser Studie erfordert keine Änderungen der Lerninhalte.

Der Ablauf der Studie wird wie folgt aussehen:

1. Sie nehmen an einem Workshop an der Universität am Dienstag, den 29.04.2014, von 09:30 bis 14:30 Uhr teil. Dort erhalten Sie eine Einführung in das Planungs-Tool, die

Nutzung von Daten aus vergleichenden Studien und die Gelegenheit zu kollegialem Austausch.
2. Sie nutzen das Planungs-Tool für die fünf darauf folgenden Physikstunden in einer Ihrer Klassen.
3. Drei bis fünf Wochen nach dem Workshop an der Universität führen wir in Ihrer Klasse einen Physiktest durch, dessen Ergebnis wir ca. vier Wochen später an Sie schriftlich zurückmelden.
4. Zusammen mit der Rückmeldung zu Ihrer Klasse senden wir Ihnen eine Reihe Fragen, verbunden mit der Bitte, diese innerhalb von etwa einer Woche zu beantworten.
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a. um Ihre Berufserfahrung,
b. Ihr Wissen über empirische Daten und
c. Ihre Reaktion auf typische Unterrichtssituationen gehen.

Die Gespräche mit Ihnen möchten wir mit Hilfe digitaler Audiorekorder aufzeichnen.

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Gefördert durch die Deutsche Forschungsgemeinschaft DFG UNIVERSITÄT KOBLENZ · LANDAU

Einverständniserklärung

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Die Einwilligung kann ich jederzeit widerrufen und ohne jeden Nachteil meine Teilnahme an der Studie beenden. Die Einverständniserklärung habe ich vollständig gelesen und verstanden.

Datum: _______________ Unterschrift: ___________________________

(Teilnehmende Lehrkraft)

Appendix L Letter to parents

Graduiertenkolleg
Unterrichtsprozesse

UPGRADE DFG gefördert

Graduiertenkolleg
Unterrichtsprozesse UPGrade
Universität Koblenz-Landau
Campus Landau
Thomas-Nast-Str. 44, 76829 Landau

Tesfaye Getinet
Doktorand

Tel. 06341 / 280 – 33511
Fax 06341 / 280 – 33 260
E-mail: getinet@uni-landau.de
http://www.upgrade.uni-landau.de/

Landau, den 13.05.2014

Informationen zum Einsatz eines Physik-Testes in der Klasse Ihres Kindes

Sehr geehrte Erziehungsberechtigte,

in der Klasse Ihres Kindes ist geplant am 26. Mai im Fach Physik einen standardisierten Test einzusetzen. Die folgenden Informationen sollen Ihnen ein Bild vermitteln, worum es dabei geht.

Warum soll der Test gemacht werden?

Der Test soll die Physiklehrkraft über den aktuellen Fähigkeits- und Kenntnisstand der Klasse informieren und zwar im Hinblick auf die Bildungsstandards und das aktuell unterrichtete Themengebiet. Entscheidend ist dabei, dass der Test es ermöglicht die Leistungen in der Klasse im Vergleich mit denen von Schülerinnen und Schülern anderer Schulen zu betrachten – eine Perspektive, die mit den üblichen Verfahren der schulischen Leistungsmessung nicht eingenommen werden kann. Um eine hohe Qualität des Testes sicherzustellen, werden die Aufgaben von einem Team der Universität in Landau zusammengestellt und im Detail ausgewertet.

Wird der Test benotet?

Nein! Der Sinn des Testes besteht nicht in der Messung der individuellen Leistung der einzelnen Schülerinnen und Schüler, sondern soll der unterrichtenden Lehrkraft wertvolle Informationen bieten, die zur Verbesserung des Unterrichts beitragen können.

Wie lange dauert der Test?

Der Test dauert eine Schulstunde.

Welche Inhalte werden im Test erfragt?

Der Test enthält zwei Typen von Aufgaben: 1) Aufgaben, die eine Orientierung hinsichtlich der Bildungsstandards bieten und 2) Aufgaben zum aktuell behandelten Themengebiet. Da die Bildungsstandards ein breites Spektrum an Themen- und Aufgabenstellungen umfassen, gibt es im Test mehr Aufgaben des ersten Typs.

Wird mein Kind alle Aufgaben lösen können?

Es ist relativ unwahrscheinlich, dass eine Schülerin oder ein Schüler alle Aufgaben lösen kann, denn insbesondere die Aufgaben zu den Bildungsstandards decken viele verschiedene Themenstellungen ab, die im Regelfall noch nicht alle im Unterricht erschöpfend behandelt wurden. Da der Test der unterrichtenden Lehrkraft einen Überblick über den Stand in der Klasse vermitteln soll, ist dies dennoch sehr sinnvoll. Mit Hilfe der so gewonnen Informationen können ggfs. neue Stoffgebiete besser eingeführt werden, da auf den schon vorhandenen Leistungsstand in der Klasse konkret eingegangen werden kann.

Wer erfährt, wie mein Kind im Test abgeschnitten hat?

Nur die unterrichtende Lehrkraft weiß, welche Schülerinnen und Schüler welche Leistungen erbracht haben. Um sicherzustellen, dass keine andere Person (auch die Mitarbeiter der Universität Landau) die Identitäten der Kinder kennt, wird auf dem Test kein Name eingetragen. Stattdessen wird eine Nummer vergeben, die lediglich von der unterrichtenden Lehrkraft dem jeweiligen Kind zugeordnet werden kann. Die Mitarbeiter der Universität werten die Tests aus und informieren die unterrichtende Lehrkraft über die Leistungen anhand der Nummern. Die Lehrkraft erklärt dann den Schülerinnen und Schülern, wie sie abgeschnitten haben. Die Auswertung der Tests wird mehrere Wochen dauern.

Wie erhalte ich weitere Informationen?

Wenn Sie weitere Fragen haben, so können Sie diese entweder an den Physiklehrer Ihres Kindes, Herr StR Michael Schindler, stellen oder sich per E-Mail an Herrn Getinet von der Universität in Landau wenden (getinet@uni-landau.de).

Mit freundlichen Grüßen,

Prof. Dr. Alexander Kauertz
Prof. Dr. Ingmar Hosenfeld
Tesfaye Getinet

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Campus Landau
Thomas-Nast-Str. 44, 76829 Landau

Tesfaye Getinet
Doktorand

Tel. 06341 / 280 – 33511
Fax 06341 / 280 – 33 260
E-mail: getinet@uni-landau.de
http://www.upgrade.uni-landau.de/

Landau, den 15.05.2014

Informationen zum Einsatz eines Physik-Testes in der Klasse Ihres Kindes

Sehr geehrte Erziehungsberechtigte,

in der Klasse Ihres Kindes ist geplant am 17. Juni im Fach Physik einen standardisierten Test einzusetzen. Die folgenden Informationen sollen Ihnen ein Bild vermitteln, worum es dabei geht.

Warum soll der Test gemacht werden?

Der Test soll die Physiklehrkraft über den aktuellen Fähigkeits- und Kenntnisstand der Klasse informieren und zwar im Hinblick auf die Bildungsstandards und das aktuell unterrichtete Themengebiet. Entscheidend ist dabei, dass der Test es ermöglicht die Leistungen in der Klasse im Vergleich mit denen von Schülerinnen und Schülern anderer Schulen zu betrachten – eine Perspektive, die mit den üblichen Verfahren der schulischen Leistungsmessung nicht eingenommen werden kann. Um eine hohe Qualität des Testes sicherzustellen, werden die Aufgaben von einem Team der Universität in Landau zusammengestellt und im Detail ausgewertet.

Wird der Test benotet?

Nein! Der Sinn des Testes besteht nicht in der Messung der individuellen Leistung der einzelnen Schülerinnen und Schüler, sondern soll der unterrichtenden Lehrkraft wertvolle Informationen bieten, die zur Verbesserung des Unterrichts beitragen können.

Wie lange dauert der Test?

Der Test dauert eine Schulstunde.

Welche Inhalte werden im Test erfragt?

Der Test enthält zwei Typen von Aufgaben: 1) Aufgaben, die eine Orientierung hinsichtlich der Bildungsstandards bieten und 2) Aufgaben zum aktuell behandelten Themengebiet. Da die Bildungsstandards ein breites Spektrum an Themen- und Aufgabenstellungen umfassen, gibt es im Test mehr Aufgaben des ersten Typs.

Wird mein Kind alle Aufgaben lösen können?

Es ist relativ unwahrscheinlich, dass eine Schülerin oder ein Schüler alle Aufgaben lösen kann, denn insbesondere die Aufgaben zu den Bildungsstandards decken viele verschiedene Themenstellungen ab, die im Regelfall noch nicht alle im Unterricht erschöpfend behandelt wurden. Da der Test der unterrichtenden Lehrkraft einen Überblick über den Stand in der Klasse vermitteln soll, ist dies dennoch sehr sinnvoll. Mit Hilfe der so gewonnen Informationen können ggfs. neue Stoffgebiete besser eingeführt werden, da auf den schon vorhandenen Leistungsstand in der Klasse konkret eingegangen werden kann.

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Wenn Sie weitere Fragen haben, so können Sie diese entweder an den Physiklehrerin Ihres Kindes, Dr. Alexander Schimmel, stellen oder sich per E-Mail an Herrn Getinet von der Universität in Landau wenden (getinet@uni-landau.de).

Mit freundlichen Grüßen,

Prof. Dr. Alexander Kauertz
Prof. Dr. Ingmar Hosenfeld
Tesfaye Getinet

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Tesfaye Getinet
Doktorand

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Fax 06341 / 280 – 33 260
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Landau, den 16.05.2014

Informationen zum Einsatz eines Physik-Testes in der Klasse Ihres Kindes

Sehr geehrte Erziehungsberechtigte,

in der Klasse Ihres Kindes ist geplant am 4. Juni im Fach Physik einen standardisierten Test einzusetzen. Die folgenden Informationen sollen Ihnen ein Bild vermitteln, worum es dabei geht.

Warum soll der Test gemacht werden?

Der Test soll die Physiklehrkraft über den aktuellen Fähigkeits- und Kenntnisstand der Klasse informieren und zwar im Hinblick auf die Bildungsstandards und das aktuell unterrichtete Themengebiet. Dabei ist entscheidend, dass mit dem Test die Leistungen der Klasse mit der Leistung anderer Klassen und Schulen verglichen werden kann – eine Perspektive, die mit den üblichen Verfahren der schulischen Leistungsmessung nicht eingenommen werden kann. Um eine hohe Qualität des Testes sicherzustellen, werden die Aufgaben von einem Team der Universität in Landau zusammengestellt und im Detail ausgewertet.

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Wie erhalte ich weitere Informationen?

Wenn Sie weitere Fragen haben, so können Sie diese entweder an den Physiklehrerin Ihres Kindes, Frau Christine Scheuermann, stellen oder sich per E-Mail an Herrn Getinet von der Universität in Landau wenden (getinet@uni-landau.de).

Mit freundlichen Grüßen,

Prof. Dr. Alexander Kauertz
Prof. Dr. Ingmar Hosenfeld
Tesfaye Getinet

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Landau, den 16.05.2014

Informationen zum Einsatz eines Physik-Testes in der Klasse Ihres Kindes

Sehr geehrte Erziehungsberechtigte,

in der Klasse Ihres Kindes ist geplant am 03. Juni im Fach Physik einen standardisierten Test einzusetzen. Die folgenden Informationen sollen Ihnen ein Bild vermitteln, worum es dabei geht.

Warum soll der Test gemacht werden?

Der Test soll die Physiklehrkraft über den aktuellen Fähigkeits- und Kenntnisstand der Klasse informieren und zwar im Hinblick auf die Bildungsstandards und das aktuell unterrichtete Themengebiet. Dabei ist entscheidend, dass mit dem Test die Leistungen der Klasse mit der Leistung anderer Klassen und Schulen verglichen werden kann – eine Perspektive, die mit den üblichen Verfahren der schulischen Leistungsmessung nicht eingenommen werden kann. Um eine hohe Qualität des Testes sicherzustellen, werden die Aufgaben von einem Team der Universität in Landau zusammengestellt und im Detail ausgewertet.

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Wie erhalte ich weitere Informationen?

Wenn Sie weitere Fragen haben, so können Sie diese entweder an den Physiklehrer Ihres Kindes, Herr Steffen Danner, stellen oder sich per E-Mail an Herrn Getinet von der Universität in Landau wenden (getinet@uni-landau.de).

Mit freundlichen Grüßen,

Prof. Dr. Alexander Kauertz
Prof. Dr. Ingmar Hosenfeld
Tesfaye Getinet

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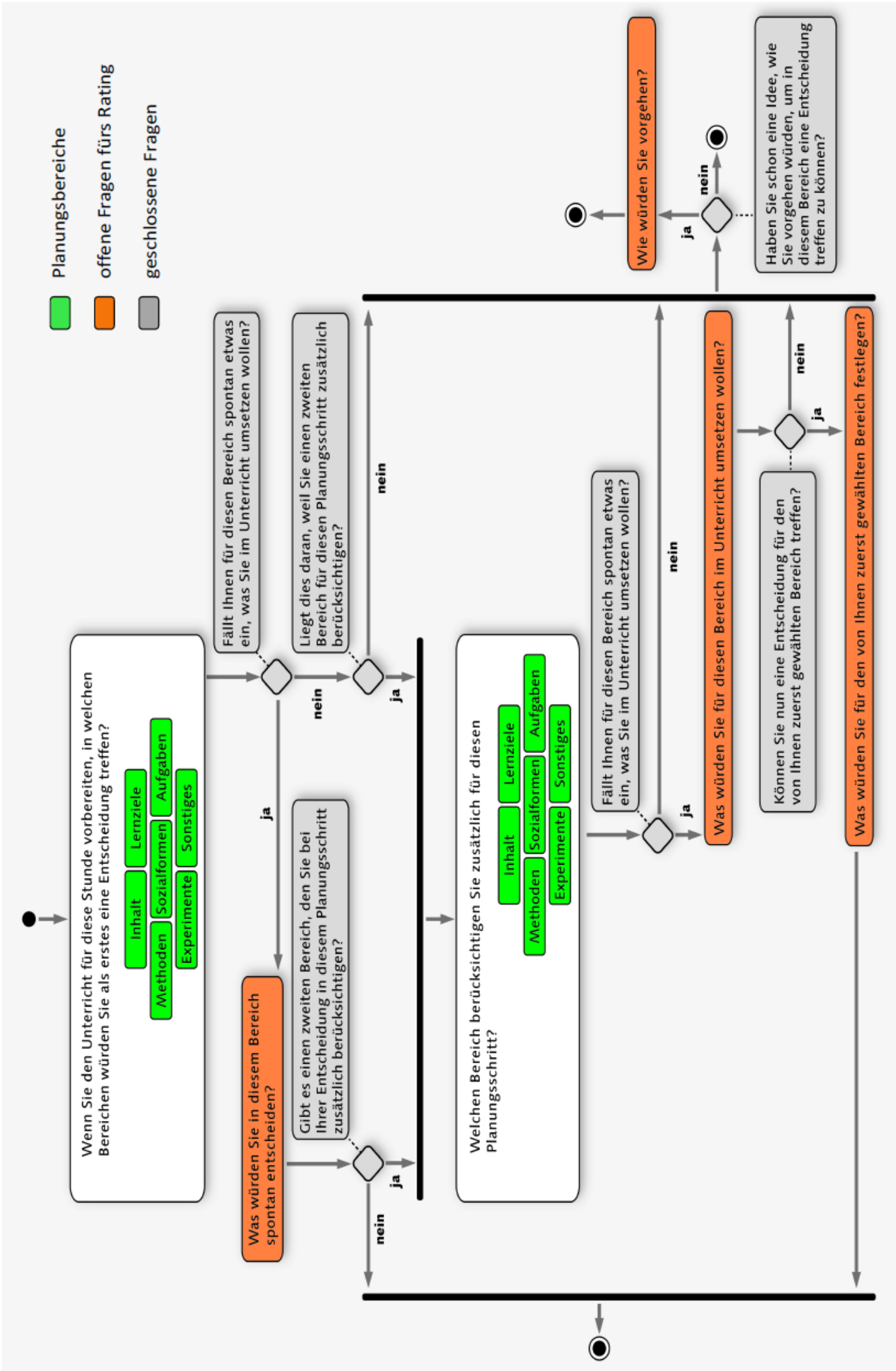
Appendix M   Flow chart of the online lesson planning tool



Appendix N Criteria for evaluating the quality of lesson plans[2]

These lesson plan evaluation criteria have been designed to evaluate the quality of lesson plans produced by physics teachers. This evaluation consists of the following main dimensions and sub dimensions: Introduction, Learning Objectives, Learning and Content Standards, Sequence of Content and Process, Higher Order Thinking, Opportunity to learn, Opportunity to develop Students Scientific Literacy, Description of student and Teacher activities, Individual and collaborative accountability in the learning processes, Differentiation, Assessment, Resources, Reflection, Rubric and checklist.

Key:

2 Good: Completely described, clear and appropriate

1 Fair: fairly described and clear

0 poor: poorly described/not described at all/unclear

1. Introduction	
	I. Learner and setting
2	The introduction mentions both the relevant characteristics of learners for whom the lesson is intended and the setting in which lesson will be given
1	The introduction mentions either the relevant characteristics of learners for whom the lesson is intended or the setting in which lesson will be given

[2] This lesson planning evaluation was prepared by the author to evaluate the quality of lessons teachers plan for their ongoing teaching practices. However, because the decision was made to use the online lesson planning tool developed by Stender (2014), the lesson plan coding manual developed by Stender was used. The material is available online.

0	The introduction does not mention both the characteristics of learners and setting or there is no introduction at all
	II. Adapted Instruction
2	The introduction describes both the reason for differentiated instruction, and the levels and areas of differentiation
1	Introduction describes either the reason for differentiated instruction or levels and areas of differentiation
0	Introduction does not describe any differentiation
	2. Learning Objectives
	I. Cognitive level demanded: knowledge, comprehension, application, analysis, synthesis, evaluation
2	The Cognitive level demanded is accurate based on described lesson plan and engages students in deep thinking like applying/analyzing/synthesizing and evaluation their learning,
1	The Cognitive level demanded is low and limited to the level of recall of facts (knowledge) and leads to surface learning.
0	The lesson plan does not clearly spell the cognitive level demanded, or learning objectives are not mentioned at all
	II. Clarity/measurability/attainability
2	The lesson plan states learning objectives and outcomes that are clear, measurable, and attainable and reflect the content and standards listed in the lesson plan and informed by the feedback data
1	The lesson plan states learning objectives and outcomes which lack clarity with regard to attainability and/or relation to the content and standards that are listed in

	the lesson plan.
0	Learning goals and objectives are unrelated to content and standards; are unclear or poorly stated.
	III. **Observability and specificity**
2	All objectives are stated in terms of observable student behavior and specified skills and knowledge
1	Objectives are stated in terms of observable student behavior, but do not specify skills and knowledge
0	Objectives are stated, but none are in terms of observable student behavior, or No objectives are stated
3. Learning and Content Standards	
2	Learning and Content standards are identified and appropriate for the described lesson plan.
1	Learning and Content standards listed are not appropriate for the described lesson plan.
0	Learning and Content standards are not listed at all.
	4. Sequence of Content and Process
2	Concepts are carefully sequenced and integrated with all content derived from the learning standards. Learning opportunities support several learning preferences. Learning opportunities from one part of the lesson connect with other parts. Activities (tasks) from one part of the lesson is meangully connected with others. Students can explore a topic from many different angles and understand the relationship of the parts to the whole.
1	The lesson has a recognizable structure with substantial content related to the

	learning standards and concepts are somehow integrated. Activities from one part of the lesson are less connected with others.
0	The lesson has no clearly defined structure, or the structure is chaotic; Concepts and activities are not integrated.
5. Higher Order Thinking	
2	The learning process and results that the students are working through in this lesson plan are at the Creating, Evaluating, Analyzing or Applying levels of Bloom's Taxonomy. Higher order thinking applications are of high quality and are appropriate for the grade level and content being served.
1	The learning process and products that the students are working through in this lesson plan are at the Understanding or Remembering levels of Bloom's Taxonomy OR the higher order thinking applications for the grade level and content being served is questionable.
0	Higher order thinking applications are not clearly outlined OR it is unclear what the target Bloom's levels are OR higher order thinking applications and target Bloom's levels are not stated.
	6. Opportunity to learn
2	The learning opportunities and activities described in the lesson plan demand that students search for in-depth understanding and ability through innovation and systematic research using a variety of sources and strategies like experimentation.
1	The learning opportunities described in the lesson plan demand minimal innovation or problem solving on the part of the student.

0	The learning opportunities/ activities described in the lesson plan demand no innovation or problem solving on the part of the student.
	7. Opportunity to develop Students Scientific Literacy
2	The lesson plan describes learning opportunities that require students to engage in a thorough exploration of a topic, concept or problem. The lesson plan provides essential questions that are contextualized, meaningful and are rich enough to help students reach the identified learning standards and develop scientific literacy.
1	The lesson plan describes learning opportunities that enable students to develop an understanding but not the use of knowledge and skills s. The lesson plan provides questions that are related to the curricular concepts and learning standards and but lack richness and contextualizing and do not help student develop scientific literacy
0	The lesson plan does not provide an opportunity for students in making meaningful connections between their own experiences and the content. The described questions in the lesson plan neither reflect the content nor the identified standards. The questions do not help student develop scientific literacy. OR The lesson plan provides neither description of opportunities that require students to engage in a thorough exploration of a topic nor questions to assist students learning.
	8. Description of student and teacher activities
2	The lesson plan completely describes both what students will be doing during the lesson and what teachers will be doing during the lesson and describes things that the teacher want to remember to do/not to do within the lesson, and how to react with the anticipated student responses and reactions.

1	The lesson plan fairly describes both what students and the teacher will be doing during the lesson.
0	The lesson plan describes only what the teacher will be doing during the lesson Or The lesson plan provides no description of both student and teacher activities
	9. Individual and collaborative accountability in the learning processes
2	The lesson plan provides ample opportunity to work in individual, collaborative, and challenging tasks and activities. It presents clearly both individual accountability and group interdependency. The planned lesson can encourage students to lead their learning and share their ideas.
1	The lesson plan includes both individual and in group works but it does not describe any accountability and group interdependency.
0	The lesson plan does not address both individual and collaborative accountability, or challenging tasks and activities or the lesson plan does not address collaborative work at all
10. Differentiation	
	I. Prior knowledge
2	The lesson plan allows learners both to process content and to make meaning of content through their own prior knowledge and teacher's notes about the prior knowledge of the students include possible misconceptions from their prior knowledge.
1	The lesson plan allows learners either to process content or to make meaning of content through their own prior knowledge and teacher's notes about the prior knowledge of the students include only minimal information about prerequisites for

	lesson.
0	The lesson plan does not allow learners to process or make meaning of content through their own prior knowledge and no information is given about prerequisites for lesson. Or no indication of differentiation through prior knowledge
	II. Learning Profile
2	The lesson plan allows learners to access content through multiple learning styles and modalities
1	The lesson plan allows learners to access content through a limited learning styles and modalities
0	The lesson plan does not allow learners to access content through different learning styles and modalities. Or no indication of differentiation for learning styles and modalities
	III. Content/process/methods of teaching
2	The lesson plan is differentiated by content, processes, methods of teaching
1	The lesson plan is differentiated either by content or processes but not differentiated by teaching methods
0	The lesson plan does not differentiate content, process and methods of teaching
11. Assessment	
	I. Appropriateness/alignment
2	The planned assessments are derived from learning objectives and standards and provide learning opportunities that measure and support the desired learning standards
1	The planned assessment measures only some aspects of the learning objectives and standards.

0	Assessment methods do not reflect learning objectives and unrelated to the learning standards.
	II. Tasks/exercises
2	Tasks/exercise are listed, match the objectives, and contain some problems that reinforce students' prior knowledge
1	Tasks/exercises are listed and match the objectives
0	No Tasks/exercises are addressed in the lesson plan
	III. Methods/techniques/Formative Assessment
2	The lesson plan provides multiple methods of assessment from the beginning to the end of the lesson in ways that support and measure student learning, inform teaching, and inform the learner.
1	The lesson plan provides limited methods of assessment and emphasis more on end-of-lesson assessments.
0	The lesson plan neither provides multiple methods of assessment nor formative assessment and assessment is limited to end-of-lesson activities or no assessment plan at all.
	IV. Details and clarity
2	Method(s) of assessment are detailed and a clear picture is given of how students will be evaluated. The described assessment(s) will help the teacher see what knowledge was gained by the students in relation to the lesson's content standards.
1	Method(s) of assessment are included with less detail on how students will be evaluated. It is not clear whether or not the teacher will understand the content knowledge that the students gained as a result of this lesson.
0	Method(s) of assessment are unclear and do not seem to provide a clear picture of

	the knowledge that students gained as a result of the lesson. Or Assessment method descriptions are incomplete or omitted.
12. Resources	
2	The plan lists multiple appropriate resources and bibliography that are up-to-date and directly support student learning in multiple perspectives related to the lesson's focus.
1	The plan lists resources that are limited in scope and depth and less related to lesson's focus.
0	Resources listed have no relation with lesson's focus. OR Resources are omitted.
	13. Reflection
2	Reflection opportunities for the students and the teacher are clearly described with supporting details.
1	Reflection opportunities for the students and/or the teacher are mentioned with little to no supporting details.
0	Reflection opportunities for the students or the teacher are omitted.
	14. Rubric and checklist
	I. Criteria
2	The lesson plan offers criteria coherent to learning objectives and include all skills to be assessed in demonstration of learning
1	The lesson plan offers criteria that are related to learning objectives and include a few skills to be assessed in demonstration of learning
0	The lesson plan offers criteria that are unrelated to learning objectives and include few or no skills to be assessed in demonstration of learning. Or Lesson plan offers no criteria at all

	II. Quality indicators
2	The lesson plan states explicit levels of proficiency required at different levels of performance
1	The lesson plan includes quality indicators that contain few details, and do not state levels of proficiency required at different levels
0	The lesson plan does not indicate quality indicators, and does not state levels of proficiency required at different levels
	III. Students self-assessment
2	The lesson plan includes measures that guide student self-assessment and reflection on both products and processes (examples, ongoing specific questions).
1	The lesson plan provides to the learners only little opportunity to self-monitor
0	The lesson plan does not provide to the learners an opportunity to self-assess

Appendix O Teachers' self-rating about their PCK and their usage of PCK[3]

Dear respected Physics Teacher, we kindly request you to mark your degree of familiarity of the statements indicated in the table below. Please also indicate your usage of these constructs/concepts in your day to day instructional practices. Note that the intent of this questionnaire is not to evaluate you as a physics teacher rather it is to be used for research purposes. Therefore, we appreciate your genuine answers. We greatly appreciate that you take the time to contribute to this important research.

	Indicate your familiarity			How often you used in your day to day teaching				
Descriptions of constructs about PCK	familiar	not sure	not familiar	never	almost never	some-times	Almost every time	every time
Designing lessons with multiple instructional strategies to meet students' diverse learning needs								
Using variety of instructional approaches to make learning responsive to each student								
Modifying instruction to meet individual students learning								

[3] This instrument was initially prepared to measure teachers PCK. However, due to the sudden change in the design of the research the instrument was not utilized.

needs								
Adjusting instruction in response to various levels of student understanding								
Adapting instruction towards the learning standards using current levels of student understanding								
Using strategies identified by Physics Education Research as best practices to teaching a content								
Planning instructional practices outlined by Physics Education Research								
Designing instruction to meet students' learning needs aligned with learning standards								
Adapting instruction that address student learning differences								
Determining current levels of student understanding before planning instruction								

Designing instruction connecting students’ prior knowledge to new learning								
Developing varied lesson to meet the learning needs of individual student								
Planning differentiated instruction to engage each student in appropriately high-level of cognitive activities								
Using multiple representation methods (motion pictures, graphs, formula, tables, charts, free body diagrams, etc.) to enhance each students’ understanding								
Creating opportunities for students to apply knowledge to their life experiences								
Developing learning objectives aligned with learning standards								
Aligning instructional decisions with learning standards								
Creating opportunities for								

students to engage in collaborative thinking								
Engaging students in an appropriately high level of cognitive thinking								
Using open tasks to develop students thinking								
Using challenging tasks to develop students reasoning ability								
Anticipating possible student misconceptions when making instructional decision								
Addressing common misconceptions in the content area outlined by Physics Education Research								
Communicating clearly with students about the learning standards they are expected to demonstrate								
Setting high expectations for each student aligned with learning standards								

Communicating assessment criteria aligned with learning standards to all students							
Communicating measures of success to all students							
Using multiple assessments measures aligned with the learning standards							
Using a variety of formative assessment to monitor the progress of each student							
Providing timely, frequent, and relevant feedback to students works							
Designing differentiated instruction based on analyses and interpretation of students' data							
Making instructional decision taking into account the context of the school system							
Anticipating physics concepts or topics that students find difficult to learn when planning							

instruction								
Linking current instructional decisions with what students have learned and expected to learn later								
Assessing different aspects of students learning such as conceptual understanding, scientific investigation, problem solving, etc.								

Curriculum Vitae

Name: Tesfaye Getinet Kibret

Date of Birth: 14 February 1973

Sex: Male

Nationality: Ethiopian

Email: tesfa_get@yahoo.com

Academic Rank: Assistant Professor

Language: Oromo, Amharic, and English

EDUCATIONAL BACKGROUND

Dec. 2012 –March. 2015

PhD studies in Physics Education at University of Koblenz-Landau, Campus Landau, Germany.

Title of PhD thesis**:** Lesson Planning and Students' Performance Feedback Data Use.

Thesis advisor: Professor Dr. Ingmar Hosenfeld.

September 2001 – July 2003

M.Sc. studies in theoretical physics at Addis Ababa University, Faculty of Science, Ethiopia.

Areas of specialization: Solid state physics.

Title of Master Thesis: Hall coefficient and coefficient of transverse magnetoresistance of heavily doped n-type silicon with mixed scattering.

Thesis advisor: Professor S.K. Sharma.

Thesis grade: Very Good.

Cumulative Grade point Average (GPA): 3.44 (maximum point 4.0).

Nov. 1996 – July 2000

Bachelor of Education studies in Physics, minor mathematics at Dilla College of Teacher Education and Health Sciences, Debub University, Ethiopia.

Bachelor Project in Physics: The use of Electromagnetic radiation in remote sensing for weather forecasting and geographical modelling.

Project advisor: Eyyasu Bunaro.

Project Grade: A.

Cumulative Grade point Average in physics 3.74 (maximum 4.0).

Cumulative Grade point Average in mathematics 3.67(maximum 4.0)

Overall CGPA 3.68(maximum 4.0).

Sept. 1990 – Dec. 1992

Diploma studies in Agricultural Engineering & Technology at Awassa College of Agriculture, Addis Ababa University, Ethiopia.

Cumulative Grade point Average in physics 3.18(maximum 4.0).

OTHER TRAINING ATTENDED

- I attended a Higher Diploma Program for one year and awarded a license of Professional Physics Teacher Educator.

Academic Employment History (Work experience)

July 2010 – Nov. 2012: Assistant Professor at Department of Physics education & Institute of Educational Research, College of Education, Addis Ababa University, Ethiopia

July 2008 - July 2010: Lecturer at Department of Physics Education, College of Education, Addis Ababa University, Ethiopia

July 2003 – July 2008: Lecturer at Department of Physics, Dilla University, Ethiopia

Sept.2001 - June 2003: Graduate Assistant II at Dilla College of Teacher Education and Health Sciences, Debub University, Ethiopia

Sept.2000 - Aug. 2001: Graduate Assistant I at Dilla College of Teacher Education and Health Sciences, Debub University, Ethiopia

Feb. 1992 – Oct. 1996: Technical Assistant (I, II, & III) in Soil & Water Conservation, Division of Natural Resource Management, at Sirinka Research Center, Institute of Agricultural Research, Ethiopia

Teaching Experience

- I have taught the following physics courses, for Bachelor Program students both at Dilla University and Addis Ababa University: Mechanics and Heat (Phys 101); Mechanics and Heat (Phys 201); Electricity and Magnetism (Phys 102); Electricity and Magnetism (Phys 202); Classical Mechanics (Phys 311); Introduction to Modern Physics (Phys 242); Introduction to optics (Phys 271); Wave and Optics (Phys 262); Electronics I (Phys 371); Electronics II (Phys 372); Electrodynamics I (phys 376); Solid State Physics I (Phys 451); Physics Laboratory I (Phys 211); Physics Laboratory II(Phys 212); Physics Laboratory III(Phys 302); and Subject Methodology (PhyEd 122).
- I have coached and supervised hundreds of undergraduates on their teaching practices (Practicum).
- I have advised several undergraduates on their action research project.
- I have advised several in-service trainees on their action research project.
- I have taught graduates the course Quantitative Research Methods in Education.
- I have supervised 12 graduate students in their master thesis work in physics education.

ASSIGNMENTS & RESPONSIBILITIES

I served in different academic administrative positions and committees in addition to the regular teaching and research.

- Head of Physics Department at Dilla University.
- Assistant Head of Continuing Education Program at Dilla University.
- Research and Publication Committee at Dilla University.
- Head of Discipline Committee for Academic support staff at Dilla University.
- Student placement committee at Dilla University.
- Head of Teaching and Learning Support Unit in the center of Teaching Learning Support and Academic Skills Enhancement at Addis Ababa University.
- Internal audit for Physical Society Association at Addis Ababa University.
- Managing editor of IER FLAMBEAU at Addis Ababa University.
- Module Approval Committee both at Dilla University and Addis Ababa University.

Publications

Getinet, T. (2010). High field dc electrical conductivity in silicon. Indian Journal of Pure and Applied Physics, 48, 192 – 195.

Getinet, T.(2010). Hole Drift Mobility, Hall Coefficient and Coefficient of Transverse Magnetoresistance in Heavily Doped p-type Silicon. International Journal of Pure and Applied Physics, 6 (2), 109 – 115.

Getinet, T. (2005). Hall coefficient and coefficient of transverse magnetoresistance of Intermediately doped n-type silicon with mixed scattering. Indian Journal of Pure and Applied Science, 43,104 - 108.

Abdisa, G & Getinet, T. (2012). The Effect of Guided Discovery on Students' Physics Achievement. Lat. Am. J. Phys. Educ. 6(4), 530 – 537.

Getinet T. (2012). Effect of Instructional Interventions on Students Learning gains: An Experimental Research, Lat. Am. J. Phys. Educ. 6(2), 187 – 195.

Getinet, T.(2011). Practices and Problems in Teaching and Learning Physics at Preparatory Schools in SNNPR (Southern Nations and Nationalities People Region) of Ethiopia. Staff and Educational Development International,15(3),155-174.

Getinet, T.(2011). Impact of Role Change in Teaching and Learning Physics on Students. Staff and Educational Development International, 15 (1), 53-62.

Getinet, T. (2007). Students Understanding of the Basic Concepts of Newtonian Mechanics vis-à-vis Lecture Method: The case of Dilla University. The Ethiopian Journal of Higher Education, 4 (2), 23 -35.

Getinet, T. (2006). Causes of High Attrition Among Physics PPC Students of Dilla University. The Ethiopian Journal of Education, 26(1), 53-66.

Teaching materials

I developed modules for undergraduates on the following physics courses:

- Introduction to modern physics
- Electronics
- Wave and optics