Effects of practicum course (Academia Kita communities) on instructional practices of preservice science teachers

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Teachers tend to implement traditional old-fashioned instructional practices while they teach. This argument led to a continues research issue and question about the effect of teacher preparation program on pre-service science teachers' instructional practices. More specifically, how the different courses, pathways and clinical practicum affect the strategies that pre-service science use while they teach science? And how these strategies developed and changed during the preparation period?

The current study examines the efficacy of an Academia Kita learning communities which is an important component practicum course of science teacher preparation program designed to train elementary level science teachers. This program lasted approximately one academic year and involved interaction between three parties: a pre service science teacher, an in-service science teacher, and an academic supervisor.

We used a mixed methods approach involving self-administered questionnaires, real time classroom observations, and semi-structured interviews to answer the following research questions: How are pre-service science teachers' instructional practices affected after participation in the interactive practicum course? To what extent are pre service science teachers' instructional practices aligned with Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013)? And which components of the practicum course were responsible for the change(s) in pre-service science teachers' teaching practices?

The results of the current study indicated that the interactive practicum course helped the pre-service elementary science teachers shift from traditional teacher-centred science instructional practices (SIP) to new up to date student-centred in accordance to Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) SIP, and that the third stage of the practicum course, which includes triangulation between the pre-service teacher, the tutor, and the academic supervisor, and was the most influential step in the course, affecting the pre-service science teachers' SIP and causing them to change their SIP.

Keywords: elementary science education; next generation science standards; pre service science teacher; science instructional practices; teacher preparation program

Introduction and Rationale

Science teacher preparation programs in general and practicum courses in particular, play an important role in science education systems and in improving the quality of education (Carrier et al., 2017; Dabney et al., 2020; Lippard et al., 2018; NSTA, 2012; 2017). Sahlberg (2012, p. 1) emphasized that "research and experience both suggest one factor that trumps all others: excellent teachers", this clearly indicates that preparing excellent teachers who are updated and use the new era instructional practices must be the goal for and teacher preparation program. Mamlok-Naaman et al. (2007) indicated that science teacher plays an essential role in structuring and guiding students' understandings of the changing world in which they live. One and essential path to bring science teacher to be able to play that important role, is to involve preservice teachers in training and preparation pathway that upgrade them in various aspects including personal, pedagogical, professional, and up-to-date science instructional practices before they start science teaching career.

Clinical experiences and practicum courses are considered as a key component—even "the most important" component of—pre-service teacher preparation (Cochran-Smith & Zeichner, 2005; Darling-Hammond, 2006; Darling-Hammond & Bransford, 2005; Levine, 2006; National Council for Accreditation of Teacher Education [NCATE], 2010; National Council for Teacher Quality [NCTQ], 2011, p. 3). Musset (2010) draws an important correlation between teacher preparation and student outcomes that aligns with the findings of the OECD (2005, p. 26), suggesting "quality of teaching" as "the single most important school variable influencing student achievement." A well-designed practicum courses which bring pre-service science teachers to change their teaching practices and to use new era science instructional practices will fulfil this target (Iordanou & Constantinou, 2014).

Many countries experience difficulties in the appointment and retention of effective

teachers (McKenzie et al., 2005). Windschitl and Stroupe (2017, p. 251) argue that "educators should use powerful principles for instruction, derived from the research referenced in the Framework, to inform the design of courses and other preparatory experiences for novice teachers." As a result, the preparation of teachers and the implementation of appropriate teaching strategies have proven to be critical factors for improving the quality of education systems and as a result enable the learners to get well prepared (Musset, 2010; Wayne & Youngs, 2003).

There has been a continual search in the field of teacher preparation for the optimum ways of training teachers for the future. It is increasingly recommended to focus on ways of developing education quality through teacher preparation programs. Teacher preparation programs, importantly, prepare teachers to support children in the most difficult circumstances when they require the most assistance (Darling-Hammond & Baratz-Snowden, 2007).

In fact, teaching instructional practice courses offer pre-service teachers the opportunity to improve their teaching behaviors by providing them with an environment where mutual reflection and discussion are facilitated (Healy et al., 2001). In their internship process, pre-service teachers learn to implement what they had learned during their preparation program under the supervision of mentors (Evagorou et al., 2015). Levine (2006) argues that pre-service teacher education is a crucial link in producing quality science teachers, stating that "the quality of tomorrow will be no better than the quality of our teacher force" (p. 11).

Science education encountered many reforms and upgrades around the world, including how the sciences are taught. For instance, in 2013, many states in the United States established new standards for science education, the next generation science standards (NGSS Lead States, 2013). Similarly, in 2018, Israel's Ministry of Education published a

"Portfolio of Lesson Plans" that emphasized the development of students' scientific skills and establishing a new era of instructional strategies in the sciences. The main common factor between these reforms is the call for significant shifts in science teaching from traditional teacher-centered approaches (using direct science instruction, science demonstration, and worksheet or textbook work) to those that enable all students to actively engage in scientific practices and apply cross-cutting concepts to core disciplinary ideas.

Thus, in spirit of the new standards of science education, it is very important build a well-structured practicum course for pre-service science teachers, that include a collaboration between the different partners who are responsible for pre-service science teachers' preparation and implementation of what they learned during their academic learning, as a new and up-to-date science instructional practices which are aligned with the new science education standards from one side, and bring their students to acquire the updated and required scientific skills which enable them to be and effective and creative citizen in their community (NGSS Lead States, 2013; Portfolio of Lesson Plans, 2018). And so, measuring the effect of practicum course that pre-service science teachers learned during their teacher preparation program on their science instructional practices can be considered an important and crucial action that can highlight the effectiveness of the practicum course, and led to what modifications could be inserted to that course, if needed, in order to induce the required change and bring the instructional practices of the pre-service teachers to the required level at the end.

This study draws on social constructivist theories of teaching and builds on the existing and emerging research in both discipline-general and discipline-specific science teaching practices. It highlights the importance of well-structured collaborative practicum course within teacher preparation program in providing the pre-service science teachers the required and up-to-date student-centred instructional practices that enable their pupils to gain

new and up to date processes of science and scientific thinking, which include problem solving, communication, collaboration, and critical and creative thinking and so on (National Research Council, 2012; NGSS Lead States, 2013). This study examines the effects of interactive practicum course as part of pre-service science teachers' preparation program that induce changes in pre-service science teachers' instructional practices from teacher-centered to student-centered, in parallel internationally in parallel with the new up to date science education standards bot internationally (NGSS Lead States, 2013) and nationally in Israel (Portfolio of Lesson Plans, 2018).

Conceptual framework and background literature

New era of elementary science education

In the United States, the Framework for K-12 Science Education (National Research Council, 2012) and The Next Generation Science Standards (NGSS Lead States, 2013) emphasize science instructional practices (SIP) at the elementary level, recommending that they be rooted in scientific abilities and skills, including scientific thinking, inquiry, the performance of scientific investigation, that each student who learned science at the elementary level must gain as an outcome of learning science, and the facilitation of student interaction with both the content and processes of science, enabling them to behave as active learners. On the one hand, these standards and framework describe what is expected from pupils in science classrooms, but on the other, little guidance is provided for science teachers about how and which SIP to use while teaching science in order to help science learners achieve the expected goals (Martinez et al., 2012; Windschitl et al., 2012).

NGSS Lead States (2013) emphasized that engaging students who learned science in the genuine processes of science and scientific thinking, which include problem-solving, communication, collaboration, and critical and creative thinking, helps them develop an in-

depth understanding of scientific content while preparing them to be scientifically minded and oriented citizens. However, initiating this level of engagement many times is difficult for many teachers, especially at the elementary level, because they lack the required and specific preparation and training and a first-hand understanding of the science processes and of what scientists do (Duschl et al., 2007). This style of teaching often also occurs in direct opposition to the more traditional teaching approaches many teachers experienced in their own learning as students (Schwartz et al., 2000). As a result, elementary teachers rarely implement this type of instructional practice, and those who do are often considered to be going against the grain (Capps & Crawford, 2013; Carlone et al., 2010).

Locally in Israel, Israeli Ministry of Education announced Curriculum portfolio for teaching staff (Portfolio of Lesson Plans, 2018) that emphasized on using new student centered instructional practices in general, and science instructional practices that guaranty students acquisition of up-to-date scientific skills such as performing observation, asking scientific questions, writing scientific argumentation, planning and performing scientific research and so on (Portfolio of Lesson Plans, 2018; Kisa, & Stein, 2015).

Efforts to improve teachers’ delivery of reform-based SIP must recognize that these limitations exist and can add complexity to how and whether reforms are enacted. Efforts toward change should be enacted in a stepwise manner, and incremental goals and gains that are meaningful to the teacher should be put in place (Jones, & Eick, 2007; Loucks-Horsley, 1998). Such an approach provides more opportunity for the teacher to experience success during the implementation process. These efforts should also be informed by context, as it is via their teaching environments that teachers are able to create practical instructional knowledge (Darling-Hammond, 1994; Van Driel et al., 2001). Approaches to this can include peer coaching and collaborative action research (Van Driel et al., 2001). Moreover, a well structured science practicum course that include the collaborative work between the different

partners who are responsible for pre-service science teachers preparation, namely; in-service teachers (tutors) and the academic supervisor, could provide supportive platform in the implementation of new student-centered science instructional reform efforts.

Science instructional practices (SIP)

Measuring science teachers' instructional practices (SIP) is considered one of the most important issues recently concern science education researchers because of the importance of these practices and their effect on students' engagement with and learning of science (Kloser, 2014). Research on science teaching practices has recently gained importance, according to many researchers, as an effective factor for improving student engagement in science learning pathways and achievement because it focuses on the "work of science teaching" (Ball & Forzani, 2009, p. 497; Gallimore et al., 2009; Grossman & McDonald, 2008; Kazemi et al., 2009; Windschitl et al., 2008). For example, Pianta et al. (2008) use instruments such as the Classroom Assessment Scoring System (CLASS) to assess classroom quality in pre kindergarten classes to grade three spectrum based on teacher-student interactions rather than the physical environment or a specific curriculum as a Measure of Effective Teaching (MET). Moreover, Kane and Staiger (2012) indicate that SIP is a better predictor of student achievement than numbers of years of teaching experience or attainment of a master's degree that science teacher had. Science teachers' enactment has an important influence on students' scores and outcomes in learning science and recognizing a core set of pre-service science teachers' SIP will be particularly helpful for effective preparation science teachers in general and in Israel in particular. Generally, foundational SIP may affect the coherence of classroom practice and limit the ability of science teachers and science teacher educators to share a common language and understanding of classroom instruction (Roth & Garnier, 2006).

A wide variety of science instructional methods can be used by science teachers, ranging from those that are teacher-centered to those that are more student-centered (Hayes et al., 2016; Treagust & Tsui, 2014). Hayes et al. (2016) conducted a comprehensive literature review regarding science instructional methods and categorized them into five major areas on a continuum from teacher-centered to student-centered; these are, specifically, (a) Traditional Instruction, (b) Engaging Prior Knowledge, (c) Science Discourse and Communication, (d) Evaluation and Explanation, and (e) Empirical Investigation.

The interactive science practicum course

The interactive practicum course is designed with the goal of strengthening the relationship between the tertiary academic system and the schooling system (Neapolitan & Levine, 2011; Shroyer et al., 2007). It is structured to meet three objectives, namely; (a) advancing science teaching according to up-to-date science teaching strategies, (b) advancing the professional development of student-teachers and their academic supervisor concurrently, and (c) beginning the teaching career from the pre-service stages.

Darling-Hammond (1994) and Van Driel et al. (2001) indicated that teacher preparation program must provide opportunities for collaboration between teachers and university faculty members that can culminate in authentic professional development in situ, including collaborative action research and curriculum development. In light of this theoretical background, the current study examines an interactive science practicum course which created and based on interactions between pre-service science teachers (apprentices), experienced in-service science teachers (tutors), and academic college faculty supervisors (academic supervisor), in order to implement change in the SIP of the apprentices.

Experienced in-service science teachers (tutors) were science teachers with experience of more than 10 years in teaching sciences at elementary level and participated in

professional development courses during the last five years in student-centered up to date science teaching strategies for elementary level according to Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013). Each tutor professionally developed 150 hours in these science teaching strategies during the last five years (30 professional development hours each year).

According to this program, the pre-service science teachers practice two days a week in schools, under the supervision of an experienced in-service science teacher (tutors), to bring together any overlap between the academic level and the schooling level. In this way, affinity will be developed that will allow for better professional development for both pre service and experienced science teachers. The pre-service practicum course is divided into three stages that take place over the course of one year. Table 1 summarizes the details of these stages.

Each day is composed from five practical hours and one workshop hour (six in total); in the practical part the pre-service science teacher perform observations for the tutor, co teaching science, and teaching science according to stage that the pre-service teacher exist (see Table 1), in the workshop hour, the pre-service science teacher, tutor and academic supervisor conduct a workshop about different topic under leadership of the academic supervisor.

Topics are centered on science teaching strategies for elementary level according to Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013). Different teacher preparation scenarios implemented in the workshop in order to bring out pre-service science teacher implement instructional practices during the practical part of the practicum course, for example, but not limited (a) inverted classroom in which pre-service teacher present new science teaching strategy in front of the workshop participants and lead a discussion around it, (a) inquired-class in which a video-taped science lesson for different pre-service science teacher is watched and analyzed by the workshop participants according

to specific pre-defined criteria, (c) roundtable discussion of new science teaching strategy that could be led by the academic supervisor, tutor, and (d) invited external science education expert from the academy or science inspection department of Ministry of Education.

Table 1. Description of the practicum course in science teaching in stages.

Stage	**Details**
1: Preparatory stage: Observations	The student-teachers observe the experienced teacher and write down their reflections so as to learn and build their own science teaching practice. (*Duration: 1 month*)
2: Student teacher assistant stage	The student-teachers take on a partial role in teaching; they help the experienced teacher teach according with his/her original lesson plan. They are responsible for some of the lesson's activities according to the agreement between them and the experienced teacher. (*Duration: 1 month*)
3: Student teacher stage	This is the most important stage. During this stage, the student-teachers: • Prepare lesson plans in cooperation with an in-service science teacher and the academic supervisor. This step includes much back and forth between the three parties to improve the lesson plan and insert any required modifications to render the SIP more *NGSS* oriented. • Teach the planned science lessons at elementary level. • Write a reflection piece about the science lessons they taught and suggest adjustments to implement and make

their SIP more *NGSS* oriented in the future.

• Prepare a reflective portfolio composed of: lesson plans, presentations, teaching aids, assessment tools that they prepared and used, and any other related staff, in addition to their reflections.

As mentioned, pre-service teachers during this stage are apprentices and receive support from an in-service teacher and an academic supervisor for modifying their SIP to help them employ *NGSS* oriented practices

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and teach in alignment with the new science teaching standards (Reiser, 2013). (*Duration: 8 months*)

Materials and methods

Research population

The research population consisted of elementary pre-service science teachers studying B.Ed. in elementary science teaching (pupils of grades one to six) in Al-Qasimi Academic college for teachers' preparation in the Arab sector of Israel.

Research sample

The research sample consisted of 25 second-year pre-service science teachers. The current research was approved by "The Research and Assessment Authority" of the academic college that the pre-service teachers belonged to. Additionally, the participation in the current study was voluntary, which means that each pre-service teacher participated in the study based on his/her own decision, and all the participants signed a participation acceptance letter. Parents of the pupils who studied in the classrooms signed acceptance letters for participation in our research; those who refused to participate were not included in the research.

Research questions

- How are pre-service science teachers' instructional practices affected after participation in the interactive practicum course?
- To what extent are pre-service science teachers' instructional practices aligned with Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013)?

- Which components of the practicum course were responsible for the change(s) in pre service science teachers' teaching practices?

Research tools

To establish an answer to the above research questions, this study employed a mixed-methods approach based on the assumption that a more complete picture could be achieved (Glaser, & Strauss, 1967; Tobin, 1995). The quantitative component consisted of Science Instructional Practices Survey (SIPS) questionnaire developed previously by Hayes et al. (2016). The qualitative component consisted of semi-structured interviews followed by thematic analysis (Nowell et al., 2017) and analysis protocol based on the constructs in Hayes et al. survey (2016) and real-time observations followed by analysis protocol based on the constructs in Hayes et al. survey (2016).

Science instructional practices survey questionnaire

The science instructional practices survey (SIPS) questionnaire was developed by Hayes et al. (2016) and was intended for elementary and middle school science teachers. The survey questions ask teachers to rate the science instructional practices that they apply with their students during science classes. This questionnaire has been used by numerous researchers (e.g., Bancroft et al., 2019; Hayes et al., 2019) to evaluate to what extent science teachers implement NGSS' oriented instructional practices in their science classrooms.

The SIPS questionnaire was translated into Arabic in order to eliminate language difficulties as a source of error in our research results (Cassels & Johnstone, 1984). The internal validity was assessed by sending the translated version to four science education experts to obtain their feedback, and the final version of the SIPS questionnaire was prepared according to that feedback before the dissemination of the final version.

The original and translated SIPS questionnaire consisted of 24 items. Each item offered response options using a 5-point Likert scale, where 1 represented *strongly disagree* and 5 represented *strongly agree*.

Internal consistency checks were conducted for the Arabic version of the SIPS questionnaire by calculating Cronbach's alpha. The reliability test score for the whole questionnaire was 0.82, indicating that it was reliable.

The SIPS questionnaire included six scales of instructional practice, four of them linked to science teaching strategies for elementary level according to Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013), and the other two related to traditional instructional practices not according to Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013); namely, traditional instruction and teaching sciences using prior knowledge of the student. More details about the SIPS questionnaire can be found in Table 2.

Table 2. Descriptive information and reliability values for the SIPS questionnaire (Arabic version)

Group	Scale NGSS Science Education Practice	Sample Item	Items	α Cronbach

Portfolio of Lesson Plans	(2018) and in Instigating an investigation	1) Questioning 3) Planning and carrying out an investigation	Generate questions or predictions to	explore 1–4 0.81

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spirit of NGSS (NGSS Lead States, 2013) oriented SIP Data collection and analysis	explanation, and argumentation 3) Planning and carrying out an investigation 4) Analyzing and interpreting data 5) Using mathematical and computational thinking 6) Constructing explanations 7) Engaging in	argument from evidence Make and record observations	behind an idea 5–9 0.78 10–15	0.81
Critique,		Explain the reasoning		
	Modeling 2) Developing and using	models Use models to predict	outcomes 16–18 0.89	
Non Portfolio of Lesson Plans	(2018) and in spirit of NGSS (NGSS Lead	States, 2013) oriented SIP Traditional instruction	Prior knowledge None Provide direct	

instruction to explain science concepts None Apply science	concepts to explain natural events or real world situations	19–21	0.79	22–24	0.82

Note. NGSS = Next Generation Science Standards.

Administration of SIPS questionnaire

Participation in the current study was voluntary. The pre-service science teachers were asked

to complete the questionnaire twice, once at the beginning of stage three of the practicum course (pre-SIP; Table 1), and once at the end of the second academic year (post-SIP), after completing the practicum course. The respondents were given about 20 minutes to complete the questionnaire.

Semi-structured interviews

Semi-structured interview technique (Merriam, 2009) was used to guide each interview with a sample (n = 10) of pre-service science teachers who had already completed the questionnaire at the end of the academic year and after completion of the practicum course. This allowed for the interview to focus on important topics and provided flexibility in interview topics, such that participants took the conversation down avenues that were salient to them. Pre-service teachers were interviewed to determine (a) how they viewed their role in facilitating science classes in accordance or not in accordance to Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013), (b) which aspects of the practicum course were responsible for the change in pre-service science teachers' teaching practices, and (c) why they employ the specific SIP while they teach science.

Real-time observations

The same pre-service science teachers ($n = 10$) who were interviewed while teaching science at the practicum schools were observed in real-time. The science class duration was 45 min. Each pre-service science teacher was observed twice: once at the beginning of stage three (see Table 1) of the practicum course (pre-SIP), and once at the end of stage three (post-SIP). The observations were video recorded and then type-scribed.

Data analysis

Quantitative data analysis

All the results of the quantitative questionnaires were analyzed statistically. The data from all the questionnaires were recorded on a computer using Excel® and analyzed using the SPSS® program for statistical analysis.

Cronbach's alpha was estimated in order to determine the reliability of the findings. The averages and standard deviations of each of the six factors' scoring were calculated. Following this, a comparison was conducted between the means of each factor for pre- and post-data.

Qualitative data analysis

Analysis of pre-service teacher-student interactions from the videotapes Real-time observations were transcribed, digested, and coded. This methodology was applied to the pre- and post-real-time classroom observations and is similar to the work conducted by Krystyniak and Heikkinen (2007), who analyzed the verbal interactions between students and their instructors during undergraduate science laboratory course. To conduct this analysis, we transcribed all the videotapes, and the transcription accuracy was confirmed by the researcher. All pre-service science teacher-student interactions were identified and noted in the transcripts by the researcher, as well as any intervals, including short pauses (< 15 seconds), long pauses (15–45 seconds), and long silences (> 45 seconds).

All verbal discourse between pre-service science teachers and their pupils was considered as pre-service science teacher-student interaction. Encounters considered to have ended when the conversation topic shifted, and no further pre-service teacher's comments were noted.

Development of categories for pre- and post-real-time observations analysis

We developed categories for analysing videotapes of the verbal discourse between pre service teacher-students and their students while they teach in the science classrooms. We developed analysis protocol based on the constructs in Hayes et al. (2016) survey. Each interaction between pre-service teacher-students and their students was assigned to a suitable scale (code). Pre-service science teacher-students discourses were separately coded by the researcher twice.

To estimate inter-rater reliability, selected portions of transcribed discourses were given to one independent coder together with the preliminary set of codes and directions for coding the transcripts. The coder, a science education researcher who had experience with qualitative research and data coding, was instructed to classify the transcribed discourses and also to identify discourses for which no appropriate scales (codes) had been defined. After completing the task, the external coder and the researcher met to discuss their experiences with the preliminary coding scheme. The coders and researcher agreed on coding assignments for 8 of 9 discourses. Cohen's kappa, an expression of inter-rater reliability, was 0.89 for all coded discourese (Lunn, 1998). The full set of codes and illustrative verbal interactions are summarized in Table 3. The codes for all discourses within each encounter were tabulated and the percentage (frequency) of each coded category was calculated for all pre-service teacher-students discourse.

Table 3. Coding scheme for pre-service-student discourse (inferred from a representative pre service science class) (*based on Hayes et al., 2016, p. 160-161*)

Code	**Examples from the representative pre-service science teachers' discourse during their science lessons**
Instigating an investigation	*"in groups that is composed from 4 students, write down 3 questions, select one of them, and formulant it as a research question"*
Modeling	
Data collection and analysis	
Critique, explanation, and argumentation	

	do think that?” *After student A gave his answer, pre-service-teacher told him: “do you have another explanation”*
Traditional instruction Prior knowledge	*“in groups that is composed from 4 students, design a model that represent effect of climate change on creatures” “using the material that I will distribute them to you, in partners design a model that help us to minimize water pollution”*
“outline the variables that is the research question last lesson and you would like to investigate, define them and decide how to measure them” *“I will distribute a photo cards for two animals, write down two observations about each of them”* *“each student have to measure the height of five colleges together with their ages. Write the in a table age- height”* *Student A says that the temperature increases in the summer seasons, the pre-service science teacher ask him: “why*	*“increasing temperature of the earth cause melting of ice in the poplars, and as a result the height of sea level increases”* *“plants are considered producers in the food network” “animals like elephant, lion are consumers in the food network”* *“in winter, moisture accumulate on our noises, this is because of condensation of our breath”* *“every one of you wash his/her hands with water and soup, because soup can kill germs and bacteria”*

Analysis of semi-structured interviews

The aim of these interviews was to secure a deeper understanding of (a) the reasons that pre service teachers use SIP during their science teaching, (b) which aspects of the practicum course were responsible for the change in pre-service science teachers' SIP, and (d) why they employ the specific SIP while they teach science.

The responses obtained from semi-structured interviews were recorded and then transcribed using Microsoft Word. Transcription was conducted by the researchers with the aid of an online transcription application (https://transcribe.wreally.com/). All identifying information was eliminated from the transcripts.

A narrative content analysis approach was employed to analyze the interview data (Riessman, 2008; Goodson, 2013). We applied the approach of "bathing in the data" (Goodson 2013, p. 40)—the transcripts were read through slowly, recording the main emergent and common ideas, and gauging when the common ideas and conclusions became saturated.

An inductive approach was used. It helped the researchers to achieve descriptions and explanations in accordance with previously mentioned aims of the semi-structured interviews.

Results and discussion

Results of the quantitative part of the study

The means and standard deviations of scores for science teaching practices were calculated for all participants. We divided the teaching practices into two groups; the first consisted of traditional instruction and the use of prior knowledge, which we called "traditional, non Portfolio of Lesson Plans (2018) and not in spirit of NGSS (NGSS Lead States, 2013) oriented SIP," and the second consisted of investigation instigation, data collection and

analysis, critique, explanation, argumentation, and modeling, which we called "Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) oriented SIP." This division was drawn according to the scientific skills that each approach tends to develop within the learner.

The data that we obtained from the SIPS questionnaire were statistically analyzed; pre-SIP data were compared statistically with the post-SIP data using a quantitative *t*-test. The results are shown in Table 4. Table 4 shows that pre-service science teachers significantly changed their science instructional practices after they had experienced the interactive practicum course. More specifically, the use of oriented Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) SIP had significantly increased from the outset of the teacher preparation process in terms of all scales; namely, investigation, data collection and analysis, critique, explanation, argumentation, and modeling. Concurrently, the use of non-oriented Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) SIP significantly decreased from the outset of the teacher preparation process in terms of two scales, traditional instruction and using prior knowledge. These results indicate that the interactive practicum course succeeded in influencing pre-service science teacher SIP to render them more oriented Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013).

Figure 1 presents the SIP for the pre-service science teachers at the end of the practicum course. It is also clear from Figure 1 that SIP for pre-service science teachers after completion of the practicum course were more Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) oriented. Additionally, they were likely to use SIP such as investigation, data collection and analysis, critique, explanation, argumentation, and modeling as new science teaching standards (Reiser, 2013).

Table 4. Statistical comparison of pre-service science teachers pre-SIP and post-SIP

	pre-SIP	*post*-SIP	$t_{(57)}$	p

Group Scale

Mean *SD* Mean *SD*

6.57 ≤ 0.0001 Data Collection and Analysis

Portfolio of Lesson Plans

Instigating an Investigation 2.57 0.63 3.09 0.54

3.61 0.57 3.83 0.52 3.70 0.001

Critique, Explanation, and Argumentation

(2018) and in spirit of

3.77 0.52 4.08 0.43 5.80 ≤ 0.0001

2013)

NGSS

oriented SIP

(NGSS

Modeling 4.14 0.57 4.45 0.48 4.63 ≤ 0.0001

Lead

States,

2013)

oriented SIP

Non

Portfolio of Lesson Plans

Traditional Instruction 4.08 0.45 2.72 0.56

(2018) and in spirit of NGSS

(NGSS

11.05 ≤ 0.0001 Prior Knowledge 3.87 0.65 2.56

Lead

0.71 10.81 0.001

States,

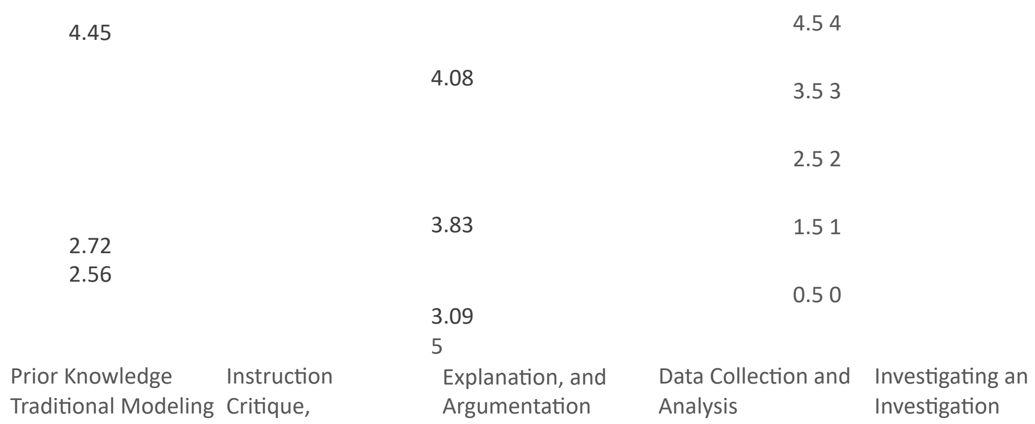

Fig. 1. Mean scores for the Science Instruction Practices of pre-service science teachers after undergoing the practicum course.

Results for the qualitative part of the study

Results of the real-time observation

In addition, we performed real-time observations of 10 science lessons for the 10 pre-service science teachers who were interviewed at the beginning of stage three of the practicum course (pre-), as well as at the end of that stage (post-; at the end of the academic year).

The main aim of the observations was to validate and triangulate the results that we obtained from the quantitative part of the study and to determine whether the situation in reality was similar to the students' answers to the questionnaires.

The average number (mean) of pre-service science teachers-student discourses of the whole ten observed pre-service science teachers' classes was calculated together with the percentages for pre- and post- observations. The results for the observations themselves are presented in Table 5.

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Table 5. Average number and frequency of pre-service science teachers-students discourse.

Group	Scale	*pre*-observation		*post*-observation	
		Mean	%	Mean	%
Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) oriented SIP	Data Collection and Analysis	1.9	8.4	3.7	15.8
	Instigating an Investigation	1.5	6.7	2.6	11.1
	Critique, Explanation, and Argumentation	2.1	9.3	6.8	29.1
	Modeling	2.2	9.8	3.8	16.2
Non Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) oriented SIP	Traditional Instruction	9.2	40.9	3.6	15.4

Prior Knowledge 5.6 24.9 2.9 12.4

Total 22.5 100 23.4 100

We conducted a statistical comparison between pre- and post- observations. Table 6 presents a statistical comparison of pre- and post-discourses between pre-service science teachers and their students of Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) oriented SIP and non-Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) oriented SIP. According to Table 7, it could be said that pre-service science teachers had significantly changed their SIP from teacher centered, old fashioned, non-Portfolio of Lesson Plans (2018) oriented and not in spirit of NGSS (NGSS Lead States, 2013) SIP to student-centred, up to date, Portfolio of Lesson Plans (2018) oriented and in spirit of NGSS (NGSS Lead States, 2013) SIP as a result of the interactive practicum course. This finding could be concluded from the real time observation that we conducted for the pre-service science teachers at the beginning of the practicum course and at the end of it.

Table 6. Statistical comparison between pre- and post- observations.

Group *Pre- Post-* χ^2 *p Mean % Mean %*

Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) oriented SIP

6.5 27.8 17.28 $\leq$ 0.0001

Non- Portfolio of Lesson Plans (2018) and not in spirit of NGSS (NGSS Lead States, 2013) oriented SIP

7.7 34.2 16.9 72.2 16.17 $\leq$ 0.0001 14.8 65.8

25

Results of the semi-structured interviews

Semi-structured interviews with a sample of the pre-service science teachers who had filled out the SIP questionnaire and were observed, were done at the end of the practicum course. The main aim of the interviews was to obtain explanations for the results that we got either from the quantitative or the qualitative tools, namely to better understand (a) why they use the specific SIP that they used while we conduct the real-time observation in his/her classroom, (b) which component(s) of the practicum course were responsible for the change(s) in pre-service science teachers' SIP. During the interviews, the pre-service science teachers were asked (a) to take an example topic that they teach and to describe briefly how do they instruct that topic within the practicum in the school, (b) what are the main component(s) that influence your SIP and let you adapt and implement your gained SIP, (c) what they think is the purpose of teaching science to their students, (d) what they think is the main role of their students during science lessons, (e) what they think is their main role as a science teacher during science lessons.

Regarding the first point to take an example topic that they teach and to describe briefly how do they instruct that topic within the practicum in the school, the following are some sample responses:

- "When I taught the topic: *Types of rocks*, I divided my class into 5 working groups, provided each group with two types of rocks, and ask them students to compare between two types of rocks by themselves."
- "When I teach my students: *plants and their components*, I distribute them into working groups and let each group to gather 3-4 observations about the plant that they get and write down them on a work sheet."

- "For example, when I taught the topic: *water solubility*, I demonstrate in front of my students dissolving salt inside water, then I ask them to write up to 3 questions that interest them that are correlated to that demonstration."

Regarding the question what are the main component(s) that influence your SIP and let you adapt and implement your gained SIP, the following are some sample responses:

- "The guidelines that I got them during our discussion meetings was very helpful for me. During that discussion meetings. I switched my teaching methods many times as a result of the guide that I received after that discussion meetings."
- "I am very thankful to my academic supervisor and my mentor for their continues advise and scaffolding that I get and let me to change my teaching strategies to be up to date."

- “The triangulation between me, the tutor, and the academic supervisor was very helpful and made me change my ideas and make modifications according to the advice and comments that they provided me with all the time.”
- “During the period that I got comments and tips either from the tutor or the academic supervisor, I really changed my teaching methods and strategies dramatically. It can be said that the comments that I got dramatically affected my thoughts and perceptions regarding science teaching.”

Regarding the question what they think is the purpose of teaching science to their students, the following are some sample responses:

- “I think that the main purpose of science teachers nowadays is to enable their pupils to think scientifically and practice scientific skills like the science researchers in any discipline do, such as chemistry, biology, physics….”

- “No doubt that nowadays gaining scientific skills is an important issue that every student who learned science must achieve. Students nowadays are very pleased to ● “I think that it is very important to allow the pupils who learn science to practice scientific practices such as investigations, analyses, etc...

Regarding the question what they think is the main role of their students during science lessons, the following are some sample responses:

- “I changed my perception of my role as a future science teacher. Now, I plan my science lessons taking into my account how I will provide my pupils with scientific skills, which I **did not** use at the beginning of this practicum course.”

- “I think that my students are an important component during my teaching process, I mean that they must participate actively during the science lessons, they must make observations, collect data, ask questions, and so on.”

- “No doubt that the student who learn science must act such as scientist. In order to achieve that we must they them practice those skills which enable them to act such as scientist such as planning investigations, preforming them, gathering data, presenting results and so on.”

Regarding the question what they think is their main role as a science teacher during science lessons, the following are some sample responses:

- “At the beginning of this year, I used to do that compare by myself because I thought that my role is to transfer the digested and ready data to my students, but later I found that this was incorrect as my learned from the workshop meetings.”

- “I think that my role is a facilitator during the science lessons. That means I must help my students, support and advise them to achieve their activities that they perform during the science lessons.”
- “My role is supporter, scaffolder, advisor to my students.”

It can be inferred and induced from the above sample of quotations that the interactive practicum course provides pre-service science teachers with a unique opportunity to change their SIP from teacher-centered, old fashioned SIP, to up-to-date student-centered SIP in accordance with Portfolio of Lesson Plans (2018) and in spirit of NGSS which is suitable for the new era of science teaching worldwide (National Research Council, 2012; NGSS Lead States, 2013). More specifically:

- Pre-service science teachers used up-to-date student-centered SIP in accordance with Portfolio of Lesson Plans (2018) and in spirit of NGSS (NGSS Lead States, 2013) while they teach science.
- The third stage of the practicum course, which includes triangulation between the pre service teacher, the tutor, and the academic supervisor, and was the most influential step in the course, affecting the pre-service science teachers' SIP and causing them to change their SIP.
- Pre-service science teachers perceive that the main goal of learning science is gain scientific skills and to act such as scientists.
- Pre-service science teachers changed their perception as science teacher from providing row scientific data to their students to a teacher who pave the way for them to achieve their objectives and to acquire the required scientific skills.

- Pre-service science teachers put their students at the center of the learning process, they recognize them as the responsible persons for performing the required scientific activities during the science lessons.

Discussion and Conclusions

A new era of science education has begun since the publication and adaptation of the Framework for K-12 Science Education (National Research Council, 2012) and the Next

Generation Science Standards (NGSS) (NGSS Lead States, 2013) in the US, and locally here in Israel since the publication of Portfolio of Lesson Plans (2018). In 2018, Israeli Ministry of Education had published Portfolio of Lesson Plans as a new standard for teaching of the whole disciplines for the new generation of students in general, and science education in particular. In April 2013, the United States released a document detailing the Next Generation Science Standards (NGSS) that set the stage for educational reforms at the national, state, and local levels (NGSS Lead States, 2013). The Next Generation Science Standards (NGSS Lead States, 2013) supply a new and up-to-date science standard that formulated the pathway for teaching and learning science for science students. Both Portfolio of Lesson Plans (2018) and Next Generation Science Standards (NGSS Lead States, 2013) focused not only on student-centered SIP, but also on imparting to students' skills and abilities that are scientifically oriented and typically performed by scientists, such as data collection, critical thinking, scientific explanation, scientific argumentation, and scientific investigation.

Pre-service science teachers play an important role in the science education system, as they are destined to become in-service science teachers after completing their science teacher preparation programs (Boyd et al., 2007; Brownell et al., 2005). Boyd et al. (2007) emphasizes the importance of teacher preparation programs and trace a correlation between

the quality of teachers and the quality of teaching outcomes. Pre-service teacher education programs aim to prepare graduates to become quality teachers equipped with pedagogical practices that will serve to meet the increasing demands associated with the teaching profession (Bransford et al., 2005). Over the last decade, the focus on developing quality teachers has received increased attention in the field of education (Barber & Mourshed, 2009; Bransford et al., 2005; Hattie, 2004). There has been a greater interest in using pedagogical teaching practices that enhance intellectual thinking and problem-solving and foster a sense of belonging and connectedness among students.

The current study examined an interactive science teacher practicum course that was designed to as a part of science teachers' preparation program for pre-service science teachers at the elementary level. This course lasted around one academic year and involved triangulation between three partners: a pre-service science teacher, a tutor, and an academic supervisor. This interactive practicum course was based on ping-pong and multiway advice given to pre-service teachers by both their in-service tutor and academic supervisor during the preparation process.

The current study used a mixed research methodology that included an SIP questionnaire developed and validated by Hayes et. al. (2016), semi-structured interviews, and real-time observation of science lessons for the pre-service science teachers in order to triangulate the effect of this interactive practicum course on the SIP of pre-service science teachers that were in science preparation programs in primary schools toward the completion of their Bachelor of Science Education degrees.

The results of the current study indicate that the interactive practicum course helped pre-service elementary science teachers to shift from traditional teacher-centered SIP to student-centered Portfolio of Lesson Plans (2018) oriented and in spirit of NGSS (NGSS Lead States, 2013) SIP.

Teachers tend to implement traditional old-fashioned instructional practices while they teach science (Crawford, 2007; Davis et. al., 2006; Jones & Leagon, 2014; Luft, & Roehrig, 2007; Marshall et. al., 2010; Van Driel et. al., 2014). This argument call and require us to build a continuous and interactive practicum course that bring science teachers to change their beliefs and implement new and up to date science instructional practices. The current study investigated an interactive practicum course that led pre-service science teachers during their clinical stage to change their SIP from old-fashioned to up to date in accordance with the new science education standards (Portfolio of Lesson Plans, 2018; National Research Council, 2012). Moreover, pre-service science had changed their perception about their role and their students role during the science classes, they also developed a new perception about the main role of science education to the new generation of science students.

The emergence of consensus that demand and emphasized the shift from viewing science teacher education as a training problem (i.e., train pre-service science teachers to carry out specific tasks) to a learning problem (i.e., teach pre-service science teachers to think like a teacher) (Loughran, 2007; 2014) lead us to think about how the thinking of pre-service science teachers has changed during their teacher education course. The current study found that the triangulation between the three partners of the practicum course; namely, the pre service teacher, the tutor and the academic supervisor from one side and the different and multiple mentoring tactics had led pre-service science teachers to change their SIP and implement to what they exposed.

Hutner et. al. (2021) investigated the alignment of goals of preservice science teachers with the instructional practice emphasized in teacher education, they found in their study that preservice science teachers adopt goals reflective of many, but not all, of the pedagogical strategies emphasized in teacher education. It is found in the current study that pre-service

science teachers who learned the interactive practicum course had significantly changed their science instructional practice.

It is worth noting that starting to work with science teachers at the teacher preparation stage (Levine, 2006; Musset, 2010; Windschitl & Stroupe, 2017) and during their practicum course, when they are the most susceptible to guidance and influence, is a very useful means of affecting change and ensuring the implementation of the desired SIP in teachers' science lessons, given that this stage is the most pivotal in characterizing the future instructional practices adopted by teachers.

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Declaration of interest

No conflicting interests existed between the participants of the current study and the research either in direct or indirect manner.

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