**Instructional Practices of Science Teachers**

**from the Arab community in Israel**

**Abstract**

The importance of science teachers’ content knowledge and pedagogical knowledge for students’ learning of sciences has received much attention among science education researchers and educators. Despite the importance of these topics, they are still not sufficient to predict teachers’ impact on students’ learning of science.

Science instructional practices and research related to them are important issues that attract researchers and policy makers in education and particularly in science education. Many countries around the world have established reforms in science teaching and learning, including science teaching practices. For instance, in the United States, new standards for science education, the Next Generation Science Standards (NGSS), were established in many states in 2013. Similarly, in Israel, Package for Learning Plans were published by the Israeli Ministry of Education in 2018 and emphasized using science education to develop scientific skills among learners and establish a new era of student-centered instructional strategies.

Science education in the Arab community in Israel is considered an important discipline. It is an essential lever of the whole educational system. Previous research has shown that Arab teachers regularly use teacher-centered teaching strategies. This study aimed to identify science instructional practices used by Arab science teachers through the lens of the NGSS and how these practices are affected by a teacher’s number of years of experience.

This research used mixed methods. The quantitative part was based on the Science Instructional Practices Survey and found that Arab science teachers mainly reported using traditional, non-NGSS instructional practices such as direct instruction, demonstration, and worksheet or textbook work, whereas they used NGSS science teaching practices such as empirical investigations and critique, explanation, and argumentation significantly less often.

In addition, novice teachers reported significantly more use of NGSS science teaching practices than did teachers with more experience. This difference was attributed to the type of program each group participated in during their teacher preparation period.

**Introduction and Rationale**

Science teaching methods play an important role in shaping the skills and abilities the pupil gains as a result of participating in science learning classes (Hayes, Lee, DiStefano, O’Connor, & Seitz, 2016). In the United States, the National Research Council (2012) and the Next Generation Science Standards (NGSS) (National Research Council, 2013) call for significant shifts in science teaching from traditional teacher-centered approaches that include 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 (National Research Council, 2013).

In 1983, the U.S. National Commission on Excellence in Education published *A Nation at Risk*, and as a result, reforms were adopted that aimed to raise the science achievement of all students by applying new higher standards regarding science teaching in the United States (Von Secker & Lissitz, 1999). In 1996, the National Research Council published the *National Science Education Standards*, a document that provided guidelines for effective science instruction at that time. The standards called for a pedagogical shift from teacher-centered science instructional methods such as direct large-group instruction, demonstration, and worksheet or textbook work, which have not been shown to be effective for teaching higher-order thinking and problem solving (Anderson, 1997; Darling-Hammond, 1996), to student-centered methods that enable students to use more socially interactive scientific inquiry and scientific thinking skills in their daily lives.

For more than three decades, experts and researchers in science education have emphasized the importance of science teachers’ instructional practices (for example, Darling-Hammond, 1996; Grossman et al., 2009; National Research Council, 1996, 2012, 2013; Rutherford & Ahlgren, 1990) on any reform in science education. In-service and preservice teacher educators are involved in supporting shifts in teaching practices toward the NGSS standards that focus on student-centered instructional practices (Huffman, Thomas, & Lawrenz, 2003). Instruction that emphasizes inquiry as an essential precursor to scientific understanding is very different from the teacher-centered courses and vocabulary-dense texts that were typical of high schools in the 1990s (Von Secker & Lissitz, 1999). Student-centered instruction, which is characterized by inquiry and discussion of open-ended questions, is expected to be more effective for promoting a deep understanding of science (Tekkumru Kisa & Stein, 2015).

***Conceptual Framework and Background Literature***

Measuring science teachers’ instructional practices has recently been considered an important issue because of their importance and influence on students’ engagement in and learning of science (Kloser, 2014). Moreover, research on teaching practice has recently gained importance among many researchers as an effective factor for improving student achievement and engagement in the learning process because it focuses on the “work of teaching” (Ball & Forzani, 2009, p. 497; Gallimore, Ermeling, Saunders, & Goldenberg, 2009; Grossman & McDonald, 2008; Kazemi, Franke, & Lampert, 2009; Windschitl, Thompson, & Braaten, 2008). For example, Pianta, La Paro, and Hamre (2008) used measures of effective teaching such as the Classroom Assessment Scoring System to assess classroom quality in prekindergarten through grade three based on teacher–student interactions rather than the physical environment or a specific curriculum. Moreover, Kane and Staiger (2012) indicated that science teachers’ practices are better predictors of student achievement than years of teaching experience or attainment of a master’s degree. Science teachers’ enactment has an important influence on students’ scores and outcomes in learning sciences, and recognizing a core set of Arab science teachers’ instructional practices will be particularly helpful for Arab science teachers in Israel. Common, foundational science instructional practices 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 methods 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 discovered that these can be categorized into five major areas on a continuum from teacher-centered to student-centered—specifically, (a) traditional instruction, (b) engaging prior knowledge, (c) science discourse and communication, (d) evaluation and explanation, and (e) empirical investigation.

***Science Education in the Arab Sector in Israel—Ethnic Perspectives***

Israel’s multicultural composition may be said to reflect the whole spectrum of the global continuum because of its subcultural variation, ranging from the culture of Jews of Western origin (e.g., Europe and America), which is characterized as the most individualistic, to Jewish culture of Eastern origin (e.g., Africa and the Middle East), then to the Christian Arab culture, followed by the Druze, and finally to the minority culture considered most collectivist—the Muslim Arab culture (including Bedouin). Israeli Arabs and Druze, composing altogether about 20% of the Israeli population, live in a collectivist society that is characterized by Arab and Jewish researchers alike as being progressively influenced by the individualistic culture of the Jewish majority (Al-Haj, 1995; Brodai & Israelashwili, 1998; Buda & Elsayed-Elkhuoly, 1998; Florian, Mikulincer, & Weller, 1993).

The Arab collectivist view traditionally places great emphasis on the authority of teachers and adults and on the need for respect. In this traditional society, learning and children’s obedience to adults is highly regarded (Al-Haj, 1995; Eilam, 2002; Haj-Yahia, 1995).

Arab schools in Israel are characterized by a high level of formality (Abu-Asbah, 2007). Moreover, Abu-Asbah (2007) indicated that teaching strategies in Arab schools in Israel are based mainly on frontal, traditional instruction or teacher-centered teaching methods, although there are increased calls to use alternative teaching strategies.

According to Abu-Asbah (2007), classrooms in the Arab sector in Israel are characterized by the following:

1. The teacher is always correct. This perception prevents students from critical discourse with their teacher and from critical and creative thinking. This type of instruction can be called autocratic.
2. No attention is given to the different individuals in the classroom.
3. High-achieving students are those who mainly manipulate discourse with the teacher, whereas low achievers do not and stay behind alone.
4. The ability to accommodate a frontal-oriented classroom is very limited, and thus, the gaps between students are growing more and more.

A comparative study conducted by Dkeidek, Mamlok-Naaman, and Hofstein (2010) revealed significant differences related to question-asking behavior of students in chemistry laboratory classrooms. The researchers found that in general, the number of questions asked by Arab students in an inquiry-type chemistry laboratory was significantly lower compared with their Jewish counterparts. Moreover, Dkeidek et al. (2012) found in a comparative study that Arab teachers perceive themselves to be the key to the learning process and the responsible person during their teaching. In addition, because of students’ inability and uncertainty, Arab teachers usually perceive students as help-seekers and support-askers.

In a recent comparative study, Gross and Issa (2020) examined the disciplinary knowledge of science teachers from the Jewish and Arab communities in Israel and found that academic achievements of Arab teachers are significantly higher than those of Jewish teachers; this finding is contrary to the results of international surveys (for example, PISA) that test scientific knowledge of students in elementary and middle schools and find that the scores of Jewish students are significantly higher than those of students in the Arab community. Gross and Issa attributed this inconsistency to other aspects of the teaching and learning process, such as the effect of culture and science teaching practices within Arab science classrooms.

***Research Questions***

This study aimed to address the following questions:

1. What science instructional practices do Arab teachers in Israel use in elementary and middle school science classes?
2. How do the science instructional practices used by Arab teachers in elementary and middle school science classes in Israel align with NGSS science instructional practices?
3. How are science instructional practices affected by the number of years of experience that the Arab teacher has?

**Methods**

***Participants***

In Israel, Arab teachers mainly teach in the segregated schools Arab students learn in (Dkeidek et al., 2012). The research population consisted of science teachers from the Arab sector in Israel who were teaching in Arab schools only.

The research sample included a total of 78 in-service Arab science teachers from Israel, who were teaching middle and high school science in 28 schools. The characteristics of these teachers are presented in Table 1.

All 78 science teachers completed the questionnaire for the quantitative data analysis, and 8 of these teachers participated in the qualitative part of the study.

Table 1

*Characteristics of the Research Sample*

|  |  |
| --- | --- |
| Characteristics | *N* = 78 |
| Males (%) | 12.8 |
| Females (%) | 87.2 |
| Mean (SD) number of years of experience in science teaching | 12.72(3.93) |
| Percentage who participated in professional development in the previous 3 years | 58.3 |

***Research Instruments***

This study used a mixed-methods approach. The quantitative component was conducted using the Science Instructional Practices Survey (SIPS) developed by Hayes et al. (2016), and the qualitative part was conducted using semistructured interviews.

***Science Instructional Practices Survey Questionnaire***

The SIPS questionnaire (Hayes et al., 2016) was intended for elementary and middle school science teachers. The survey questions ask teachers to rate the science instructional practices they use with their students during science teaching and learning classes. This questionnaire has been used previously (e.g., Bancroft, Herrington, & Dumitrache, 2019; Hayes, Wheaton, & Tucker, 2019;) to evaluate the application of science teachers’ NGSS instructional practices within science classrooms.

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

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

Internal consistency was conducted for the Arabic version of the SIPS questionnaire by calculating Cronbach alpha. The result of the reliability test for the whole questionnaire was 0.812, which indicated that it was reliable.

The SIPS questionnaire includes six scales of instructional practice, four of them linked to NGSS science instructional practices and the other two related to traditional, non-NGSS instructional practices: namely, traditional instruction and teaching science using the students’ prior knowledge. More details about the SIPS questionnaire can be found in Table 2.

In addition, the survey collected background information about the teachers, including sociodemographic characteristics such as age and gender, seniority in science teaching, and whether they had participated in professional development in science teaching during the previous three years.

Table 2

*Characteristics of the Research Sample*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  Group | Scale | NGSS Science Education Practice | Sample Item | Items |
| NGSS Practices | Instigating an investigation | 1) Questioning3) Planning and carrying out an investigation | Generate questions or predictions to explore | 1–4 |
| Data collection and analysis | 3) Planning and carrying out an investigation4) Analyzing and interpreting data5) Using mathematical and computational thinking | Make and record observations | 5–9 |
| Critique, explanation, and argumentation | 6) Constructing explanations7) Engaging in argument from evidence | Explain the reasoning behind an idea | 10–15 |
| Modeling | 2) Developing and using models | Use models to predict outcomes | 16–18 |
| Non-NGSS Traditional Practices | Traditional instruction | None | Provide direct instruction to explain science concepts | 19–21 |
| Prior knowledge | None | Apply science concepts to explain natural events or real-world situations | 22–24 |

*Note*. NGSS = Next Generation Science Standards.

***Semistructured Teacher Interview***

Semistructured interviews with eight of the Arab science teachers were conducted to better understand how they viewed their role during their instruction in the science classes and the reasons for the responses obtained from quantitative or qualitative data.

***Administration of the SIPS Questionnaire***

Participation in the current study was voluntary. Teachers had approximately 15 to 20 minutes to complete the optional questionnaire.

**Data Analysis**

***Quantitative Data Analysis***

The results of the quantitative questionnaires were analyzed statistically. Data from the questionnaires were recorded using Microsoft Excel and analyzed using the SPSS Statistics software program for statistical analysis.

Cronbach alpha was estimated to determine the reliability of the findings.

The mean scores and standard deviations of each of the six individual factors were calculated, and a comparison between the means of the factors was done using one-way ANOVA and *t* tests.

***Qualitative Data Analysis***

Semistructured interviews were conducted with a sample of the teachers who completed the questionnaire. The responses were recorded and then transcribed using Microsoft Word. The aim of these interviews was to understand the science teachers’ reasons for selecting the specific science instructional practices they used during science classes.

**Results and Discussion**

***Average Rating of Science Instruction Practices***

The means and standard deviations of the scores for each of the six instruction-practice areas were calculated; the results are presented in Figure 1.



*Figure 1*.Means and Standard Deviations of Scores for Science Instruction Practices.

One-way ANOVA was conducted to test statistical differences between the six instructional practices. Tukey post hoc tests were conducted to identify the source of the differences between the instructional practices. The results showed a significant difference between all scales of the science instructional practices (F[5,78] = 6.3, *p* < .01) except data collection and analysis and critique, explanation, and argumentation.

As shown in Figure 1, the mean scores for prior knowledge and traditional instruction, which are not correlated to NGSS scientific skills, were the highest, whereas the mean scores of the other four practices (instigating an investigation, data collection and analysis, critique, explanation, and argumentation, and modeling), which are directly in the spirit of NGSS, were significantly lower.

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 contained traditional instruction and prior knowledge, which we called traditional, non-NGSS science teaching practices, and the second contained instigating an investigation, data collection and analysis, critique, explanation, and argumentation, and modeling, which we called NGSS science teaching practices. The division was made according to the scientific skills that each practice develops within the learner. A paired-sample *t* test was performed to test statistical differences between the two groups (NGSS practices and traditional, non-NGSS practices); the results are presented in Table 3.

Table 3

*Statistical Differences Between Groups of NGSS and non-NGSS Science Teaching Practices Used by Arab Teachers*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Teaching Practices | Mean (SD) Score | *t*(78) | *p* |
| NGSS | 3.20 (0.49) | 1.79 | < .01 |
| non-NGSS | 4.41 (0.69) |

*Note*. NGSS = Next Generation Science Standards; SD = standard deviation.

As shown in Table 3, Arab science teachers tend to use non-NGSS science teaching practices significantly more than NGSS science teaching practices, despite the national and international call to follow standards based on new-era NGSS science teaching practices (Beernaert et al., 2015; National Academies of Sciences, Engineering, and Medicine, 2015; National Research Council, 2012, 2013; Paniagua & Istance, 2018).

We conducted semistructured interviews with a sample of the teachers who completed the SIPS questionnaire to understand how they perceive their role and their pupils’ role and the reasons for their science instructional behaviors. The following are some sample responses:

* “*I think that pupils must know the scientific knowledge in order to well understand sciences.*”
* “*The main purpose of pupil participation in science classes is to gain scientific knowledge, such as facts, rules, principles…*”
* “*If pupils did not remember the knowledge that they learned from science classes, there is no gain from these classes and the pupils will not benefit at all.*”
* “*My role as a science teacher is to give my pupils scientific data that they need in order to become scientifically-oriented people in their community.*”
* “*The first and major responsibilities of science teachers is to transfer scientific data to their pupils.*”

It could be inferred from the sample interview responses that Arab science teachers perceive their role as being transmitters of scientific knowledge and data to their pupils, and they seem to think that their pupils have to gain that scientific knowledge in a passive manner.

The last research question was “How are science instructional practices affected by the number of years of experience that the Arab teacher has?” We divided the participants into two groups: group 1 (expert teachers) had more than 10 years of experience in science teaching, and group 2 (novice teachers) had less than 10 years.

Independent *t* tests were conducted to identify significant differences between these two groups within the NGSS and non-NGSS instructional practice groups. The results are presented in Table 4.

Table 4

*Statistical Comparison Between Expert and Novice Teachers Regarding Using NGSS and Non-NGSS Science Teaching Practices*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Teaching Practices | Novice Teachers, Mean (SD) Score | Expert Teachers, Mean (SD) Score | *t*(78) | *p* |
| NGSS | 3.58 (0.61) | 3.07 (0.73)  | 2.10 | < .01 |
| Non-NGSS | 4.38 (0.59) | 4.39 (0.54) | 0.51 | .39  |

*Note*. NGSS = Next Generation Science Standards; SD = standard deviation.

Table 4 shows that novice teachers used significantly more NGSS practices during science teaching than their counterpart expert teachers, whereas there were no significant differences between these two groups in traditional, non-NGSS science teaching practices.

Moreover, an independent *t* test was conducted to compare expert and novice science teachers regarding their science teaching practices in the six scales. The results are presented in Table 5.

Table 5

*Differences in Science Instructional Practices Between Novice and Expert Teachers*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  Scale  | Expert Teachers (*n* = 45), Mean (SD) Score | Novice Teachers (*n* = 33), Mean (SD) Score | *t*(78) | *p* |
| Instigating an Investigation | 3.24 (0.75) | 3.78 (0.62) | 2.86 | <.01 |
| Data Collection and Analysis | 3.12 (0.88) | 3.33 (0.88) | 1.06 | <.01 |
| Critique, Explanation, and Argumentation | 3.04 (0.70) | 3.44 (0.61) | 3.23 | <.01 |
| Modeling | 2.91 (0.84) | 3.81 (0.97) | 1.26 | <.01 |
| Traditional Instruction | 4.27 (0.59) | 4.22 (0.59) | 0.42 | .68 |
| Prior Knowledge | 4.48 (0.58) | 4.56 (0.48) | 0.60 | .54 |

Table 5 shows that novice teachers used instigating an investigation, data collection and analysis, critique, explanation, and argumentation, and modeling teaching strategies significantly more often (mean [SD] score = 3.78 [0.62]) than their counterpart expert teachers (mean [SD] score = 3.24 [0.75], *p* < .01).

The results shown in Tables 4 and 5 might relate to the fact that novice teachers finished their teacher preparation program more recently and had already gained and prepared up-to-date NGSS science teaching strategies, whereas expert teachers finished their preparation programs more than 10 years earlier (before the year 2010), and it is probable that at that time, science education standards were different from up-to-date science education standards (National Research Council, 1994; Schoen, 1987; Shulman, 1987). Accordingly, the science teaching practices the expert teachers primarily used were traditional, non-NGSS practices.

**Summary, Conclusions, and Recommendations**

The current study examined the science instructional practices Arab teachers in Israel use in elementary and middle school science classes and how they are aligned to the new and up-to-date NGSS science instructional practices. Moreover, science teaching practices were compared between novice and expert teachers.

This study found that Arab science teachers in Israel seem to use non-NGSS science teaching practices, such as traditional instruction and using students’ prior knowledge, significantly more than NGSS instructional practices such as instigating an investigation, data collection and analysis, critique, explanation, and argumentation, and modeling. This finding is in parallel to Abu-Asbah (2007), who indicated that teaching strategies in Arab schools in Israel are based mainly on frontal, traditional instruction and teacher-centered teaching methods, although there are increased calls to use alternative teaching strategies. Markic et al. (2016) found in a comparative study that Israeli Arab chemistry teachers’ beliefs about the chemistry classroom are very self-centered, in contrast to the modern science education teaching standards that call for student-centered NGSS science teaching practices (National Academies of Sciences, Engineering, and Medicine, 2015; National Research Council, 2013). In this study, Arab science teachers’ reports about their science teaching practices were teacher-centered and transmission-oriented, as was described for chemistry teachers in other Arab societies (Al-Amoush, Markic, & Eilks, 2012; Al-Amoush, Usak, Erdogan, Markic, & Eilks, 2014).

In a similar manner, Dkeidek et al. (2012) found that Arab teachers in Israel perceive themselves to be the key to the learning process and the responsible person during their teaching. This perception seems to lead them to use non-NGSS science teaching practices that focus on traditional instruction and using students’ prior knowledge, with less focus on NGSS science teaching practices that require students to perform investigation, data collection, criticism and argumentation, and modeling. This seems to be a result of the teachers’ perception of their students as help-seekers and support-askers owing to students’ inability and uncertainty (Dkeidek et al., 2012).

Moreover, the current study found that novice Arab science teachers seem to use up-to-date instructional practices such as instigating an investigation, data collection and analysis, critique, explanation, and argumentation, and modeling more than traditional, non-NGSS practices. This finding was attributed to the fact that the novice teachers finished their science teacher preparation programs more recently, and it is probable that they had more exposure to new NGSS-oriented science teaching practices than did expert teachers who had finished their science teacher preparation programs more than 10 years ago and at that time gained science teaching practices that are less NGSS oriented.

These findings suggest that it could be highly beneficial for Arab science teachers in Israel, especially those with more teaching experience, to participate in professional development programs to gain up-to-date, NGSS-oriented science instructional practices such as instigating an investigation, data collection and analysis, critique, explanation, and argumentation, and modeling and implement them during their science teaching, thus bringing their students to such a level that they obtain these 21st-century skills and meet the Next Generation Science Standards (National Research Council, 2013).

**References**

Abu-Asbah, K. (2007). *The Arab education in Israel: Dilemmas of a national minority*. Jerusalem: The Floersheimer Institute for Policy Studies.

Al-Amoush, S., Markic, S., & Eilks, I. (2012). Jordanian chemistry teachers’ views on teaching practices and educational reform. *Chemistry Education Research and Practice, 13*, 314–324.

Al-Amoush, S., Usak, M., Erdogan, M., Markic, S., & Eilks, I. (2014). Beliefs about chemistry teaching and learning—A comparison of teachers and student teachers from Jordan, Turkey and Germany. *International Journal of Science and Mathematics Education, 12*, 767–792.

Anderson, O. R. (1997). A neurocognitive perspective on current learning theory and science instructional strategies. *Science Education, 81*, 67–89.

Bae, C. L., Hayes, K. N., & DeBusk‐Lane, M. (2019, December 30). Profiles of middle school science teachers: Accounting for cognitive and motivational characteristics. *Journal of Research in Science Teaching,* 1–32.

Bancroft, S. F., Herrington, D. G., & Dumitrache, R. (2019). Semi-quantitative characterization of secondary science teachers’ use of three-dimensional instruction. *Journal of Science Teacher Education, 30 (4)*, 379–408.

Beernaert, Y., Constantinou, C., Deca, L., Grangeat, M., Karikorpi, M., Lazoudis, M., … Welzel-Breuer, M. (2015). *Science education for responsible citizenship*. Luxembourg: Publications Office of the European Union.

Cassels, J. R. T., & Johnstone, A. H. (1984). The effect of language on student performance on multiple choice tests in chemistry. *Journal of Chemical Education*, *61*(7), 613–615.

Darling-Hammond, L. (1996). The right to learn and the advancement of teaching: Research, policy, and practice for democratic education. *Educational Researcher, 25*, 5–17.

Dkeidek, I., Mamlok-Naaman, R., & Hofstein, A. (2010). Effect of culture on high-school students’ question-asking ability resulting from an inquiry-oriented chemistry laboratory. *International Journal of Science and Mathematics Education, 15*, 59–85.

Dkeidek, I., Mamlok-Naaman, R., & Hofstein, A. (2012). Assessment of the laboratory learning environment in an inquiry-oriented chemistry laboratory in Arab and Jewish high schools in Israel. *Learning Environments Research, 15*, 141–169.

Gross, T., & Issa, N. (2020). Disciplinary knowledge of science teachers at different stages of professional development in the Jewish and the Arab sectors. *Daphemm*, *72*, ISSN: 1565-5385.

Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. (2009). Teaching practice: A cross-professional perspective. *The Teachers College Record, 111*(9), 2055–2100.

Haj-Yahia, M. M. (1995). Toward culturally sensitive intervention with Arab families in Israel. *Contemporary Family Therapy, 17*(4), 429–447.

Hayes, K. N., Lee, C. S., DiStefano, R., O’Connor, D., & Seitz, J. C. (2016). Measuring science instructional practice: A survey tool for the age of NGSS. *Journal of Science Teacher Education, 27*, 137–164.

Hayes, K. N., Wheaton, M., & Tucker, D. (2019). Understanding teacher instructional change: The case of integrating NGSS and stewardship in professional development. *Environmental Education Research, 25*, 115–134.

Huffman, D., Thomas, K., & Lawrenz, F. (2003). Relationship between professional development, teachers’ instructional practices, and the achievement of students in science and mathematics. *School Science and Mathematics, 103*, 378–387.

Markic, S., Eilks, I., Mamlok-Naaman, R., Hugerat, M., Kortam, N., Dkeidek, I., & Hofstein, A. (2016). One country, two cultures—A multi-perspective view on Israeli chemistry teachers’ beliefs about teaching and learning. *Teachers and Teaching: Theory and Practice*, *22*(2), 131–147.

National Academies of Sciences, Engineering, and Medicine. (2015). *Science teachers learning: Enhancing opportunities, creating supportive contexts*. Washington, DC: National Academies Press.

National Commission on Excellence in Education. (1983). *A nation at risk*. Washington, DC: U.S. Department of Education.

National Research Council. (1994). *Learning, remembering, believing: Enhancing human performance*. D. Druckman and R. A. Bjork, eds. Washington, DC: National Academy Press

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

National Research Council. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press.

Paniagua, A. & Istance, D. (2018). *Teachers and designers of learning environments: The importance of innovative pedagogies*. Paris: OECD Center for Educational Research and Innovation.

Rutherford, F. J., & Ahlgren, A. (1990). *Science for all Americans*. New York: Oxford University Press.

Schoen, D. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. San Francisco: Jossey-Bass.

Shulman, L. S. (1987). Knowledge and teaching foundations of the new reform. *Harvard Education Review, 57*(1), 1–22.

Tekkumru Kisa, M. T., & Stein, M. K. (2015). Learning to see teaching in new ways: A foundation for maintaining cognitive demand. *American Educational Research Journal*, *52*(1), 105–136.

Von Secker, C. E., and Lissitz, R.W. (1999). Estimating the impact of instructional practices on student achievement in science. *Journal of Research in Science Teaching*, *36*, 1110–1126.