# Teachers’ views on implementing storytelling as a way to motivate inquiry learning in high-school chemistry teaching

Ran Pelega, Malka Yayona , Dvora Katchevicha, Rachel Mamlok-Naamana, David Fortusa, Ingo Eilksb and Avi Hofsteina

a - Department of Science Teaching, Weizmann Institute of Science, Herzel Street 234, Rehovot 76100, Israel

b – Institute for Science Education, Dep. of Biology and Chemistry, Leobener Str. NW2, University of Bremen, 28359 Bremen, Germany

**Abstract:** Educational research and policy suggest inquiry as one of the most prominent ways of promoting effective science education. However, traditional approaches towards inquiry learning are not always sufficiently motivating for all learners. The EU-funded project, TEMI- Teaching Enquiry with Mysteries Incorporated, suggests that mysterious scientific phenomena introduced via drama-based pedagogies and showmanship skills could have the potential to engage more students emotionally in science and to entice them to solve the mysteries through inquiry. This paper reports teachers’ views on using storytelling in connection with mysteries in the science classroom. The data stem from a case of chemistry teachers’ continuous professional development within the TEMI project in Israel. Data were collected from 14 teachers by means of a questionnaire, interviews, observations, and written reflection essays. The case discusses teachers’ views on the benefits and difficulties of using story-based science inquiry activities.

**Keywords:** Inquiry-Based Science Education, Scientific Mysteries, Showmanship, Storytelling, Teacher Continuous Professional Development, TEMI

## Introduction

Science education research (Bybee, 2000; Hofstein and Lunetta, 2004), books for teacher education (Abrahams, 2011; Hofstein, Kipnis and Abrahams, 2013), and educational policy (NRC, 1996; EC, 2007) all suggest inquiry as one of the most promising ways for effective learning and for teaching science. However, traditional approaches towards inquiry learning do not always motivate all learners. It is suggested that this is based on differences in students’ interests and learning styles (Hofstein and Kempa, 1985). Varying the classroom learning environment by implementing various types of instructional techniques (or pedagogical interventions) is suggested to have the potential to enhance these students’ situational interest and motivation in science, which are usually not triggered by traditional curricular and pedagogical approaches (Hofstein and Kempa, 1985; Kempa and Diaz, 1990; Bolte, Streller and Hofstein, 2013).

The project TEMI - Teaching Enquiry with Mysteries Incorporated, funded by the European Union under the 7th Framework Programme from 2012-2016, suggests that “mysterious” scientific phenomena could have the potential to engage students emotionally in science, by enticing them to solve a given mystery through inquiry (TEMI Project, 2015). TEMI seeks to engage students in scientific inquiry by presenting mysterious scientific phenomena to the learners using different elements of drama-based pedagogies, such as drama, storytelling or mime.

Here we report chemistry teachers’ views on introducing drama-based pedagogies into the science classroom after they had participated in a professional development program in the TEMI project in Israel. We discuss how teachers considered using drama-based pedagogies in connection with mysterious phenomena that could be operated by them and could engage learners emotionally, enticing them to solve various mysteries through inquiry.

In addition, we describe the theoretical background when using drama-based pedagogies aligned with inquiry learning and a case illustrating how this took place in a continuous professional development workshop in Israel. This reflective case focuses on teachers’ views on their openness, the benefits and difficulties of implementing story-based science inquiry activities in high-school chemistry classes.

The research questions addressed here are (1) How open are chemistry teachers in implementing student-centred approaches based on storytelling with mysteries incorporated (a form of drama-based pedagogy, DBP), in regard to scientific inquiry learning? And (2) What are the promoting and hindering factors in implementing such a DBP approach in high-school chemistry education?

**Theoretical framework**

Inquiry-based science education has the potential to elevate students' attainment levels, to improve their attitudes towards science (Hofstein and Lunetta, 2004; Lunetta, Hofstein and Clough, 2007; Lin, 2014) and to provide students with a deeper understanding of science (Bybee, 2000; EC, 2007; Harlen, 2013). However, some students find it difficult to engage in inquiry during science lessons (Zohar, 2000; Hofstein and Lunetta, 2004). One way to overcome this difficulty is to raise students’ situational interest. Hidi and Renninger (2006) describe situational interest as a state of positive emotion and heightened concentration, a state of focused attention and the corresponding affective reactions caused by an environmental stimulus at a specific moment. The TEMI Project suggests that scientific mysteries are one way to provide such a stimulus for raising situational interest. TEMI defines its understanding of mysteries as

*“a phenomenon or event that induces the perception of suspense and wonder in the learner, initiating an emotion-laden 'want to know'-feeling which promotes curiosity and initiates the posing of questions to be answered by enquiry and problem-solving activities.”* (TEMI project, 2015, p. 5)

TEMI suggests that introducing inquiry-based activities based on mysteries and magic activities can be an effective pedagogical tool for promoting situational interest and thus active engagement in inquiry-based activities. Such a positive influence of using mysterious events in connection with inquiry on students’ attitudes towards science has already been reported (Lin, 2014). One such “mystery” used in TEMI involves hydrophobic sand (Vitz, 1990; Goldsmith, 2000; Peleg *et al.*, 2015). Whereas building sand castles with regular sand is well known to students, the hydrophobic sand phenomenon should be unfamiliar to most learners. It thus creates a good and fruitful mystery that, by inducing a cognitive conflict, can generate curiosity and thus generate situational interest. This phenomenon can be investigated using school-based scientific inquiry in one or two lessons and fits within high-school students' abilities and the related zone of proximal development. The phenomena of hydrogen bonds and hydrophilic and hydrophobic materials are central to any chemistry curriculum, making the example with hydrophobic sand well justified.

The open question still remaining is how can such a phenomenon like hydrophobic sand be introduced (Peleg *et al.*, 2015) in the chemistry classroom. In TEMI it is suggested that one of the main factors that influence students' engagement is the way the teacher presents the mystery (TEMI Project, 2015). Since there are various ways to present a mystery (such as by showing a video, a demonstration, performing an unexpected experiment, a quiz, among others) TEMI draws on the art of showmanship. Showmanship can be understood as ‘the art of making something look interesting and great’ (TEMI project, 2015, p.36). The TEMI Project (2015) introduces and operates inquiry learning around mysteries enriched by using elements of showmanship, such as storytelling, drama, or mime. Since these are uncommon pedagogies for teaching science, TEMI made showmanship a part of the continuous professional development (CPD) program offered by the TEMI project in the participating countries.

Regarding the mystery of the hydrophobic sand, a TEMI inquiry activity was developed (Peleg *et al.*, 2015) based on the BSCS 5E model of inquiry learning (Bybee *et al.*, 2006; Bybee, 2015), since it was shown to be suitable for similar scenarios (Lin, 2014). The lesson’s activity, described in Peleg *et al*. (2015), became a central element in the Israeli TEMI CPD. It required teachers to learn and reflect upon how to present mysteries to students in connection with fictitious stories. The introduction to the mystery was based on a story about two sand castle competitions, one with regular sand and a more challenging one with special (hydrophobic) sand.

A theoretical justification for using stories in science classes was suggested in the past by Bruner (1985, 1991). He identified two modes of thought and discourse: a paradigmatic, logical mode (a formal method of linking ideas through logic) and a narrative mode (the more familiar form of a story). Formal science naturally relies on the former mode, since we can often see it in science-type published papers. However, research has shown that even scientists in everyday discussions often prefer the narrative mode of communication, especially when discussing matters with novice learners. Despite the advantages of using stories and narratives, most of the time science teaching resorts to paradigmatic modes of explanation. In general, despite the ubiquitous nature of stories, academic disciplines prefer logical paradigmatic reasoning to narrative reasoning because it is considered to be more “scientific” (Jonassen and Hernandez-Serrano, 2002).

Storytelling can be considered as part of Drama-Based Pedagogies (DBP; Lee *et al.*, 2015). DBP include a range of drama-based teaching and learning strategies (Lee *et al.*, 2015). The major features defining DBP are that (a) it is facilitated by a teacher, a teaching artist or other facilitators trained in DBP, (b) it aims at academic and/or psychosocial outcomes for the participating students, (c) it focuses on process-oriented and reflective experiences and (d) it draws on a broad range of applied theatrical strategies. Lee *et al.* (2015) state that DBP has a positive and significant impact on achievement outcomes. Despite the overall positive effect of DBP on students’ learning outcomes, little is known as to the conditions under which it is more or less effective. This domain is both under theorized and under researched (Ødegaard, 2003; Lee *et al.*, 2015). However, there are a few studies available reporting the use of stories and DBP in science education. The studies encompass a variety of domains such as electricity (Braund, 1999), molecules and the states of matter (Metcalfe *et al.*, 1984) as well as mixtures and solutions (Arieli, 2007). In science education, stories have, for example, also been used to teach argumentation (Erduran and Pabuccu, 2015).

Research findings suggest that drama and storytelling activities might not necessarily improve factual recall (Metcalfe *et al.*, 1984; Ødegaard, 2003) but can lead to a deeper understanding of the topic learned (Braund, 1999; Arieli, 2007). Research has also shown that, on the one hand, teachers spontaneously use drama and story activities in the science classroom even if the teachers are untrained and even if they do not consider their pedagogy as DBP (Dorion, 2009). On the other hand, it was reported that many teachers, while appreciating the potential benefits of DBP, feel a lack of confidence and lack skills to implement such activities in their classroom (Alrutz, 2004).

In the current study we focus on teachers’ views regarding implementing storytelling, a simple and accessible form of DBP: one that teachers can easily apply even if they lack formal training in drama and in the performing arts. Stories are a powerful tool to organize, store, describe, and communicate knowledge. In general, narrative forms of explanations are what people use most of the time when solving everyday problems (Lave, 1988 as cited in Jonassen & Hernandez-Serrano, 2002). From a neuroscience point of view, hearing narratives seems to activate many supposedly unrelated areas of the brain (Sabatinelli *et al.*, 2006).

**Background, sample and method**

In order to effectively engage students and guide the mysterious phenomena into inquiry activities, TEMI is aimed at enabling teachers to introduce the mystery to students by showmanship skills and DBP such as storytelling. In Israel, a 16-hour continuous professional development (CPD) program for chemistry teachers was devised. The instructional model of the workshop was that of the Gradual Release of Responsibility – GRR (Pearson and Gallagher, 1983), in which teachers acted as learners initially and gradually assumed more active roles. During the CPD teacher were told that the CPD will be accompanied by a research project and that all materials gathered will be available for internal use only (evaluation and research). Interview and questionnaire data were collected only after the CPD ended, as not to pose a threat to teachers' accreditation from the workshop. In order to provide a meaningful and long-lasting effect, the programme was divided into four afternoon meetings spread over a period of six months at regular intervals. This allowed teachers to practice what they had learned in their classrooms between the meetings. The CPD focused on three types of activities: (1) activities aimed at providing teachers with presentation skills and storytelling skills, (2) ready-made inquiry activities and materials, and (3) construction of classroom activities by the teachers themselves. One of the central examples of (1) and (2) was the mystery involving hydrophobic sand and a story about a sand-castle competition (Peleg *et al.*, 2015). Overall five such TEMI activities were presented in the CPD.

The sample in this case study consisted of 14 practicing high-school chemistry teachers from Israel. Teachers were mixed regarding their level of experience. Half (7 out of 14) had over 15 years of experience but almost a half (6 out of 14) had less than five years of teaching practice. Data were collected by a questionnaire administered online to all the teachers two to three weeks after the last CPD meeting. The questionnaire included open and objective-type items intended to capture teachers' reflective experiences regarding the CPD and how the activities were implemented in class. Two months after the last CPD meeting attempts were made to schedule semi-structured face-to-face or phone interviews.. Three attempts were made to schedule an interview before attempts were abandoned. The final interview sample consisted of ten teachers. Before each interview teachers were informed of the purpose of the study and asked for consent to participate and consent to have the interview recorded. Teachers were also assured that their names and details will not be mentioned in publication. Interview questions were related to how the activities were implemented in class and teachers’ reflections regarding the CPD. Additionally, seven of the teachers were supervised concerning their enactment of a mysterious activity in class: Five of the teachers implemented activities created by the CPD providers and another two conducted activities developed on their own. Finally, observation and documentation of discussions, conducted in all the CPD sessions, were monitored and written reflective accounts of the implementation in class were received by ten of the participating teachers.

The data from the interviews and the open questionnaire items were analysed using qualitative content analysis. Initial categories were derived from the research interest (teachers’ perception of themselves in using DBP in science education, the challenges of using mystery stories, as well as teachers' perspectives on the effect of using DBP on students' motivation). These categories were refined and others were added with emerging themes. Finally, all data from the different sources was triangulated to better create meanings and interpretations.

**Findings and discussion**

Several themes emerged from the data concerning the challenges faced by the teachers in introducing storytelling to the inquiry activity. Some were specific regarding the nature of using a story (such as the use of fiction), whereas others were related to introducing DBP in connection to science teaching in general (relevance, suitability).

One of the central issues concerned the question of authenticity and truth, at least regarding the meaning of accepted and reliable scientific knowledge. Some teachers suggested that fictitious stories add a new dimension to the science classroom normally not encountered by students – the dimension of untruth. This issue was prominent in several interviews. Some teachers (8/10) reflected that adding the dimension of fiction can get other students more involved in science than they would normally be able to achieve:

*"I always thought Chemistry was interesting enough as is … but there are always those [students] who are simply not interested, so I understood that I can reach a wider student audience if I tell a story.”*

However, some chemistry teachers from this sample (3/10) thought that their students always expect the science teacher to give only authentic, proven, reliable and true information. Apparently, they think that their students expect a science teacher not to give any fictitious, erroneous or incomplete information, not even for methodological reasons, in connection to science learning (such as the case of introducing a mysterious event by using a fictitious story). However, some teachers (4/10) also reported no reluctance in using such stories as long as they served the purpose of increasing their students' motivation. One said: "*The story was very much welcomed by the students. Students love to hear stories, even if they find out at the end that the story was not real*." Another teacher said that "*Using the story converts the language of chemistry into a language the students are familiar with.*"

Some teachers reflected a lot about students’ assumed perception of the fictitious stories, but they felt that they were not really lying or telling stories that are considered as only half true. One teacher prepared little greeting cards as a mystery on which she wrote with erasable ink that disappears upon heating and reappears upon cooling. She intentionally heated the cards to make the ink disappear; however, she told her students that it happened unintentionally and that she did not know what made the ink disappear and how to make it return. Relating to the issue of authenticity, she claimed that:

"It didn't bother me at all. There isn't any mistake regarding the mystery. They still had to discover why the ink had disappeared. It wasn't as if I lied to them and there was nothing written on the cards. I really wrote something and that something disappeared; now they have to make it come back. I don't see a problem with this story."

Other teachers (2/10) found it more difficult to overcome the hurdle of telling a story that is not real, which they felt breached their students' confidence by 'lying' to them. Something that might be completely normal to a language and literature teacher was considered not feasible for a science teacher:

"I am not very good in pretending – that's just my personality. The presence of [one of the researchers] in the activity helped me overcome my inhibitions and made my students believe the cover story was real. In the following lesson after the activity I discussed the issue with my students and they admitted that they weren't expecting me to lie to them. But they really enjoyed the activity."

When relating to how their students reacted to this issue, teachers mentioned that students frequently asked whether the story was real. In interviews and in the reflective accounts teachers (4/10) mentioned that their students confessed to being disappointed upon discovering that the story was not real but that most students felt that it was worth the disappointment. One teacher quoted a student: "*It would be more interesting had it been real, but I'm not heartbroken*".

In discussions that were held in the CPD sessions teachers claimed that what helped them tell a story was to tell it as if these stories really happened to them or to a friend of theirs in order to make them more credible. The most important thing in making the story effective is to have the teacher feeling comfortable in telling it, be it by altering the story or by simplifying it. In an interview, one of the teachers summed this up by saying that just like different students have different learning styles, different teachers have different teaching styles – some will like the use of stories and some will not.

Another important issue concerned the curriculum. For many teachers (10/14), use of the mystery activities must align with the teacher's overall teaching programme and the curriculum. Thus, if the teacher is preparing students for a national high-stakes exam, the topic of inquiry must fit the curriculum. Teachers in the CPD program most appreciated ready-made demonstrations and activities that fit their curricula. The teachers viewed these provisions of experiments and materials as relevant to their teaching. Only about a third of the teachers mentioned the storytelling and drama components of the CPD as a favourable part of the programme. Interview data helped reveal that many of the teachers (5/10) did not consider this as very relevant for their teaching and did not quite see the rationale of these components, even though they did realize the potential of using stories in the activity. Regarding the use of a story in an activity, one teacher who used a TEMI activity that she developed with other teachers stated: "*I think it added a more attractive, inquisitive side to the activity. It gave a feeling of 'we are doing something different', which engaged the students more.*" Further in the interview she stated that:

"*The storytelling activity in which you get a script and tell a story – I can link to it. The rest of the activities, I didn't see a take-away message I can use with the students. That's why I didn't engage withmaking the faces and laughing [referring to the drama activities]. That's not for me. What can I do?*"

Data from the interviews and the observations revealed some of the obstacles hindering teachers from implementing such mystery activities in class. One of the main factors hindering teachers from implementing the mystery activities in class was a notable lack of confidence in leading such activities. Many teachers (4/10) felt uncomfortable in implementing activities that required varying degrees of showmanship such as storytelling. It became clear that drama or even body language was something the teachers were not very familiar with and learned about in the workshop. One teacher said: *… now I also know that I can't come to class with a hunched back, because the body communicates as well.“*

Another hindrance mentioned was the lack of imagination to align the activities with the curriculum and the lack of time. One teacher described the lack of confidence, time and curricular pressure as:

"I need the holidays to think about implementing such an activity. During the year I find it difficult to organise and learn a new activity. The thing is, if I try one of these activities and it doesn't go well, then I will have lost a whole lab report. I always think. Will I be confident enough to implement the activity in class?"

Teachers (3/10) also mentioned that mystery activities might require one or more materials that are not readily available in the lab (such as erasable pens, hydrophobic sand or a superabsorbent polymer). This may put a logistical constraint on performing the activity. Even though activities and materials were provided to the teachers during the CPD, a potential difficulty or an additional demand in time and in organizing the corresponding materials was mentioned by the teachers as a hindrance.

Although there was a lot of scepticism in implementing showmanship activities, the teachers were not totally reluctant to do so. Whether or not the teachers implemented the mystery activities in class, most interviewed teachers claimed that the CPD had a positive effect on their everyday teaching. Many claimed that participating in the CPD had given them the necessary tools and that they had gained more confidence in telling stories, so that once in a while they would spontaneously engage in storytelling during class time:

"I always used to tell stories, but up to now my stories were not complete. In the workshop I learned how to properly construct a story."

"I don't really know, but I think that now when I tell them a story I use all three elements we were taught [a balanced combination of facts, emotions and details]. But to tell the truth I now do it automatically."

One of the teachers declared that changing their everyday teaching style was why she chose to attend the CPD:

"I came to the CPD to learn a new teaching style. I want my students to like the lessons more – not necessarily the chemistry – rather, I want them to like listening to me. I want them to like being in class with me. Not necessarily the chemistry. It's not always 'wow'. I want them to enjoy the lessons."

From interview data and from classroom observations, it became clear that some teachers (6/10) felt that the mystery story was an effective means of promoting situational interest among the students. One of the teachers, in her reflective account of implementing the stories, quoted students she interviewed by saying:

"Experiments such as this one are the reason I chose to study chemistry in the first place." "Can you give us more such activities?" "I finally understood what fire is all about [referring to an activity about candles and fire]." "I learned about new things that I never had thought about, yet they are daily activities."

Some of the teachers (2/10) also reported that students stayed during the break to continue their work on the mysteries (which was also seen in the observations), suggesting that situational interest was not only aroused, but also sustained during the activity and beyond it. From the teachers' perspectives, apparently the situational interest was created in one of three ways. It was raised:

1. By igniting interest and engagement in the activity through the story. In the words of those teachers who tried using a mystery story: "*The story built up their interest in what happened and set up an appropriate atmosphere. I think the story contributed a lot to the lab and gave students the motivation to decide what they had to do in order to identify each of the white powders.”*
2. By the power of a surprising and mysterious phenomenon that is counterintuitive to students' daily lives. Relating to an activity with erasable pens, one of the teachers claimed that "*It was very interesting. I'm not sure how interesting the story was, as much as the pen that they use in their everyday lives. We need to ask them. I started the activity with the story, but I'm not sure to what extent it contributed to the activity*."
3. By promoting a sense of urgency and competition among the students. One of the teachers provided an activity in which she first handed out a cake that tasted salty to the students. Among the students' reactions to the ill-tasting cake, she took out five unlabeled jars of white powders (salt, sugar, baking powder, corn starch and tartaric acid). She then claimed that she must have replaced the sugar with the salt and that maybe the students could help her distinguish between the powders. In the past she attempted this activity without the introductory story and without having students taste the cake (i.e., simply handing out containers with five different unlabeled powders). She claimed that the addition of the introductory story added "*a heightened motivation to find out what went wrong"* and that *"each team battled the others to find out what happened first.*"

To what extent each of these components helped create situational interest is not yet known, but further research with students may clarify this issue. However, it seems that the synergy of all three elements is what makes these activities successful in engaging and maintaining interest among the students.

**Conclusions and implications**

This case study reports on teachers’ views on the role of stories as a tool for introducing and framing inquiry activities. From both theory and from teachers’ experiences in telling stories, it seems that stories are a supportive tool that can enrich the pedagogy of inquiry learning. Nevertheless, there is an obvious reluctance among at least some of the teachers to use fictitious stories in science (chemistry) classes. Apparently there is a mismatch of both the teachers’ perceptions about themselves as science teachers as well as what their expected image is, as seen by the students. Although it can be assumed that most of the teachers read books or watch stories in the movies or on TV, apparently they do not make the connection that the attraction of fictitious stories can be used in science classes. Some teachers suggest that science teachers have to present a different picture about themselves concerning the validity and authenticity of the information provided by them and that it is only worthwhile in, for example, language, music and art classes.

The science teachers struggle and feel uncomfortable about how to deal with a fictitious story in a classroom involving real science. How can the teacher deal with facts and tell the students a 'lie'? The teacher may opt to tell students in advance that they will hear a story that is not entirely true, but the students felt that this will decrease its effect. The teacher may choose not to confess that the story was fictitious, but many science teachers seem to find this difficult to do. In fact, we want students to "suspend their disbelief" similar to audiences that enter a theatre hall.

However, if stories are so effective for memorization, one needs to ask whether the students really want to have a picture of the science teacher only telling the “truth”, facts and theories. Maybe it is especially among those students who are not intrinsically motivated to study science who need other unconventional approaches. It may also help to give science in general and chemistry in particular, a more humanistic flavour that can help overcome the big gap in studying science and diminish its irrelevance, which is perceived by many students. This would necessitate additional science teacher education and continuous professional development. Not every science teacher will perform as an actor in class; however, creating and telling a good and motivating story should be possible for everyone. Based on the current case study detailed here, it is suggested that it is worth enriching science and chemistry education by incorporating elements of drama-based pedagogy. However, more research is needed to provide information regarding the best working and the most motivating elements of DBR in the context of science education, and concerning the most effective contexts, fictitious stories and pedagogies for this purpose.

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