What Brain Imaging Research and Science of Reading Can Do for Arabic Language Teaching & Learning?

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Abstract: Due to political, economic and socio-cultural circumstances, research on Arabic language teaching and learning has been lagging behind. This has led to a series of ineffective and stubborn recycling of old ideas in Arabic pedagogy that resulted in below average student performance on international Arabic literacy tests. However, recent results of research studies utilizing the use of Functional magnetic resonance imaging (FMRI) and Electroencephalography (EEG) to understand how languages are learned and how the brain can process different languages are promising a new dawn for language teaching and learning. This chapter will explore the very young body of Science of Reading research available on Arabic language teaching and learning and will explore further the new concept of the science of reading and its implications for Arabic language. Moreover, the chapter will argue that the new advancements in the field of brain research, science of reading and education will help show the field the best ways to teach Arabic language and give the powers that be the needed evidence that would pave the way to changing how Arabic reading and literacy in general are approached in educational circles.

Keywords: Science of Reading - Arabic Language - Teaching & Learning - Brain-based research – Arabic language best practices

Introduction: But what is SOR?

Maryam has been teaching grade two Arabic language arts for the past 16 years. Her approach to teaching reading has been a mix and match of practices that she learned while being a student herself, text-dictated approaches and strategies picked up here and there from conferences and webinars she attended over the years. Her constant frustration is that whatever she does, her students are still not reading fluently. This is where the Science of Reading (SOR) can help teachers by filtering through only the most reliable

research findings and offering teachers a clear view for the first time probably on what actually works and what doesn't in the Arabic language classroom. The Science of Reading era, if we might call it that, is upon us and it is a departure from the "reading wars" days when educators were split into two camps between those supporting phonics and those supporting the whole language approach.

However, it would be important here to clarify what is meant by the Science of Reading. The International Literacy Association (ILR) defined the SOR as "the corpus of objective investigation and accumulation of reliable evidence about how humans learn to read and how reading should be taught" (ILR, 2020). The SOR benefits from an interdisciplinary approach to research whereby, it derives its strength from the collaboration between several sciences including psychology, cognition, neuro-science, education, linguistics and socio-cultural studies. Science of reading employs a wide-angle lens to understanding reading that uses diverse disciplines, but also employs a tele-photo type lens that is quite focused on studying the micro elements affecting learning how to read. Without both lenses, most practitioners working on teaching reading would be shooting in the dark and would be resorting to a trial-and-error methodology with the children as experimental subjects where so much time can be wasted in ineffective and inefficient approaches to teaching reading.

This chapter is an attempt to explore the very young body of Science of Reading research available on Arabic language teaching and learning what that would mean for Arabic language

What does international brain imaging research and Science of Reading research say?

Scanlon and Anderson (2020) reviewed 25 years of research on reading and concluded that combining a phonics approach with a context-based approach can help build learners' sight words, which will enable readers to focus their attention the goal of reading and that is meaning-making. Additionally, there is also evidence that this attention to word-solving skills including spelling, pronunciation and focus on meaning-making help solidify them into the learners' memory and as such enhance memory for learning vocabulary (Ehri, 2020). Thus, the inclusion of working memory training in curricula and classroom practices is called for based on evidence from the field and could become in the near future one of the basics of any reading intervention program (Goodrich, 2020).

Petscher et al (2020) and Cervetti et (2020) emphasize the importance of foundational skills, namely phonics, decoding and reading fluency in addition to building a well-knitted fabric of skills that will enable learners to interact meaningfully with texts. This will mean carefully designed reading materials that are

focused on building learners' repertoire of reading, vocabulary and word-attack strategies are needed in addition to reading intervention programs (Cervetti et al, 2020; Compton-Lilly et al, 2020; GoldenPetscher, 2020). This is the wide-angle lens that doesn't focus on one approach but rather reflectively adheres to best practices evolving from the Science of Reading. Word-attack or word-solving skills have been emphasized as skills that help leaners investigate the words they are reading and observe what is around them and in them including engaging in morphological deconstruction of words and contextual analysis (Scanlon et al, 2020). According to Cabell and Hwang (2020), vocabulary instruction cannot be a stand-alone skill that is taught in the absence of extensive work done on building content knowledge. They argue that building learners' not only content knowledge, but cultural, linguistic and strategic knowledge as well (Hattan et al, 2020; Nogueron-Liu, 2020) using techniques such as pre-reading discussions (Kaefer, 2020), for example, is essential to help students understand texts that they read and as such language knowledge cannot be separated and dealt with as parallel plains but rather, it should be looked at as intertwining and interconnected.

Cervetti et al (2020) poses an important argument that is sometimes overlooked by the proponents of SOR and that is the development of early oral language skills which are the entryway into language instruction and into building learners' background knowledge. Without engaging learners in oral language activities and listening comprehension activities early on even before they go to school, their readiness for language instruction in school might be at risk.

Another interesting skill that comes into play based on evidence from the field is the interconnected and interdependent relationship between reading and writing (Graham, 2020). Meta-analyses have shown that a focus on reading instruction positively impacts writing and a focus on writing instruction positively impacts reading (Graham, 2020).

The above notions that constitute SOR as we know it today can have critical implications for teacher pre-service preparation and in-service training (Hindman et al, 2020; Shanahan, 2020; Solari et al, 2020). According to the authors, it is not enough to have studies on SOR only, but what is needed are also studies and work regarding how to imbed SOR in teaching practices and what would that really mean for teachers and practitioners in the field (Shanahan, 2020). Both pre and in-service programs will need to think about how to include specifically-designed interventions around reading instruction that are compatible with the body of knowledge available to us today. Pedagogical innovations that in line with what we know about SOR need to be highlighted, funded and supported through high level policies and actual ideas and practices that are transferrable into the classroom (Shanahan, 2020; Peng et al, 2020). Solari et al (2020)

went as far as suggesting that not only teachers need to be involved and included as key stakeholders in SOR translation into classrooms, but also communities and parents need to be informed and engaged in those conversations.

A very interesting observation was noted on the dynamics between SOR and teachers, who are having to deal with the expanding body of knowledge in that field, was voiced by (Hoffman et al, 2020) and has to do with the idea that SOR and all the research linked to it can have a "silencing" effect on teacher voices, a disregard to their lived experiences in the classroom and their expertise and calls for SOR enthusiasts to consider this new era possibly as a dynamic collaboration between what teachers have to say and what SOR research says. More than ever now, dialogues between teachers and SOR researchers is critically needed (Hoffman et al, 2020). Vaughn (2020) argues that just taking the SOR foundational skills and working on it with learners one skill at a time might be a missed opportunity and that it would take having some adaptive teachers who are flexible and are able to embed the SOR ideas into their instruction in culturally, socially and linguistically appropriates ways, to make SOR ideas successful in the classroom (Vaughn, 2020; Mosley Wetzel et al, 2020).

Why is the science of reading important for Arabic language?

Table 1 below shows student results on the most recent results available from the Progress in International Reading Literacy Study (PIRLS) reading test (2016), including results from eight Arab countries where Grade 4 students were tested on Arabic reading comprehension skills. PIRLS is an international, standardized, literacy achievement test for native fourth graders in primary schools.

Each country takes this literacy (reading comprehension) test in its own national language. The test's purpose is to measure students' ability to read in their native language and comprehend both literary and informational texts using the following framework: (1) being able to access straightforward information, (2) making explicit inferences, (3) explaining ideas presented in the text, and (4) analyzing the meanings, language, and other features presented in the text (Mullis et al, 2012).

Results from the 2016 PIRLS test (in graph below) show that out of the 50 countries participating in the test focused on Arabic reading comprehension, Egypt was ranked 49th, Morocco 48th, Kuwait 47th, Oman 46th, Saudi Arabia 44th, Qatar 43rd, Bahrain 42nd, and United Arab Emirates 41st all scoring below the international scale average of 500. Countries with the highest achievement on the PIRLS 2016 test were Russian Federation, Singapore, Hong Kong, Ireland, Finland and Poland. High performing countries

demonstrated strength in the ability to interpret, integrate, and evaluate reading comprehension skills and strategies (Mullis et al., 2012). The PIRLS test administrators analyze five indicators that could affect students' reading performance. Those are (1) home environment, (2) teacher education, (3) school resources for reading, (4) school climate, and (5) classroom instruction.

Table 1: Distribution of Reading Achievement, 4th Grade

SOURCE: IEA's Progress in International Reading Literacy Study – PIRLS 2016

Country Reading Achievement	Average Scale Score
Russian Federation	581 (2.2)
3 Singapore	576 (3.2)
2 †Hong Kong SAR	569 (2.7)
Ireland	567 (2.5)
Finland	566 (1.8)
Poland	565 (2.1)
Northern Ireland	565 (2.2)
Norway (5)	559 (2.3)
Chinese Taipei	559 (2.0)
England	559 (1.9)
2 Latvia	558 (1.7)
Sweden	555 (2.4)
Hungary	554 (2.9)
Bulgaria	552 (4.2)
† United States	549 (3.1)
Lithuania	548 (2.6)
Italy	548 (2.2)
2 Denmark	547 (2.1)
Macao SAR	546 (1.0)
† Netherlands	545 (1.7)
Australia	544 (2.5)
Czech Republic	543 (2.1)
1 2 Canada	543 (1.8)
Slovenia	542 (2.0)
2 Austria	541 (2.4)
Germany	537 (3.2)
Kazakhstan	536 (2.5)
Slovak Republic	535 (3.1)
3 Israel	530 (2.5)
2 Portugal	528 (2.3)
Spain	528 (1.7)
Belgium (Flemish)	525 (1.9)
New Zealand	523 (2.2)
France	511 (2.2)
PIRLS Scale Centerpoint	500
2 Belgium (French)	497 (2.6)
Chile	494 (2.5)
1 Georgia	488 (2.8)
Trinidad and Tobago	479 (3.3)

Azerbaijan	472 (4.2)
2 Malta	452 (1.8)
United Arab Emirates	450 (3.2)
Bahrain	446 (2.3)
Qatar	442 (1.8)
Saudi Arabia	430 (4.2)
Iran, Islamic Rep. of	428 (4.0)
Oman	418 (3.3)
Kuwait	393 (4.1)
Morocco	358 (3.9)
Egypt	330 (5.6)
South Africa	320 (4.4)
Moscow City, Russian Fed.	612 (2.2)
2 Madrid, Spain	549 (2.0)
☰ Quebec, Canada	547 (2.8)
Ontario, Canada	544 (3.2)
Andalusia, Spain	525 (2.1)
Norway (4)	517 (2.0)
Dubai, UAE	515 (1.9)
2 Denmark (3)	501 (2.7)
Buenos Aires, Argentina	480 (3.1)
Abu Dhabi, UAE	414 (4.7)
Eng/Afr/Zulu - RSA (5)	406 (6.0)

The results of Arab countries participating in international tests do not come as a surprise. They are the result of many glitches and decades-old challenges to the educational system that are common to many of them including the lack of effective and modern teacher pre-service preparation programs (Taha, 2017). Added to that, quality control measures are absent and periodical national standardized tests that illicit useful data to help track students' progress and achievement are either non-existent or data obtained from them is not used for developing reading recovery and intervention plans (AlDannan, 2010; Alrajhi, 2006; Obeid, 2010, Taha-Thomure, 2008). Furthermore, there is the absence of Arabic language academic and pedagogical authorities in charge of drafting national language policies, accrediting Arabic language teachers and programs, producing quality research on Arabic language teaching and learning, assessing Arabic language national learning outcomes and drafting policies based on results (Taha, 2017). It has to be said that over the years there have been many efforts launched to improve and modernize the teaching and learning of Arabic, but those have mostly remained individual effort by researchers and activists in the field or have been short-lived efforts that are of "firework" quality, meaning, they don't last beyond the show or the press release, especially those launched by ministries of education. Currently, there is a resurgence of interest and effort to take a serious and more sustainable look at how students'

results on Arabic language international tests can be improved coupled with a revived awareness of mother tongue proficiency as being a gate to economic and career prosperity.

Utilizing the science of reading and focusing on what really works in Arabic language teaching and learning can possibly help low-performing countries improve their scores on international test, empower the youth by a higher quality educational system, better invest in their human capital and adopt new teaching and learning practices that are research and evidence based. The idea of utilizing findings from the SOR to inform Arabic language teaching and learning can be quite a ground-breaking effort.

According to a World Bank report on advancing Arabic language teaching and learning (Gregory et al, 2021), MENA region has a learning poverty rate of 62%, one of the highest in the world (Gregory et al, 2021). Learning poverty is defined as the rate of 10-year-old children who are not able to read and comprehend an age-appropriate text (Table 2 below).

Table 2. Learning Poverty Rates, c.2016

Percent of children not reaching proficiency by late primary school age

Source: World Bank EdStats database

Percent of children	Country/region
29	Malta
32	Bahrain
34	United Arab Emirates
35	Qatar
36	Iran
38	Saudi Arabia
42	Oman
51	Kuwait
52	Jordan
65	Tunisia
66	Morocco
70	Egypt
95	Yemen
63	Total MENA Region

The report published by the World Bank in 2021 (Gregory et al, 2021), highlights several urgent recommendations that include: 1) Aligning key stakeholders with a shared understanding of evidence-

based SOR strategies to support children's learning of MSA, 2) focusing on a research agenda that can strengthen the knowledge base on Arabic pedagogy, 3) reinforcing the need to expose children early to vocabulary in engaging ways, including reading aloud to young children, 4) Revisiting Arabic language teacher education (preservice) programs to add evidence-based Arabic language pedagogy, extensive practical experience in best practice schools, 4) Devoting sufficient time in the curriculum to the development of oral and foundational Arabic language skills, particularly in preschool and the early grades, including content knowledge, higher-order reading and writing skills, 5) Identifying, supporting with early intervention, and monitoring struggling readers, especially in the earliest grades. The report adds that it is essential that shared an understanding of the science of reading and effective teaching of the Arabic language is reached via intensive on research in order to ensure that teachers are utilizing the evidence-based approaches in the classroom (Gregory et al, 2021; World Bank, 2019a; 2019b; 2021).

Table 3. A Path for Reducing Learning Poverty in MENA

Source: Gregory et al, 2021

1	**Set Literacy Goals:** Set quantifiable national goals and standards for Arabic language learning outcomes with highest-level commitment.
2	**Build bridge from colloquial to modern standard Arabic (MSA):** Harness common features/vocabulary of MSA and colloquial Arabic to help learn MSA.
3	**Expand early MSA exposure:** Expand children's early exposure to MSA in engaging ways
4	**Align instructional resources** to follow a systematic phonetic approach with a focus on reading comprehension in a literature-rich environment.
5	**Revisit Arabic language teacher education programs**: Align preservice and in-service teacher training programs to focus on effective methods of teaching Arabic with extensive practical experience opportunities.
6	**Reduce achievement gaps**: Recognize literacy achievement gaps — gender, regional, socioeconomic — and provide targeted support to schools with underperforming students.
7	**Intervene early with struggling readers**: Assess, diagnose, support with early interventions, and monitor struggling readers.
8	**Promote family and community awareness**: Encourage families, community groups, and the private sector to understand and prioritize children's Arabic literacy development
9	**Balance purposeful use of technology**: Ensure technology investments are based on evidence of effectiveness and that they encourage more MSA listening, speaking, reading, and writing and/or streamline the work of teachers, balanced with proven paper-pencil methods.

What does Arabic language brain imaging and science of reading research say?

The use of brain imaging to inform science of reading in Arabic language is not a developed field yet and as such there are still big gaps in our current knowledge compared to that of other world languages. However, a few researchers from the MENA are currently utilizing new technologies and brain imaging (FMRI & EEG) in their research which can shed some light and help the science of reading in Arabic language evolve. In this section, I will attempt to summarize the main findings available to us to date.

Diglossic effects in Arabic

One feature of Arabic language is Diglossia which is a socio-linguistic situation in which two forms of the language live side by side (Ferguson, 1959). A spoken form (SpA) used in everyday life and situations and a literary form known as Modern Standard Arabic (MSA) used for reading and in written language, formal communication, in schools and textbooks. The earlier children's exposure is to MSA, the faster they are able to close the gap between SpA and MSA (Taha Thomure et al, 2021).

Some researchers have referred to SpA as first language learned at home and MSA as a second language that is learned at school (Hallberg and Niehorster, 2021). Abou-Ghazaleh et al, 2018, set out to test that assumption using fMRI analysis during picture naming tasks in SpA and MSA. fMRI analysis showed no difference between SpA and MSA. Similar results were mentioned by Nevat et al in (2014), who using fMRI analysis collected from Arabic-Hebrew bilinguals found that performance on MSA was better than SpA and Hebrew indicating an advantage for MSA in their study most probably due to participants' proficiency in reading Arabic (Nevat et al, 2014). This is in line with some studies that suggest an increased preference for MSA the more proficiency in that form participants have (Abu-Rabia, 2000).

Another study sought to check whether SpA and MSA cognitively act as 1st and 2nd language, Madi-Tarabya et al (2021) used a brain-imaging technique using functional Near-Infra Red Spectroscopy (fNIRS) to test the neural basis of Arabic diglossia in native speakers of the language. Results revealed an advantage for literary Arabic (MSA) high-frequency words over Literary Arabic (MSA) low-frequency words and SpA high-frequency ones (Madi-Tarabya et al, 2021).

Bourisly et al (2013) used a FMRI analysis to understand the neural correlates of diacritics in Arabic. The researchers investigated brain activation patterns in adult readers who were asked to read real words with diacritics on them and words with no diacritics. Findings suggest no significant differences in reading accuracy between real words with or without diacritics (Bourisly et al, 2013). One interesting finding in Bourisly et al (2013), however, was that for adult readers who are usually proficient readers, words with no diacritics yielded a shorter response time. In contrast, words with diacritics yielded longer response time possibly suggesting more time needed in processing words with diacritics (Bourisly et al, 2013). This is in line with Taha's findings (2016) suggesting that the better participants reading proficiency is, the more visual burden diacritics exert.

Abou-Ghazaleh et al, (2020), used fMRI to analyze language control in diglossic and bilingual contexts trying to understand whether MSA functions as a second language which was in this instance Hebrew. They asked participants to perform picture naming tasks in SpA, a first language selection mixing SpA and MSA and in a second language selection mixing SpA and Hebrew where participants responded using the language or language variety to use based on cues they received from the researchers. Analysis revealed that simple naming tasks were easier in SpA than in MSA and Hebrew and that response time in MSA was faster than Hebrew (Abou-Ghazaleh et al, 2020). Another observation the researcher in this study noted has to do with contextualization of language use. They noted that participants who are proficient in both SpA and MSA to where the two varieties, *two first languages*, are usually able to make the switch between the two varieties quite easily when using them in context, however, this task became harder and more competitive when the context of their study forced them to respond at the single word level (naming pictures shown) with no contextualization involved (Abou-Ghazaleh et al, 2020).

Orthographic processing in Arabic

A study by Taha et al (2012) used event-related potentials (ERP) to measure the brain response rates during a visual word recognition activity. The researchers wanted to check what happen when students are dealing with Arabic orthography in which letters can take on different forms where some of the letters when written in words must be written connected to other letters (cursive) while other letters in Arabic do not connect to other letters. Findings show that orthographic connectivity (reading words with letters connected) did not slow readers which is the contrary of what was expected. Connectivity of letters had a positive effect on the reading process especially for the more proficient readers (Taha et al, 2012; Taha

& Taha, 2020). Another study was conducted by Khateb et al (2014) that measured students in different grade levels reaction time to connected words (Cw) vs. not connected words (NCw) while reading Arabic. Results indicated that for 3rd graders' recognition of NCw was faster and more accurate, while for 6th and 9th graders' recognition of Cw was faster and more accurate than NCw (Kahteb et al, 2014). This has great implications regarding the relationship between exposure to Arabic MSA early on and acquiring the proficiency needed to make it a medium that is easier for learners to use and learn through.

Another orthographic task that used an ERP (Taha et al, 2013) analyzed subjects' reaction time to reading Arabic pseudo homophones and words. Arabic has several emphatic phonemic letters that are phonologically similar to other letters which can lead to spelling mistakes and might lead students and writers in general to misspell words with homophones. The study (Taha et al, 2012) tested readers' reaction time to real words was faster than their reaction time to pseudo homophones which might reveal the importance of meaning and context when reading words with homophones in Arabic.

Diacritics in Arabic

In addition to connected letters, Arabic orthography utilizes the use of diacritics that appear over and under the letters. There are three short diacritical vowels known as diacritics (a, i, u) (AlGhanem & Kearns, 2014; Hussein, 2014). It is important to mention here that the effect of vowelization on reading accuracy and speed in Arabic is a matter of debate. Ibrahim (2013) found that native Arab typical students from the 8th grade exhibited higher accuracy and speed levels during reading unvowelized (no diacritic marks present) than fully vowelized connected text (diacritic marks present on letters). These findings were explained by Ibrahim as a situation of "visual load" due to the existence of the vowelization signs. Recently, Taha (2016) examined the effect of vowelization on reading performances of isolated real words and texts among typical and poor native Arabic readers using cross sectional procedure (2nd, 4th and 6th grades). The results indicate that among the typical group of readers, the non-vowelized connected text was read more accurately than vowelized words. Among the poor group of readers, such significant differences were found among the older reader groups only (4th and 6th grades). The differences in reading speed of vowelized and non-vowelized words were significant for older groups only within both groups of readers. However, in his studies, Abu-Rabia (1997, 1998, 1999, 2006) consistently reported the positive contribution of vowelization of MSA connected text to reading accuracy, rate and comprehension.

However, some recent research in reading comprehension suggests that fully vowelized text may still be opaque for some readers (Asadi et al, 2017).

Morphological processing in Arabic

In a making sense of a mismatch negativity study (MMN) that utilizes measured brain responses, Boudelaa et al (2010) tried to see whether Arabic morphology is a domain of knowledge that is linked to a certain type of neurocognitive representation in the brain or whether there is no specific brain area predicted to promote those morphological processes. Findings suggest that for Arabic language morphemes indeed have specific memory traces and that languages with rich morphological systems such as Arabic, their morphological processes are supported by specific neural networks (Boudelaa et al, 2010). Similar results were suggested by Bick et al (2011) and Eviator et al (2004). An interesting study that used fMRI, Bick et al (2011) found that processes linked to reading might not be universal and common for all languages. Bick et al (2011) found that for Hebrew, morphological activation was independent of semantics, while in English, morphological activation was dependent on semantics. If those results can withstand replication on speakers of other languages including Arabic, might have some direct implications on Arabic language teaching and learning. Similar results were cited by Eviator and Ibrahim (2004) where they tested the effects of morphological and orthographic differences between Arabic, English and Hebrew on the functioning of the two cerebral hemispheres. Arabic and Hebrew speakers showed the same hemispheric difference pattern which was different from the English readers hemispheric patterns (Eviator & Ibrahim, 2004). Arabic and Hebrew readers required longer exposure to syllables than English readers, suggesting again that processes linked to reading might not be the same in all languages.

Implications of science of Reading on Arabic curriculum design and classroom practices

Although brain imaging research and research into the science of reading in Arabic are still in their infancy they, however, promise to help shed light onto areas that can have an impact on how we think about Arabic language and how to most effectively teach it in schools. It is important to note that thus far, brain-based research on Arabic language has not shocked the field with unexpected results or conclusions. This is actually not a bad sign as it can probably be a premature testament to what the research that has predated the era of brain-imaging research and science of reading has been able to accomplish. In this

section we will summarize the expected impact of the research cited in this chapter on Arabic language curriculum design and classroom teaching practices.

Research so far has highlighted the existence of a pre-instructional phase that is key for Arabic and really anyone working with children in terms of language acquisition. Parents, care-givers and teachers should be aware of that this pre-instructional phase that is primarily focused on listening comprehension, oral language activities and working memory training. This pre-instructional starts at home way before children attend school. Ensuring that parents and care-givers engage children in language by merely speaking with them, reading Arabic children's literature to them, telling them stories, exposing them to cartoons in MSA, idioms, proverbs, and encouraging them to converse and express themselves linguistically and artistically are foundational elements that can help get children ready for school (Gregory et al, 2021; Tsimpera-Maluch et al, 2021).

In schools, research is now informing us, that it is important to know that reading is not a skill that students just "pick up" accidentally and suddenly along the way, but rather it is a long-term process that includes explicit and systematic instruction in all the key elements of reading: phonics, contextualized vocabulary and word study, reading comprehension, thinking skills and content knowledge (Taha Thomure et al, 2021).

Carefully designed curricula and Arabic language teaching practices need to pay close attention to the study of phonics which can include phonemic and phonological awareness, alphabetic principle, explicit word study and vocabulary instruction, fluency, morphological, orthographic and diglossic awareness in addition to work on listening and reading comprehension strategies (Al-Rajhi 2006; Harb and Taha Thomure, 2020; Mohamed et al, 2011).

Texts developed for use in the Arabic classroom need to allow students the option of choosing to read them with diacritics or with no diacritics (Gregory et al, 2021; Taha, 2016). The popular availability of e-books and online platforms would make this option, via a menu for example, to read a text with or without diacritics quite possible nowadays.

Teachers need to be aware of what the science of reading is and integrate a phonics approach with children-literature rich approach that can engage them in Arabic print early on and build their repertoire of daily life and academic vocabulary in addition to training them on the needed strategies to understand literary and informational texts (Phillips Galloway et al, 2020; Silverman et al, 2020). Phillips Galloway et (2020) reviewed many studies on the topic of academic vocabulary and concluded that knowledge and

skills that are developed over an extended period of time contribute to reading comprehension and that reading comprehension itself is a relationship or a result of the learners knowledge of academic vocabulary and ability to interact with the text they read and bringing into it their own knowledge, skills and emotions (Phillips Galloway et al, 2020), making reading comprehension not only a cognitive pursuit but also a sociocultural one. Moreover, SOR informs us the reading impacts writing and writing impacts reading, so having Arabic language arts classrooms designed around voluminous reading and writing might be a better investment that the current practices that teach the language in a disconnected and disjointed manner.

In addition, Arabic language arts Teacher pre-service preparation programs and in-service training planning need to utilize what we know today and reform their programs accordingly.

Those research-driven practices when done regularly and systematically can ensure the development of the neural paths that can support reading fluency and automaticity in Arabic and enable students to engage with Arabic language arts in meaningful and efficient ways (Alexander, 2020).

Conclusion

Maryam, whom we have met earlier in this chapter, and thousands in her positions as Arabic language arts teachers would be so much better off if they were aware of the recent research findings from the different fields of knowledge that inform the science of reading. The teaching practices they employ in their classrooms might be quite different if those findings were part of their teacher preparation program or teacher training that they receive in their schools. Would we see a difference in Arabic language arts student achievement if teachers were trained in ways that were in alignment with the most reliable research findings? The answer is most probably, yes. At least we will see an improvement in some areas of student learning in addition to offering teachers a clear view on what actually works and what doesn't in the Arabic language arts classroom. Woulfin et al argued in their 2020 paper on the interconnected infrastructure for improving reading instruction that curriculum, professional development and leadership are mutually supportive and as such have to converge if any success on reading instruction is to be reached.

We are still at a starting point with SOR, but it is a promising beginning that needs to be supported and closely followed by researchers and practitioners alike to ensure that a kind of synergy between them can be achieved and can be translated into actual classroom practices and student achievement.

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