Science Teachers' and Their Students' Perceptions of Science and Scientists

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Abstract

The purpose of this study was to explore school science teachers' and their students' perceptions of science and scientists. The participants included 116 in-service middle school chemistry teachers who attended a training program at the Faculty of Education, Lebanese University, and 250 of their students, randomly selected from a larger sample of 2345, enrolled in Grades 7-9 at Lebanese public schools all over Lebanon. Using the Draw-a-scientist-test (DAST), qualitative and quantitative data was collected from the participating teachers and their students. The teachers themselves administered the test to their students. Results showed that the stereotypical image of a scientist being a Caucasian, male, working in a lab, and conducting experiments mainly in chemistry were prevalent. There was absence of contemporary scientists and female scientists among the preferred names of scientists delivered by the students. The participants held positive attitudes towards scientists and many students were usually positive about pursuing careers in science and technology. Compared to their teachers, more students thought that scientists make inventions in the field of technology. Students in lower grades had more diverse images of scientists. The stereotypical images increased among students of higher grades and became more similar to those of their teachers and the authors of the textbooks that they use.

Introduction

The main purpose of this study was to explore Lebanese in-service science teachers' and their students' perceptions of science and scientists in order to understand how they perceived scientists and what (stereotypical) images they did possess. The participating teachers were middle school chemistry teachers and their students were enrolled in Grades 7, 8 and 9. Considering that the participating teachers were the ones who taught science and about scientists to the participating students, one focus of the study involved exploring how the teachers' perceptions of scientists compare to those of their students. Initially proposed by Chambers (1983), Draw-A-Scientist-Test (DAST) and its various versions have been used in many research studies in various contexts to study perceptions of scientists held by science teachers (McDuffie, 2001) as well as students (e.g., Sjøberg 2000; Villar & Guppy 2015), including those at the primary (Painter & Tretter, 2006) and middle school levels (e.g., Fralick, Kearn, Thompson & Lyons, 2009). Participants' stereotypical images of scientists were a common finding in these studies.

Among the stereotypes possessed by elementary and middle school students are that scientists are white Caucasian (Barman 1999) and males (Akcay, 2011; Barman, 1999; Jane, Fleer & Gipps, 2007). These students often perceive scientists as weird, bad and mad people (Jane, Fleer & Gipps, 2007), who work alone (Barman, 1999), and who conduct experiments indoors (Akcay, 2011; Camci-Erdogan, 2019; Erten, Kiray & Sen-Gumus, 2013; Fralick, Kearn, Thompson & Lyons, 2009; Jane, Fleer & Gipps, 2007). Students at different grade levels have stereotypical image of scientists (e.g., Archer, DeWitt, Osborne, Dillon, Willis & Wong, 2010; Cakmakci, Tosun, Turgut, Orenler, Sengul & Top, 2011). However, as children progress to higher grade levels their images of scientists become more stereotypical (Finson & Beaver, 1995). In a study conducted with grade 3-10 students across 5 countries, fewer stereotypes were reported among lower grades compared to higher grades (Narayan, Park, Peker & Suh, 2013). Certain factors such as age (Fung, 2002), culture (Christidou, Bonati & Kontoloulou, 2016), gender (Ajai & Imoko, 2015; Samaras, Bonoti, & Christidou, 2012; She, 1988), and socioeconomic status (Baldu, 2006) seem to play a role in shaping the stereotypical images of scientists that students possess.

Some level of similarity has been reported in images of scientists among participants of different studies conducted in various parts of the world (Sjøberg, 2000; Sjøberg & Schreiner, 2006; She, 1998; Song & Kim, 1999). The present study could be thought about as a platform for DAST in Lebanon, considering that no precedent studies were conducted on a large-scale basis not only in Lebanon but also in many other Arab countries. This is not surprising considering the scarcity of published research in science education in general that comes out of the Arab world (Ayoubi, 2017). In this study the Lebanese context was scrutinized, with the purpose of identifying similarities that it shares with other contexts and highlighting particularities that it may have.

Stereotypical images of scientists are also present among pre-service and in-service science teachers. The stereotypical images that they hold are related to their learning experiences as students (Elmas, Demirdogen & Geban, 2011). In a study conducted at a Turkish university, Ünver (2010) reported that 4th year pre-service science teachers had more stereotypical views of scientists than grade 5 students. The pre-service teachers depicted scientists with glasses, beard, a white coat and a dishevelled appearance. Based on a study with 550 pre- and in-service science teachers, McDuffie (2001) reported most drawings depicted middle-aged males and almost half showed scientists to be intelligent and wearing white coats. McCarthy (2015), on the other hand, based on a study with pre-service science teachers enrolled in a College of Education at a university in Louisiana, USA, reported that about half of the 91 participants drew female scientists, and most drawings showed happy scientists. Nonetheless, the researcher reported absence of diversity in the drawings.

Despite a considerable amount of research on students' perceptions of scientists, there exist few studies comparing elementary school students' perception with those of teachers (e.g., Moseley & Norris, 1999). Our sample aimed at comparing upper elementary and lower middle school students' perceptions of scientists with those of their teachers. The comparison of these two populations is significant in terms of the assumption that the teachers' perceptions of scientists influence their students' perception of scientists, considering that the teachers are the ones who teach science and about scientists to the elementary students. The study aimed at contributing to the literature of comparative studies between teachers' and students' perceptions of scientists and at setting forth implications for science teacher education.

Many researchers interested in studying teachers' epistemic beliefs seem to share the assumption that teachers' epistemic beliefs may affect their teaching practices (Abu Karsh, 2018; Ayoubi et al. 2017; Pajares, 1992; Uhomoibhi & Ross, 2018) and this affects their students' understanding of science concepts and subsequently of their perceptions of science and scientists (Wells, 2015). Nevertheless, no significant correlation was reported between middle school teachers' teaching style and their students' perceptions of scientists (Finson, Pedersen & Thomas 2006). Jane, Fleer, and Gipps (2007) highlighted the role of the communal context and children's engagement in hands-on, authentic and relevant scientific activities as requirements to challenge students' views about scientists.

The Lebanese science curriculum underemphasizes science as a way of knowing (BouJaoude, 2002). On the other hand, the scientists portrayed in the Lebanese national science textbooks are predominantly white males of European descent, rational individuals who work alone, who conduct experiments in their labs by following the scientific method (Yacoubian, Al-Khatib & Mardirossian 2017). Despite some existing literature on science curricula and textbooks, little is known about the science teachers' and their students' perceptions of scientists. Hence, the research questions of this study were as follows:

1. What are Lebanese in-service science teachers' perceptions of scientists?
2. What are Lebanese students' perceptions of scientists?
3. Do Lebanese students have similar perceptions of scientists as their teachers?

Method

The Lebanese Ministry of Education and Higher Education cooperates with the Faculty of Education, Lebanese University, in training in-service teachers of public schools in Lebanon. The first author of this paper, who is actively engaged in training middle school chemistry teachers, had noticed that in-service teachers place quite heavy focus on transmitting the subject matter in a traditional way. This is not surprising, considering that many of these teachers hold Bachelor degrees in Chemistry or Biochemistry with minimum formal pedagogical training. Moreover, many of them have not enrolled in any professional development courses in science education. From this perspective the current study was developed.

A sample of 116 public school science teachers participated in this study. The teachers were enrolled at an in-service teacher training program at the Lebanese University. In Lebanon science is mostly taught in a foreign language (English or French). Forty two teachers (36%) taught science in English and 74 teachers (64%) taught in French. Seventy four percent of the sample consisted of female teachers and 26% of male teachers.

The participating teachers came from schools located within different governorates of the country. Thus, all geographic locations of the country from North to South and East to West were covered. Almost all the in-service teachers teaching science in French were graduates from the Lebanese University; while almost half of those teaching in English had graduated from the Lebanese University, the other half being graduates of private universities in Lebanon. The number of years of teaching experience ranged from 2 to 22 years with an average of 9.33 years.

Two questionnaires were used in this survey that were developed through following the guidance of the Draw a Scientist Test (DAST) (Chambers, 1983), the Draw a Scientist Test – Checklist (DAST-C) (Finson & Beaver, 1995), and the ROSE-study (Sjøberg & Schreiner, 2006). These questionnaires were administered to the participating teachers during the first session of the training program. The teachers were then asked to administer the questionnaires for students in their classes, similar to the method administered by Barman (1999). All teachers submitted their students' questionnaires back to the first author during the first month of the training program.

The total number of questionnaires derived from students was 2345. The students were enrolled in the participating teachers' Grades 7-9 science classrooms. Considering that the current study is part of a larger study and that it was not possible to analyze all 2345 questionnaires, 250 student questionnaires were randomly selected from the larger sample of 2345. In what follows the report is based on the sample size of 250 students. In this sample, 90 students (36%) were enrolled in Grade 7, 85 students (34%) were in Grade 8, and 75 students (30%) were in Grade 9.

The participants' drawings and responses to the open-ended questions were analyzed based on guidelines provided by Chambers (1983), Finson and Beaver (1995), and Sjøberg and Schreiner (2006). Characteristics of stereotypical images of scientist such as the scientist's workplace (e.g., working indoors and in a chemistry lab), scientist's gender (male only), race (Caucasian only), facial expressions (smiling or not), mythic look (e.g., looking like Frankenstein, nerd), clothing (wearing a lab coat and eyeglasses); presence of symbols of research (e.g., lab equipment such as chemistry glassware) and knowledge (e.g., books and posters); indications of danger (e.g., nuclear danger, explosions); relevant captions (e.g., chemical formulae); and presence of technology (e.g., microscope, LCD projector, etc.) were considered in analyzing the drawings. The teachers' and students' perceptions were analyzed not only through their drawings but also through their responses to the open-ended questions.

Descriptive statistics was used to analyze the quantitative data, mostly in terms of frequency and percentages. Qualitative data were coded, categorized and accordingly themes were derived. It is worth noting that at many instances it was not possible to categorize the participants' drawings based on the stereotype indicators. For example, not all drawings revealed the gender of the scientist. Hence, the report is based on those which was possible to categorize. Indicators with high percentages (above 50%) were considered in making generalizations and deriving conclusions. To increase reliability, the participating teachers and the students were asked to describe their drawings in 2 sentences. In addition, the two researchers had regular meetings to analyze the data. Disagreements were resolved through discussions, further consulting the data and reaching consensus. In some cases other experienced researchers were also consulted for their input.

Results

Tables 1 and 2 show the stereotypes of scientists that the teachers and the students hold respectively. Almost two thirds of the participating teachers have the stereotypical male scientist, more than half have the stereotypical image of a Caucasian scientist, and most of them (83.6%) have the stereotypical image of the scientist working indoors. Moreover, the female teachers more than the male teachers had included details in their drawings such as symbols of knowledge and relevant captions. As for the students, most of them have revealed stereotypical image of a Caucasian scientist and that of scientists working indoors.

Table 1. Frequency and percentages of stereotypes in teachers' drawings as a function of gender

Stereotype indicator	Female (n= 86)	Male (n= 30)	Total (N= 116)
Male gender only	55	19	74
	64%	63.3%	63.8%
Caucasian only	43	17	60
	50%	56.7%	51.7%
Clothing	23	11	34
	26.7%	36.7%	29.3%
Scientist's facial expression	17	5	22
	19.8%	16.7%	19%
Scientist working indoors	73	24	97
	84.8%	80%	83.6%
Symbols of research displayed	70	24	94
	81.4%	80%	81%
Symbols of knowledge	22	4	26
	25.6%	13.3%	22.4%
Technology represented	13	3	16
	15.1%	10%	13.8%
Relevant captions	36	5	41
	41.9%	16.7%	35.3%
Mythic stereotypes	20	8	28
	23.2%	28.6%	24.1%
Indications of danger	9	2	11
	10.5%	6.7%	9.5%

Table 2. Frequency and percentages of stereotypes in students' drawings

Stereotype indicator	Total (N=250)
Male gender only	64
	25.6%
Caucasian only	193
	77.2%
Clothing	65
	26%
Scientist's facial expression	56
	22.4%
Scientist working indoors	178
	71.2%
Symbols of research displayed	60
	24%
Symbols of knowledge	31
	12.4%
Technology represented	35
	14%
Relevant captions	18
	7.2%
Mythic stereotypes	0
	0%
Indications of danger	8
	3.2%

More than half of the participating teachers and almost half of the students hold the stereotypical image of a chemist working in the lab (see Table 3). The percentage of students possessing this stereotype increases with grade level (see Table 4).

Table 3. Stereotypical image of a chemist in a lab by teachers and their students

Responses	Chemist in a lab
Teachers	66
(N=116)	(57%)
Students	120
(N=250)	(48%)

Table 4. Students' stereotypical image of a chemist in a lab as a function of grade level

	Grade 7 (n = 90)	Grade 8 (n = 85)	Grade 9 (n = 75)	Total (N = 250)
Chemist in a lab	32 (35.5%)	43 (50.5%)	45 (60%)	120 (48%)

Most three frequent teacher responses to what scientists are doing in their drawings involve conducting experiments, applying previous experiments and searching (see Table 5).

Table 5. Most frequent teacher responses to what the scientists are doing

Teacher responses	Female (n= 86)	Male (n=30)	Total (N=116)
Conducting experiments	63 (73.2%)	21 (70%)	84 (72.4%)
Applying previous experiments	69 (80.2%)	24 (80%)	93 (80.1%)
Searching	56 (65.1%)	17 (56.7%)	73 (63%)
Writing reports	41 (47.7%)	14 (46.7%)	55 (47.4%)
Reading books	30 (34.9%)	11 (36.7%)	41 (35.3%)
Attending Conferences	4 (4.7%)	0 (0%)	4 (3.4%)
Doing Sports	3 (3.5%)	2 (6.7%)	5 (4.3%)

As for students, their most frequent three responses include conducting an experiment, conducting a chemistry experiment and making inventions in the field of technology (see Table 6). In addition, students' responses show more variety than those of their teachers.

Table 6. Most frequent student responses to what the scientists are doing

Student responses	Total (N=250)
Doing an experiment (steps of the scientific method)	53 (21.2%)
Doing a chemistry experiment	43 (17.2%)
Inventing/ inventing technology such as computer, radio, TV	39 (15.6%)
Inventing/ physics and nuclear inventions/ inventing flying machine	24 (9.6%)
Medical inventions for children	17 (6.8%)
Explaining about nature and life	11(4.4%)
Reading a book, an article	9 (3.6%)
Researching, publishing	8 (3.2%)
Writing books and articles	8(3.2%)
Poet, sculptor, farmer, astronaut	6 (2.4%)
Others: selling physical products, selling his books, relaxing, swimming, eating, doing sport, teaching, doing scientific trips, drawing, etc.	32 (12.8%)

The participating teachers and students have provided mostly positive attributes for scientists (Tables 7 and 8). The teacher responses are more focused on work-related attributes of scientists compared to those of their students, who have provided several examples of humanistic attributes of scientists.

Table 7. Teachers' Scientist Attributes

Scientist attributes	Female (n= 86)	Male (n=30)	Total (N=116)
Problem Solving	30 (34.8%)	9 (30%)	39 (33.6%)
Critical Thinking	26 (30.2%)	14 (46.7%)	40 (34.5%)
Creativity	37 (43%)	14 (46.7%)	40 (34.5%)
Patience	32 (37.2%)	7 (23.3%)	39 (33.6%)
Being active	32 (37.2%)	13 (43.3%)	45 (38.8%)
Strictness	15 (17.4%)	4 (13.3%)	21 (18.1%)
Accuracy	28 (32.5%)	11 (36.7%)	39 (33.6%)
Imagination	39 (45.3%)	8 (26.7%)	47 (40.5%)
Love of his/her work	17 (19.8%)	4 (13.3%)	21 (18.1%)

Table 8. Students' scientist attributes

Scientist attributes	Total (N=250)
Observation, analysis, thinker, reflection	20 (8%)
Creative	18 (7.2%)
Inventor	16 (6.4%)
Communicate with others/with students	16 (6.4%)
Loves his/her work	16 (6.4%)
Active/has a healthy life	16 (6.4%)
Organized	15 (6%)
Imagination	15 (6%)
Explorer	14 (5.6%)
Helps others	13 (5.2%)
Generous	13 (5.2%)
Cares for others	12 (4.8%)
Sociable	12 (4.8%)
Improves himself/herself	11(4.4%)
Explorer	10 (4%)
Hard worker	9 (3.6%)
Serious	7 (2.8%)
Manager	6 (2.4%)
Doesn't sleep	6 (2.4%)
Stays alone	5 (2%)

Table 9 shows that the participating students mostly named deceased scientists as their favourite ones.

Table 9. Students' favorite scientists

Favorite Scientist	Grade 7 (n= 90)	Grade 8 (n=85)	Grade 9 (n=75)	Total (N=250)
Lavoisier	14	5	0	19 (7.6%)
Einstein	12	4	0	16 (6.4%)
Newton	3	2	1	6 (2.4%)
Edison	3	6	6	15 (6%)
Pasteur	3	1	2	6 (2.4%)
Nils Armstrong	3	0	0	3 (1.2%)
Ibn Sina	3	0	2	5 (2%)
Ibn Batouta	1	0	0	1 (0.4%)
El Khwarizmi	5	0	0	5 (2%)
K. Gibran	6	3	0	9 (3.6%)
H. Kamel Sabbah	16	15	1	32 (12.8%)
Michael Dabaghi	8	5	0	13 (5.2%)
Rammal Rammal	1	0	0	1 (0.4%)
Fleming	1	0	3	4 (1.6%)
Mendel	0	0	2	2 (0.8%)
Dalton	0	0	3	3 (1.2%)
Avogadro	0	0	1	1 (0.4%)
Democritus	0	0	2	2 (0.8%)
Plato	4	0	0	4 (1.6%)
Pythagoras	2	2	0	4 (1.6%
Galileo Galilee	1	1	0	2 (0.8%)
Pascal	1	0	0	1 (0.4%)
Gutenberg	1	0	0	1 (0.4%)
Copernicus	1	0	0	1 (0.4%)
Da Vinci	1	0	0	1 (0.4%)
Mme Curie	1	0	0	1 (0.4%)
Bell	1	0	0	1 (0.4%)
Total	92	44	23	159
No answer/ no scientist name	4	41	52	91

As seen from Table 9, all their favourite scientists are males with the exception of one grade 7 student who has cited Madame Curie. The list is more diverse for grade 7 students compared to that of grades 8 and 9. It contains higher number of names of Arab scientists as well as Lebanese doctors and scientists. Based on data reiteration, these names were mentioned by the grade 7 students irrelevant of the school location. Grade 9 students mentioned scientists such as Avogadro, Mendel and Dalton, which were absent in lower grades.

Table 10 shows that almost half of the participating students are positive about pursuing careers as scientists and almost two thirds of the students are positive about pursuing careers in technology.

Table 10. Frequency and percentages of students who like to be scientists and who like to work in technology (N=250)

Item	Yes
I like to be a scientist	133 (53.2%)
I like to work in technology	168 (67.2%)

Figures 1 and 2 show sample drawings of teachers and students at different grade levels. The student drawings were richer and more diverse compared to their teachers' drawings.
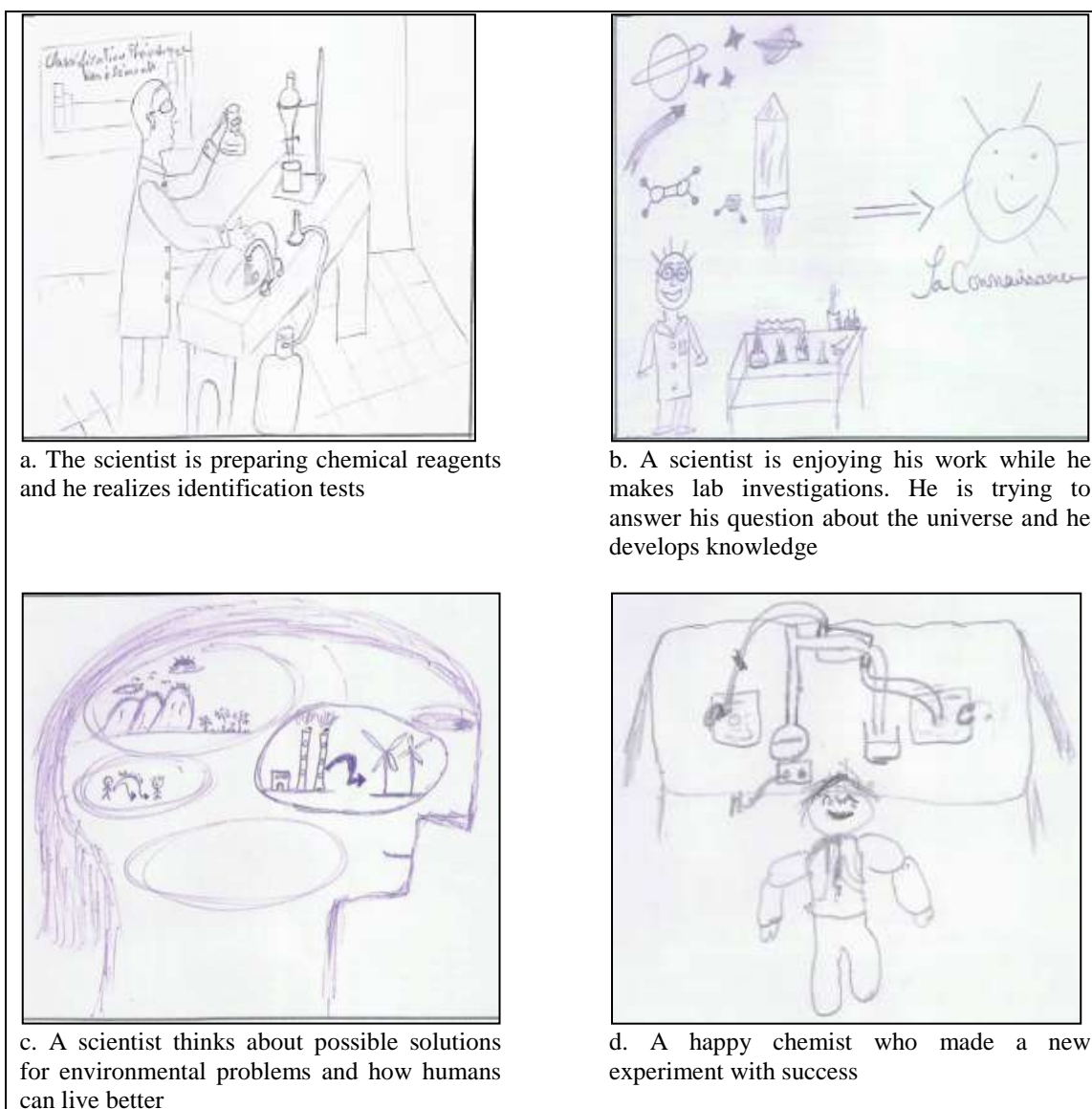

a. The scientist is preparing chemical reagents and he realizes identification tests

b. A scientist is enjoying his work while he makes lab investigations. He is trying to answer his question about the universe and he develops knowledge

c. A scientist thinks about possible solutions for environmental problems and how humans can live better

d. A happy chemist who made a new experiment with success

Figure 1. Examples of teachers' drawings (a, b: drawings by 2 female teachers; c, d: drawings by 2 male teachers)

a. A scientist who builds aircrafts

b. A farmer is a scientist, because he learned what are his land needs: water and nutrients

c. A scientist is doing an experiment to be applied in the future

d. Teacher doing an experiment to produce CO_2

e. My teacher preparing mixtures
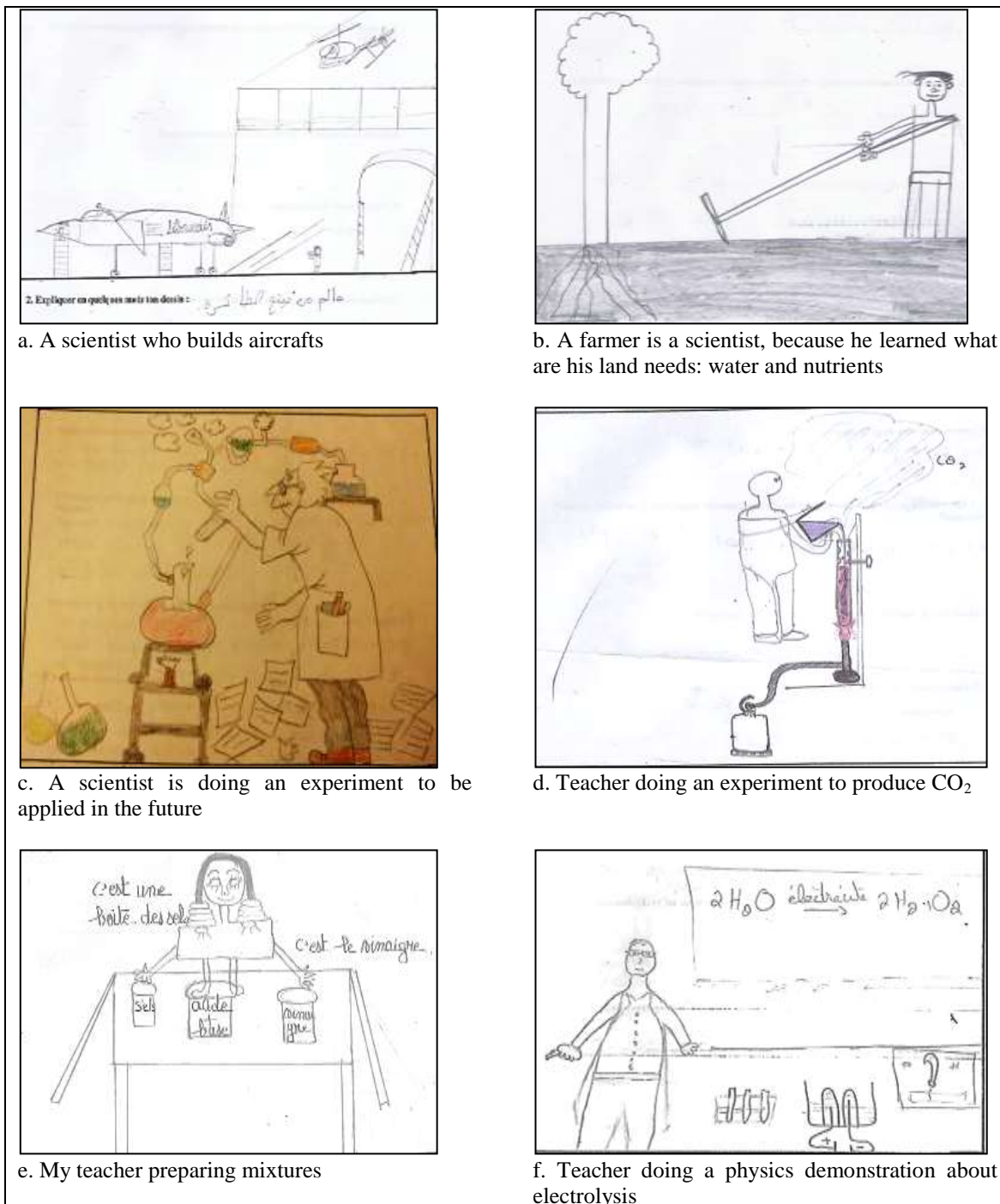

f. Teacher doing a physics demonstration about electrolysis

Figure 2. Examples of students' drawings (a: Grade 7 female students; b: Grade 7 male student; c: Grade 8 female student; d: Grade 8 male student; e: Grade 9 female student; f: Grade 9 male student)

Discussion and Conclusions

The stereotypical image of a scientist being a Caucasian, male, working in a lab, and conducting experiments mainly in chemistry is prevalent among Lebanese middle school science teachers. Their students possess similar stereotypes except for gender. Many of the students' drawings did not reveal the gender of the scientist. However, considering their favorite scientists, one can think about a stereotypical male ideal present in the student perceptions. One limitation of the current study involved the lack of interviews with the participants which could have provided more input. However, generally speaking, these stereotypical images are similar to those possessed by teachers and students in other contexts (e.g., Akcay, 2011; Barman 1999; Fralick, Kearn, Thompson & Lyons, 2009; McDuffie, 2001).

It is worth noting that the participating teachers and their students mostly held positive attitudes towards scientists. Not only did they give positive attributes to characterize scientists but also their drawings did not include mythical stereotypes such as dangerous, nerd and mad individuals isolated from society. This is aligned with the findings reported by El Takach (2018) within the context of pre-service science teachers in Lebanon and unlike studies conducted in other Western contexts (e.g., Archer et al., 2010; Koren & Bar, 2009). In addition, the participating students were usually positive about pursuing careers in science and technology. This is again unlike studies in certain Western contexts (e.g., Murphy & Beggs, 2005; Osborne, Simmons & Collins, 2003) but quite similar to the findings reported by DeWitt et al. (2010) within the context of ethnic minorities, where Asian students revealed high attitudes and aspirations in science. We believe that the immediate society of these students might have played a role here, considering that many perceive that careers in science and technology would facilitate upward mobility, provide better economic opportunities and easier access for immigration to developed countries. This is open for future research.

Compared to their teachers, more students thought that scientists make inventions in the field of technology. This is perhaps related to the fact that students are digital natives compared to their teachers (Autio, 2016; Gündoğmuş, Orhan, & Şahin, 2016; Koumachi, 2019; Prensky, 2001; Pambayun et al., 2019; Serhan, 2019; Walters, Gee, & Mohammed, 2019; Vu & Feinstein, 2017). Moreover, the images of scientists drawn by the students were rich and diverse, which can be due to the multicultural Lebanese society. However, the images were more diverse among students in lower grades compared to those in higher grades and to their teachers. In addition, more students, especially in grade 7, had a humanistic view of scientist, thus appreciating their human attributes in addition to their work-related characteristics.

The stereotypical images of scientists increased among students of higher grades. This finding is aligned with other findings in the literature (DeWitt, Archer & Osborne, 2013; Finson & Beaver, 1995; Narayan, Park, Peker, & Suh, 2013). Grade 9 students' perceptions of scientists were more similar to their teachers' perceptions compared to the grade 7 students' perceptions. Particularly at lower grade levels, students' perceptions about scientists were less similar to those of their teachers. These students do not seem to be directly influenced by their teachers' perceptions of scientists even if the teachers might indirectly and implicitly transmit some of their perceptions to students. There may be several factors such as media, cartoons and movies that can shape the students' perceptions of scientists. Future studies should target studying the impact of some of these factors.

There was almost complete absence of contemporary scientists and female scientists in the citations of students. Moreover, even though grade 7 students cited diverse range of scientists as their favorite ones, the diversity decreased with grade level. Grade 9 students' preferences became more restricted to scientists of European decent as well as to scientists portrayed in their science textbooks. In fact in grade 9 the student perceptions of scientists and their drawings became more similar to the perceptions of the authors of the national science textbooks that they use as well as to the illustrations of scientists found inside those textbooks. These findings complement those reported by Yacoubian et al. (2017) within the context of K-9 national science textbooks used in Lebanon. The researchers reported absence of female as well as Lebanese and Arab scientists in Lebanese national science textbooks. This indicates that science textbooks have an important role in shaping students' perceptions of scientists even if they are not the only source. Future research needs to target why students in younger grades are more prone to cite Lebanese scientists compared to their peers in higher grade levels.

The present study has implications for classroom practice as well as for science teacher education. Based on the findings of this research it is recommended that science as a way of thinking becomes part of the explicit curriculum of school science and university science education courses. This entails integrating history, philosophy and sociology of science in developmentally appropriate ways. Learners need to be encouraged to reflect on their perceptions of science and scientists. Learners' images of scientists say much about their understandings of the nature of science. Science teachers and university professors can make use of student images to engage the learners in explicit reflective discussions on the nature of science. This is important in order to target misinformed views about science that the learners might possess. Moreover, school teachers and university professors can develop their courses relying on material that embraces multiculturalism and that highlights the contributions of diverse scientists including female and non-Western scientists in science knowledge production.

Acknowledgements

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