

STUDYING ONE'S OWN INSTRUCTION: ASKING FOUR QUESTIONS

Hagar Gal
Inna Kremenetsky
David Yellin Academic College of Education, Israel

ABSTRACT

Teachers' awareness of how they teach and what their students learn is a cornerstone of instruction. This paper describes a case study of Ada, a pre-service teacher, who conducted a research project as part of her Master of Teaching program. Her study dealt with three sequential gaps in practice: (a) the gap between planning a lesson and actually teaching it, (b) the gap between what the teacher says and what the students hear, and (c) the gap between what the students hear and what they understand. To engage the Master of Teaching pre-service teachers in considering these gaps they were requested to research their own instruction, by asking the four questions: (1) What did I plan to teach? (2) What did I actually teach? (3) What did the students hear? (4) What did they understand? Ada detected gaps between what she planned to teach and what she actually taught, between what her students heard and what they understood. She also detected traces of her 'concept image' in her instruction. The results suggest that confronting pre-service teachers with the concept of these three gaps during their own instruction is a valuable practice for deepening their pedagogical understanding and awareness, as well as strengthening the interconnection between theory and practice. In addition, the results suggest that involving preservice teachers in conducting such research has the potential to better equip them as future educators. It can enable them to critically reflect on their practice through their careful analysis of their own instruction thereby raising their awareness of such potential gaps and how they apply to praxis.

Keywords: Analyzing teaching, Concept image, Learning to teach; Master of Teaching, Metacognition, Noticing, Novice teachers, Pre-service teacher education, Teacher awareness, Teacher preparation

INTRODUCTION

The art of teaching is complex and has many elements including pedagogic knowledge (PK), content knowledge (CK) and pedagogic content knowledge (PCK). Teachers must be capable of evaluation and critical reflection, able to be attentive to students' different needs, and knowledgeable in classroom management and discourse. Often preservice and novice teachers are not aware of and do not appreciate such complexity (Grossman et al., 2009; Munby, Russell, & Martin, 2001; Nghia & Tai, 2017). As a result, many prospective obstacles to instruction are either not anticipated or ignored.

There is no clear, concise, empirical answer to the question of how teacher preparation programs should be designed to ensure that graduates become expert teachers (Hiebert, Morris, Berk, & Jansen, 2007). Gal's (2011) 'list' of requirements emphasises (a) that teachers be confronted with the limitations of their own beliefs, creating cognitive dissonance (Kagan,

1992); (b) that they come to realize that executing an algorithm or obtaining a correct answer does not imply a conceptual understanding (Graeber, 1999); and that (c) they, like their students, become active learners and participants (Stocks & Schofield, 1997). Thus, Hiebert et al. (2007) focus on teachers' ability to analyze their teaching in terms of its effect on student learning. They ask the following questions: "What did students learn, and how and why did instruction influence such learning? How could lessons based on this information be revised to be more effective when teaching them next time?" (p. 48). Moreover, these researchers anticipate that fostering intentional and systematic attention to cause-effect relationships will be a major challenge to acquiring the skills necessary to answer the above questions.

The authors' own three decades of experience as teacher educators, has also taught them that they, as well as preservice, novice and expert teachers around them, are often unaware of gaps that may occur during instruction and learning. Thus, to address this challenge it was decided to involve the preservice teachers in 'self-research', where they would examine their own teaching from the perspective of a series of questions that focused on potential gaps arising in practice. The rationale for using this approach was to engage participants' collaboration (preservice-, in-service- teachers) in what was considered 'a process of change' regarding practicum learning experiences, where, first, there was a need for all involved to recognize the need for change. To achieve this goal, the researchers followed Kagan's (1992) suggestion to confront the preservice- and in-service- teachers with their existing gaps in practice through their self-research in order to create cognitive dissonance, which would in turn motivate their critical inquiry and search to reduce that dissonance. Cognitive dissonance refers to the state of discomfort, which is created when two cognitive elements are inconsistent, i.e., if one element follows from the opposite conflicts with the other (Festinger, 1957; Gawronski, 2012; Harmon-Jones & Harmon-Jones, 2007). As Delamarter (2019) notes:

The dissonance that sets in when expectations run headfirst into reality is not an uncommon state for pre-service teachers to find themselves in. A growing body of research underscores just how normal this kind of cognitive dissonance is, and nearly every book on the process of becoming a teacher addresses this issue to some degree (p. 133).

The Master of Teaching program

The Master of Teaching program offered by The David Yellin College of Education aims to prepare students, who have already earned academic degrees in fields relevant to high school studies, to become school teachers. These students have no general PK and PCK background. Thus, program aims to equip the students with PK and PCK, together with providing practical experience in teaching. The academic courses of the program focus on psychology, learning difficulties, social conflicts, educational dilemmas, instruction in teaching heterogeneous classes, metacognitive thinking, curriculum planning, project-based learning (PBL), and educational research methods.

The College offers a specially designed model of practical classroom experience. The participants act as autonomous classroom teachers for two hours a week throughout their entire course of study (totalling 12 months). The students are guided by a disciplinary pedagogical advisor who meets with them on a weekly basis to discuss PCK and PK issues, conduct critiques of their lesson plans, and to attend their classroom sessions and provide feedback. Thus, the preservice teachers are able to reflect on their practice over the long term, with continuity of students in class.

Implementation of the self-research into classroom instruction

One of the courses in the program is 'Implementing Research into Instruction'. The course aims to assist and advise the students in their first steps as researchers of the instruction of their discipline, emphasising metacognitive learning and teaching. It attempts to establish a professional learning community that will reflect on the teacher's role during the educational process, using systematic, evidence-based practice. The path to achieving these aims is through self-research conducted by each of the students throughout the year. All students have to answer the same four research questions, applied and tailored to their disciplines and the topics they are teaching: (1) What did I plan to teach (concerning a specific concept that is part of the subject I teach)? (2) What did I actually teach? (3) What did the students hear during my instruction? (4) What did they understand concerning that concept? Finally, the students have to reflect on the process and report what they have learned.

The first semester of the course was used to set the goals of the course, to plan the research, build the research tools, and begin the first cycle of literature review. As the course teachers, first, the authors/researchers introduced the participants to the idea of academic research. For that purpose it meant considering differences between the participants' academic, theoretical knowledge concerning research methods (both qualitative and quantitative), and their practical knowledge (choice of research method, tools, questions, variables, and data analysis).

This was followed by a focus on raising the pre-service teachers' awareness (Gal, 2011; Mason, 1998) of the gaps between planning and execution, the difference between what their pupils heard and understood, and how a teacher's concept image emerges during teaching. The pre-service teachers were given the four research questions. In order to answer them, they were required to choose a specific concept that was part of the curriculum they intended to teach in their class, and then design appropriate research tools. The teaching subjects of the students were determined by their majors, which included mathematics, biology, chemistry, history, communication, and bible studies. The concepts they chose to focus on were 'equations', 'atom', 'chemical connections', 'the first world war', 'propaganda', and 'godly miracle'. The students were directed to use both qualitative and quantitative methodologies. The first two questions were studied through a qualitative methodology and the third and fourth through a quantitative methodology. For more details see the methodology section.

The second semester was used to carry out the research, analyze the data, and report and discuss the results. At the end of the year each student was required to provide a written structured research report as well as present the research orally in a special academic formal session. The data were collected from one specific lesson taught by the student, using six research tools, which were planned in the first semester. All six tools were required to be ready for a fixed two weeks of data collection: (1) the lesson plan (used to answer the first question); (2) the audio-recording of the lesson taught by the student (used to answer the second question); (3) a "hearing" questionnaire, which was provided to every pupil in the student's class at the end of the initial lesson (used to answer the third question); (4) an "understanding" questionnaire, which was provided to every pupil in the subsequent lesson (used to answer the fourth question); (5) a semi-structured interview of the teacher (conducted by a colleague) to detect and characterise the teacher's concept image; (6) a similar semi-structured interview of a pupil (conducted by the student) to detect and characterise the pupil's concept image.

The authors of this article were the course teachers and participated in all meetings and discussions during the course. The course had elements of a professional learning community (PLC), where students and course instructors learned from each other's experience and shared ideas on how to conduct research and analyze results. More specifically, the authors/researchers acted together as consultants, supervisors, facilitators, and critical friends (Costa & Kallick, 1993), taking advantage of the course to raise the participants' awareness of instructional gaps

in their teaching through the use of self-research. This special model of practice, which draws upon the approach of Hiebert et al. (2007), where teachers analyze their own instruction and its effects on their students' learning by asking the specific questions of this study enabled the participants to analyze their own work. As a result of this approach, the preservice teachers, like their pupils, can become active learners and participants in their practice (Stocks & Schofield, 1997). Thus, to provide deep insights into this approach this article provides a case study of one of the 10 students (pseudonym Ada) who participated in the course as described above.

TOWARDS THE RESEARCH

Defining Understanding

In order to answer the fourth research question, the students first had to define what meaning they ascribed to "understanding". The dictionary's definition (Merriam-Webster online, 2018) states:

(1) a mental grasp: comprehension; (2) (a) the power of comprehending; especially: the capacity to apprehend general relations of particulars (b) the power to make experience intelligible by applying concepts and categories; (3) explanation, interpretation.

Many researchers define understanding by the ability to perform actions, which requires thinking, such as explanations, argumentations, proving, generalizing, making relations, concluding, implying and representing (e.g. Fisher & Frey, 2015; Skemp, 1986; Van Hiele, 1986). Van Hiele (1986) refers to 'insight' as a concept close to understanding, stating (1) Insight can be observed when there has been an adequate action in a new situation. (2) Insight can be ascertained when there has been action on the strength of an established structure from which the answer can be read. (3) The best examples of insight happen unexpectedly. They are not brought about by planning. (p.154) . . . Insight is always recognized as such, if a person acts adequately with intention in a new situation. (p. 159).

Skemp (1986) defines 'understanding' as assimilation into an appropriate scheme, which 'explains the subjective nature of understanding and also makes clear that this is not usually an all-or-nothing state' (p.43). He differentiates between 'relational understanding' – knowing why, and 'instrumental understanding' – knowing how (Skemp, 1976). Bloom (1990) suggests a taxonomy of six levels to categorize 'educational objects': (1) knowledge, recall of specifics and universals, of methods and processes, of a pattern, structure, or setting (for measurement purposes, the recall situation involves little more than bringing to mind the appropriate material); (2) comprehension, the lowest level of understanding, a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications (translation, interpretation, extrapolation); (3) application, the use of abstractions in particular and concrete situations; (4) analysis, the breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit; (5) synthesis, the putting together of elements and parts so as to form a whole; (6) evaluation, judgments about the value of material and methods for given purposes, in terms of internal evidence or external criteria. Note that comprehension is not made synonymous with complete understanding or even with the fullest grasp of a message.

Based on their literature review and class discussion, most students adopted the following list of criteria to test understanding in their research: (a) the pupil is able to provide his/her own explanation; (b) there has been adequate action in a new situation; (c) the pupil can point at and construct relations between the concept taught and other concepts; (d) the pupil is able to reflect on and critique his/her own arguments. Note that the purpose of examining the meaning of understanding was to make the student teachers realize that executing an algorithm or obtaining a correct answer does not imply a conceptual understanding (Graeber, 1999).

Concept Image and Concept Definition

An additional aspect of the student teachers' study was tracing their own, as well as their student's concept image of the concept they taught. Fischbein et al. (1979) distinguish between two aspects of a mathematical concept. This is a distinction that is probably relevant to concepts in fields other than mathematics as well:

There are two fundamentally different aspects . . . There is the ideal, pure, final mathematical structure . . . And there is psychological reality of the same concept which may remain complex, contradictory, strongly related to intuitive difficulties . . . (p. 3)

A similar distinction is made by Tall and Vinner (1981) between "concept image" and "concept definition". The term "concept image" is used to describe the total cognitive structure that is associated with the concept, which includes all the mental pictures and associated properties and processes. It is built up over the years through experiences of all kinds, changing as the individual meets new stimuli and matures. The term "concept definition" is quite a different matter and is regarded to be a form of words used to specify that concept. There might be interaction between the two though they can be formed independently (Vinner, 1983). In their study, the students aimed at detecting traces of their own concept image in their planning and instruction as well as traces of their pupils' concept images in their answers to the questionnaires.

DESIGN AND METHODOLOGY

Research Questions

All the pre-service teachers in the course aimed to study the same four research questions: (1) What did I plan to teach? (2) What did I actually teach? (3) What did the pupils hear during my instruction? (4) What did they understand concerning that concept? They were directed to use both qualitative and quantitative data collection methods (note that their sample - the number of pupils in their class, was small ranging from 12 to 20).

Method

In order to answer the first question (What did I plan to teach?), a qualitative paradigm was used. The students collected and analyzed their relevant lesson plans to detect the main ideas that they had planned to cover and emphasize, either deliberately or unconsciously. This was done by text analysis, according to pre-determined categories they had chosen.

They also tried to communicate their own concept image to a colleague in a semi-structured interview, which frequently was guided by questions such as: "When you close your eyes and think about [the name of the concept, e.g. a mixture,], what do you see?" or "Can you describe freely what you see when you think about [the name of the concept]?" (see later the

example of Ada's concept image). After reviewing their own concept image, the students tried to detect its traces in their lesson plans or in the lesson they actually taught.

In order to answer the second question (What did I actually teach?), a qualitative paradigm was again used. The students' audio-recorded the one specific lesson they chose to focus on in their study and while listening to the recording and reading its transcript, they searched for the implicit as well as explicit "essence" of the lesson. This was done through detecting the main ideas approach they actually applied during this lesson, repeated statements, repeated words, examples they used, and replies to 'expected' as well as 'unexpected' questions from the pupils. Generally, the pre-service teachers chose similar categories for both first and second research questions, which later made it simpler to compare what was actually said to what was planned to be said.

To answer the third question (What did the pupils hear during my instruction?), the preservice teachers used a quantitative paradigm. They employed a questionnaire which they prepared in advance of the specific lesson based on what they planned to say or not to say, and in which they asked: "What did I say about . . .?", "According to what you remember – how did I define . . .?", "Did I use the word . . .?", "Can you give an example that I gave during the lesson?" Note that in order to find out what the pupils heard in the specific lesson, the questionnaire had to be provided at the time of that specific lesson. Therefore, it had to be prepared in advance, i.e., before the teachers could be sure about what exactly they would say or not say. Indeed, sometimes what they thought they would say - they did not and vice versa. To analyse the answers, of course they had to check the recording. About this time the students also tried to investigate one of their pupil's concept image, using the same method of semi-structured interview as was described before concerning their own concept image.

The fourth question ('What did they understand concerning that concept?') required defining general criteria for 'understanding' and deriving relevant implications for the concept in hand. The pre-service teachers were instructed to choose three criteria as operational variables. Most students chose three of the four criteria mentioned earlier: provide one's own explanation; adequate action in a new situation; point at and construct relations between the concept taught and other concepts; reflect on and critique one's own arguments. Then they adjusted these criteria to the studied concept. An example of an assignment aimed to provide one's own explanation is: "How will you explain to a friend in your own words what is a mixture?" In order to point out and construct relations between the concept taught and other concepts, one of the pre-service teachers required the student: "Explain the relation between mixture and chemical bonding". The following is an example of 'reflect and critique one's own arguments: Yossi says, "Chemical bonding has no significance in nature but only in everyday life. Do you agree? Provide an explanation". The questionnaire was provided to the whole class in the lesson following the one that was recorded. Each question was graded according to a planned scale, and following quantitative methodology, the answers of the whole class were collected and analyzed.

The Case Study of Ada

Ada (pseudonym) was one of 10 second year students in the Master of Teaching program. The students in the program were all graduates in their chosen disciplines and studying toward the master's degree in teaching together with a teaching diploma in their discipline. Ada held a Bachelor of Science in Biotechnology and was studying towards the Master of Teaching and a Diploma of Teaching in Biology-Chemistry. As part of program, she was the science teacher for two hours per week for the entire year, of one 8th grade class in a central city in Israel. In accordance with the College's model of practical educational experience, the pre-service teachers act as autonomous instructors, and as such are required to manage the class by themselves, plan and execute evaluation of learning, as well as carry out

all other roles of a teacher. Ada's topic for this study was teaching the class the concept of 'mixture'. Her class comprised twenty, 8th grade, pupils, who were studying in an average, socio-economic level high school, where students were mostly of average to high ability.

ADA'S RESULTS, DISCUSSION

Below are the results of Ada's research concerning her instruction of the concept 'mixture'.

1 “What did I plan to teach (concerning the concept of mixture)?”

The Essentials of the Planning

One of Ada's goals in planning the lesson was that her pupils 'will understand the difference between 'mixture' and 'compound' (i.e. chemical compound) and would be able to distinguish between them'. She planned to draw a table illustrating physical and chemical changes that occur in each of them. She intended to describe the substances and processes for which they are the product, and the type of bonding that exists within them. Ada explained: “I planned to say that in a compound, the original qualities of the substances are not preserved, whereas in a mixture each ingredient retains its own chemical properties.” Ada noted that this point was repeated and stressed several times in the lesson plan.

Ada's Concept Image

Ada was interviewed by a colleague, another pre-service teacher from the course, who attempted to discover Ada's concept image of a mixture. Ada stated that to her, a mixture was 'something different from similar things,' and to understand it she needed to compare 'elements', 'compounds' and 'pure materials'. While thinking about homogenous or heterogeneous mixtures, she imagined 'chocolate drink' or 'salad', correspondingly, as her prototype examples.

2 “What did I actually teach?”

Ada's actual lesson began with a reminder of what a compound is, emphasizing the concept of chemical bonding before proceeding to a discussion of the differences between a mixture and a compound. She noticed that her concept image, based on 'what is not a mixture', influenced her instruction and caused her to explain her material through comparisons. Analyzing her recorded lesson, she found out that she 'forgot to say that in a compound, the former qualities of the substances are not preserved . . . which made the comparison unbalanced'. The examples she used in the lesson, to illustrate homogenous and heterogeneous mixtures, were the same she provided during the interview ('chocolate drink' and 'salad').

3 “What did the pupils hear during my instruction?”

A questionnaire was distributed to the pupils in the last 10 minutes of the lesson which aimed to discover if what the students heard was what the teacher actually said. This questionnaire contained three sections (categories): (a) identifying words or expressions which were used by the teacher to describe the concept 'mixture' during the lesson (b) explaining in their own words what they learned from the lesson about the concept 'mixture' (c) completing specific sentences providing explanations and examples that were given during the lesson.

(a) Identifying Words

The pupils were asked to identify words or expressions which were used by the teacher to describe the concept 'mixture' (a list of 30 words such as "homogeneous", "salt", "concentrate"; (Weight of this section: 15 points out of 100). Such an assignment was potentially confusing since some of these words were mentioned during the lesson in a different context. Out of 20 pupils, 13 received a score of more than 60%.

(b) Explaining in Their Own Words

The pupils were asked to explain in their own words what they learned from the lesson about the concept 'mixture' (Weight: 35 points out of 100). Only 9 out of 20 received a score of more than 60%. Some gave examples of mixtures without explaining what a mixture was; others provided general explanations such as 'a mixture is a combination of materials'; others gave incorrect answers such as 'a mixture is a material which has several things in it'.

(c) Completing Sentences

The pupils were asked to complete four specific sentences providing explanations and examples that were given during the lesson (such as "a mixture is . . ." or "examples of a homogenous mixture given in the lesson are . . ." (weight: 50 points out of 100). The majority (13) received a score of between 60 and 80%. Most pupils could provide the examples given in class (e.g. chocolate drink and salad), although some gave only partial or inaccurate answers.

Summary of 'Hearing Questionnaire' Results

To sum up, analyzing the results of each of the three sections (categories) used in the 'hearing questionnaire' (identifying words, explaining in their own words, completing sentences) suggest (see Figure 1) that as far as the hearing questionnaire is concerned, the explaining in their own words assignment (section b) was the most difficult for the pupils while completing sentences was the easiest (section c). The value of Cronbach's Alpha of the questionnaire, which is based on the data that was introduces by the graph (Figure 1) is 0.58 and considered to be a quite low internal consistency of the categories describing the hearing. Yet since a qualitative interview was held by the teacher with one of the students, she decided not to take off the statistics of some of the answered questionnaires.

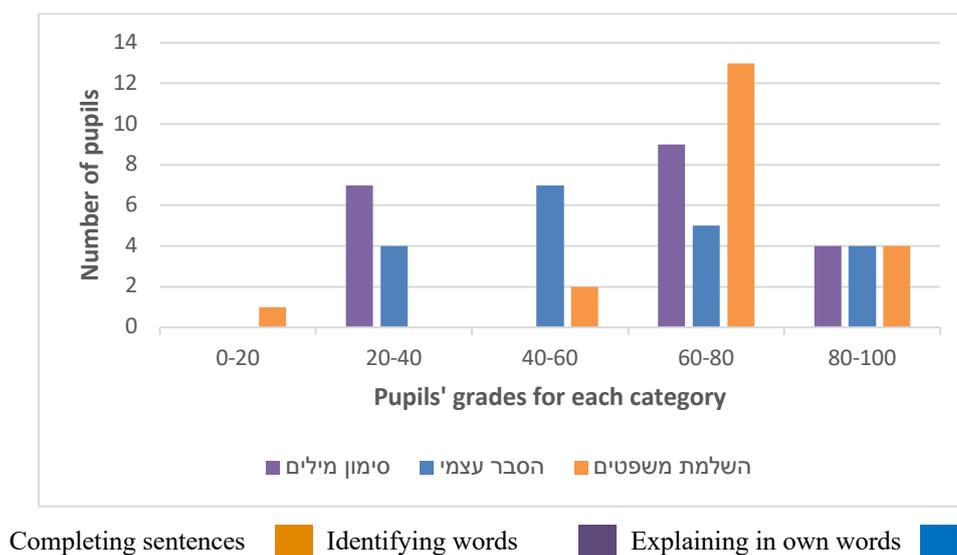


Figure 1. Distribution of grades in the 'hearing questionnaire'

4 “What did the pupils understand concerning that concept?”

Ada chose to study the pupils’ understanding using the following three criteria (each was tested through three different independent questions): (a) being able to provide his/her own explanation of the concept (explain, use given vocabulary to describe and classify mixtures); (b) being able to point at and construct relations between the concept taught and other concepts (relating the concept of mixture to two other concepts and arranging them in a flow chart); (c) being able to reflect on and critique his/her own arguments (provide explanation or critique for

given statements). The questionnaire was distributed to the pupils several weeks after they first began to study the concept of mixture.

This time only 13 pupils completed the questionnaire. The Cronbach's Alpha in this questionnaire was 0.8 which is considered to reflect a good reliability. Out of 13, 2 failed to answer the questions, but 9 received a score of 70-89%. The explanations were of a higher quality and more detailed than those provided in the earlier 'hearing' questionnaire.

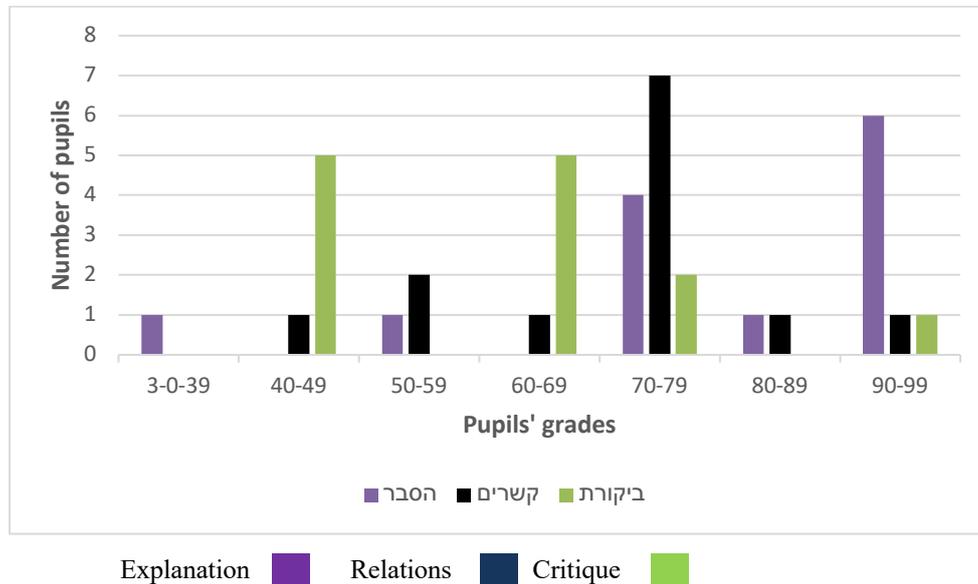


Figure 2. Distribution of grades in the 'understanding questionnaire' according to categories

Figure 2 shows that in the category of explanation, most pupils had good or excellent scores. However, in the category of critique, their scores were much lower. These results may be explained by the difference in the cognitive demand of each of the tasks in terms Bloom's taxonomy (Bloom, 1990). Ada also studied the correlation between what the pupils heard and what they understood using the Pearson correlation coefficient. For that purpose she only used the responses of students who had filled out both questionnaires. The result showed a strong positive correlation ($R=0.81$) between the two questionnaires, i.e. the better the pupil heard, the greater likelihood that the pupil understood.

More information was gathered through a qualitative semi-structured interview with a pupil, similar to the one made with the teacher, which aimed at tracking her concept image of 'mixture'. The pupil's first word to describe a mixture was 'cutlets'. When the interviewer asked 'why?' she answered: 'because of the shape of the mixture in which all the substances are mixed in a bowl'. Later she added 'volume' as a characteristic of a mixture, explaining: 'if you mix flour and eggs they stick to each other and there is volume, therefore it is a mixture, in contrast to salt and pepper together, which is not a mixture'. The pupil also explained that a mixture can be separated only before mixing the ingredients, providing the example of onion in cutlets. According to the student, the smaller the components of a mixture, 'the more it is considered to be a mixture', i.e. the more typical it is.

Ada's Discussion

The research report submitted by this pre-service teacher at the end of the research, required a chapter of discussion. In her discussion, Ada identified the gap between what she had planned to teach (referring to her lesson plans) and what she actually had said in the lesson (referring to the lesson recording). For example, she explained: "in the lesson I did not mention

that the substances that the mixture is made of do keep their properties". Ada also observed traces of her concept image in her lesson plan as well as in her instruction, with the same examples of 'chocolate drink' and 'salad'.

Concerning the poor results of the hearing test, she provided explanations based on the literature (see Hall, 2006; Nickerson, 1998), explaining that "if the 'receiver', i. e. the pupil, does not adopt the meaning that the 'producer', i.e. the teacher, provides, then the pupil will not be able to assimilate and make sense of the information". She added that this could also be a result of selective listening or response to other kinds of "noise" in the communication process. Ada also referred to the interview that was held regarding the pupil's concept image after the instruction of the concept took place. She noted the pupil's concept image did not reflect the scientific definition of a mixture (following her concept image when providing her answers). Ada also noticed that the student's hierarchy in classifying mixtures into more or less 'considered to be mixtures', was consistent with other studies about categorizations and prototype (Rosch, 1973).

Discussing the results of the test of understanding, Ada referred to the hierarchy defined by Bloom (1990). Following Adams (2015), she analyzed the hierarchy of the three questions, explanation, construction of relations and reflection, as corresponding to knowledge (Bloom's Level 1), analysis (Bloom's Level 4), and evaluation (Bloom's Level 6), which provided an explanation to the decreasing scores on the three questions.

Ada was aware that the pupils' concept image was reflected in the understanding questionnaire. She mentioned the work of Vinner & Linchevski (1994) concerning the role of the teacher's concept image in addressing the student's concept image and the role of the student's concept image in deciding 'what is' and 'what is not' an example of a concept (Vinner & Dreyfus, 1989).

Ada summed up her study by concluding that a teacher should be aware of the gaps between all levels of instruction: what the teacher planned, what s/he actually did, what the students heard, and what they understood. She realized the essential role of her own concept image, the gap between the concept image and the scientific definition, and the 'penetration' of the teacher's concept image into that of the student. She also recognized that it was advisable to follow Gardner's (2016) suggestion to use understanding tests regularly.

CONCLUSION

Scholars and teacher educators are equally interested in teachers' planning and instruction but few studies link planning with instruction. Moreover, even fewer studies examine planning, instruction, and reflection as a holistic process (for a review of these, see Hall & Smith, 2006). In this study the researchers directed pre-service teacher teachers to study their own process of planning, instruction, and reflection. It is the researchers' belief that it is through planning that teachers are able to learn about teaching and through teaching they are able to learn about planning (Mutton, Hagger, & Burn, 2011), and that pre-service teacher teachers need to develop an awareness of what planning can and cannot achieve.

Pre-service teachers are often not aware of and have trouble comprehending the need for structuring, organizing and managing their instruction (Hall & Smith, 2006). Confronting them with the gaps, which appear during the various steps of instruction, leads them to better evaluate their teaching plans and their teaching. The four questions which guided the pre-service teachers' research can be viewed as serving the role of reflection-in-action and reflection-on-action (Schon, 1987): the process of analyzing and interpreting during action, as opposed to the same type of process following action. Using reflection-in-action can be associated with teacher decision-making during instruction, and reflection-on-action with following instruction.

In the present research pre-service teachers participating in the course 'Implementing of Research into Instruction' studied their own instruction and their pupils' learning, aiming to confront instructional gaps. The goal was to encourage teachers to become aware of the unnoticed gaps during the process of instruction. This study suggests that such pre-service teachers' research, with a structured or guided reflection on the results, is a critical practice to support their reflection and in turn deepen their pedagogical understanding, by making the connection between theory and practice and vice versa. Thus, it is argued the employment of this approach has the potential to influence pre-service teachers in their future instruction, which would ideally be the focus of further, more longitudinal, research.

Research indicates that the pre-service teachers, in studying their own instruction, paid attention to the potential gaps under consideration. Although one could claim that they were directed to do so, the research showed they were, eventually, independently aware of what was happening at each stage of their instruction, and were also able to reflect on their practice through the structured aids provided. The case study of Ada demonstrates these claims and suggests that self-awareness can and needs to be successfully handled as part of teacher preparation.

At times we found it difficult to guide the pre-service teachers in tracing the concept images of their colleagues or their pupils. They often asked the interviewees questions like "What is a . . .?" or "What are the properties of . . .?" To distinguish the concept image from an interviewee's formal knowledge, it would have been preferable for the interviewer to ask: "When you close your eyes – what are the images of . . . that appear to you?" An interesting discovery was that some of the course pre-service teachers had difficulties in tracing their own concept image in both their lesson plans and their instruction. They believed, and from their perspective, seemed to 'prove' that all went exactly as planned and expected, though this was not the case. Thus, the research suggests more creative ways are needed to raise such preservice teachers' awareness and deepen their understanding of this issue, thus indicating a need for further research. On the other hand, there were pre-service teachers who were surprised to clearly recognize footprints of their concept image used by them during the lesson – far from the concept definition they were familiar with – while providing concept examples or answering an unexpected question of a pupil. These findings were independent of the subject the pre-service teachers taught, the discipline (humanities or sciences), and the age of their pupils. Despite the small group of 10 pre-service teachers in the course, each conducting their own research, these findings may have broad relevance. Future teachers or novice teachers need to be aware of gaps during instruction and be attentive to the differences between planning and execution, what they say and what is heard, and what is heard and what is understood (O'Neill & Geoghegan, 2011; 2012; van Es & Sherin, 2002).

The course at the focus of this research was also a great opportunity for the researchers themselves, as experienced lecturers and teacher educators, to reflect on their own practice. It was discovered that what they planned to teach during the course 'Implementing of Research into Instruction' and during the time of guiding the pre-service teachers' research, was not quite what they actually taught either. It was concluded that what was said was far from what the students heard, and ever further from what they understood. For the researchers it was an illustration of the Jewish saying that "We can learn more from our students than from our teachers and friends".

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Address for correspondence: Dr Hagar Gal, David Yellin Academic College of Education, Jerusalem, Israel. Email: <hagarg@dyellin.ac.il>

REFERENCES

- Adams, N. E. (2015). Bloom's taxonomy of cognitive learning objectives. *Journal of the Medical Library Association: JMLA*, 103(3), 152-153.
- Bloom, B. S. (Ed.). (1990). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Costa, A. L., & Kallick, B. (1993). Through the lens of a critical friend. *Educational Leadership*, 51, 49-51.
- Delamarter, J. (2019). *Proactive images for pre-service teachers: Identity, expectations, and avoiding practice shock*. Cham, Switzerland: Springer Nature.
- Festinger, L. (1957). *A theory of cognitive dissonance*. Evanston, IL: Row Peterson.
- Fischbein, E., Tirosh, D., & Hess, P. (1979). The intuition of infinity. *Educational Studies in Mathematics*, 10(1), 3-40.
- Fisher, D., & Frey, N. (2015). Checking for understanding digitally during content area learning. *The Reading Teacher*, 69(3), 281-286.
- Gal, H. (2011). From another perspective: Training teachers to cope with problematic learning situations in geometry. *Educational Studies in Mathematics*, 78(2), 183-203.
- Gardner, H. (2016). Why also high achieving students in high achieving schools do not understand? In H. Harpaz (Ed.), *To understand understanding, to teach to understand. Concepts and actions* (pp. 109-127). Raanana, Israel: MOFET Institute. (Hebrew)
- Gawronski, B. (2012). Back to the future of dissonance theory: Cognitive consistency as a core motive. *Social Cognition*, 30(6), 652-668.
- Graeber, A. O. (1999). Forms of knowing mathematics: What preservice teachers should learn. In D. Tirosh (Ed.), *Forms of mathematical knowledge* (pp. 189-208) Dordrecht, The Netherlands: Kluwer.
- Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record* 111(9), 2055-2100.
- Hall, S. (2006). Encoding/decoding. In M. G. Durham, & D. M. Keller (Eds.), *Media and cultural studies* (pp. 163-173). Malden, MA: Blackwell Publishing.
- Hall, T. J., & Smith, M. A. (2006). Teacher planning, instruction and reflection: What we know about teacher cognitive processes. *Quest*, 58(4), 424-442.
- Harmon-Jones, E., & Harmon-Jones, C. (2007). Cognitive dissonance theory after 50 years of development. *Zeitschrift für Sozialpsychologie*, 38(1), 7-16.
- Hiebert, J., Morris, A., Berk, D., & Jansen, A. (2007). Preparing teachers to learn from teaching. *Journal of Teacher Education* 58(1), 47-61.
- Kagan, D. M. (1992). Professional growth among preservice and beginning teachers. *Review of Educational Research*, 62(2), 129-169.
- Mason, J. (1998). Enabling teachers to be real teachers: Necessary levels of awareness and structure of attention. *Journal of Mathematics Teacher Education*, 1, 243-267.

- Munby, H., Russell, T., & Martin, A. K. (2001). Teachers' knowledge and how it develops. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed., pp. 877–905). Washington, DC: American Educational Research Association.
- Mutton, T., Hagger, H. & Burn, K. (2011). Learning to plan, planning to learn: the developing expertise of beginning teachers. *Teachers and Teaching*, 17(4), 399-416.
- Nghia, T. L. H., & Tai, H. N. (2017). Preservice teachers' identity development during the teaching internship. *Australian Journal of Teacher Education*, 42(8), 1-15.
- Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology*, 2(2), 175-220.
- O'Neill, S., & Geoghegan, D. (2012). Pre-service teachers' comparative analyses of teacher-/parent-child talk: Making literacy teaching explicit and childrebb's literacy visible. *International Journal of Studies in English*, 12(1), 97-128.
- O'Neill, S., & Geoghegan, D. (2011). First year pre-service teachers' views about literacy: Exploring the breadth and depth of their pedagogical needs. *International Journal of Pedagogies and Learning*, 6(3), 187-205.
- Rosch, E. H. (1973). Natural categories. *Cognitive Psychology*, 4(3), 328–350.
- Schon, D.A. (1987). *Educating the reflective practitioner*. New York, NY: Basic Books, Inc.
- Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77(1), 20-26.
- Skemp, R. R. (1986). *The psychology of learning mathematics*. London, England: Penguin Books.
- Stocks, J., & Schofield, J. (1997). Educational reform and professional development. In: E. Fennema & B. S. Nelson (Eds.), *Mathematics teacher in transition* (pp. 283–308). Mahwah, NJ: Erlbaum.
- Tall, D. O., & Vinner, S. (1981). Concept image and concept definition in mathematics with particular reference to limits and continuity. *Educational Studies in Mathematics*, 12(2), 151-169.
- Understanding. (2018). In Merriam-Webster.com. Retrieved from <https://www.merriamwebster.com/dictionary/understanding>
- van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, 10(4), 571–596.
- Van Hiele, P. M. (1986). *Structure and insight. A theory of mathematics education*. New York, NY: Academic Press.
- Vinner, S. (1983). Concept definition, concept image and notion of function. *International Journal of Mathematics Education Science and Technology*, 14(3), 293-305.
- Vinner, S., & Dreyfus, T. (1989). Images and definitions for the concept of function. *Journal for Research in Mathematics Education*, 20(4), 356-366.
- Vinner, S., & Linchevski, L. (1994). Over generalizations in the concept image of multiplication. *Megamot*, 4, 407-420. (Hebrew)