

Adapting Hands-on Science to ESL students and Special Needs students: Nature and Experiences of Hands-on Science

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INTRODUCTION

A quality science education is essential to the future success of all students. It provides an excellent platform onto which to build positive attitudes towards school, such as developing a motivation to learn, desiring to expand one's strong areas as well as growing in weaker ones. Science helps all students to develop various skills, including critical thinking, problem solving, teamwork and communication. In an increasingly complex technological society we are constantly surrounded by science, and the future will demand more familiarity with science-driven social issues. In addition, our society is diverse, and today's classrooms welcome students from all different backgrounds who have varying styles of learning. Some students do not speak English, while other students may require a longer time to learn a particular concept, or they may learn differently from other students. English as a Second Language (ESL) and special needs students must be offered an equal opportunity to excel in our technologically advanced society and to obtain tomorrow's jobs - some of which may be in science and/or other science-related fields. Through quality science education all students gain appreciation of the world around them.

Furthermore, formal science education should emphasize that science is not only concepts and skills, but also applications and attitudes. Students can learn science concepts and various skills through the direct application of science to real life situations, and thus they can see the relevance of science as well as build positive attitudes for learning science. Stronger science background enables all students to better respond to everyday situations of global living. Students in science classes could be introduced to many innovative, fun and hands-on science outreach programs that exist across Canada. The outreach programs inspire youth in science, improve the scientific literacy of all Canadians, and prepare everyone for a better future. In recent years teaching science has shifted more towards inquiry-based teaching, including simple hands-on activities. This

approach has been the subject of research for many science educators, and we hope to bring as much innovation to formal science education in order to engage the minds of all youth and inspire them to become scientists in their own science classrooms. With this in mind, the objective of all science educators should be to bridge formal science education with outreach programs, such as *Let's Talk Science*, in order to further engage students' minds and make science exciting, relevant and rewarding for everyone.

Throughout this document we discuss the nature of the hands-on science and how an outreach organization, called *Let's Talk Science* (LTS), adapts practical science to all elementary students through its innovative in-class workshops. The key question is how to engage the minds of the ESL and special needs student during the hands-on workshops. In addition, how can presenters of hands-on science better prepare for an in-class workshop? And how do we help all students continue the learning after fun, hands-on activities?

NATURE OF HANDS-ON SCIENCE

Teaching science takes a lot more than simply talking to students about scientific concepts, and asking them to regurgitate the information, which they may not even understand. Formal science education has been traditionally known for this 'regurgitative-method', however recently science educators recognize that instead of teaching more science, they should teach it better. A science classroom can be a place where ESL/special needs students learn how to ask questions, test their interesting hypotheses, convey silly and smart ideas, and help each other meet new scientific challenges. Science textbooks are still an excellent resource of information for both teachers and students, but most textbooks require complex literacy and study skills, which ESL and special needs students often lack. To include a child with language barriers or educational challenges, might not be easy, but does that mean we should not try? ESL and special needs students are no different if we value all children equally.

The *hands-on approach* is one of the most popular strategies to teach science to everyone, and can be easily adapted to ESL and special needs students. Hands-on science is particularly beneficial for ESL and special needs students since it promotes inquiry-

based learning, and most, if not all students, generally sustain a higher level of interest and enthusiasm for science. In addition, all students experience the most success when learning activities are tailored to their interests and abilities (Hardman *et al.*, 1981). Hands-on science ensures maximum involvement of each student; its cooperative learning environments promote inter-student communication, and thus, it fosters language development. All students become active team players in various hands-on activities and they learn important observation, problem-solving and communications skills. In addition, the teachers need to further emphasize the applications of science in everyday lives of students in order to make science more relevant and more fun for all active participants. It is important to remember that in hands-on science the teachers are facilitators of learning, rather than distributors of scientific information (Polloway and Patton, 1995). ESL and special needs students can be guided through each hands-on activity, and the teachers can help all students build 'science confidence' through rewarding activities whose applications extend into students' lives.

Hands-on science may provide interactive and kinesthetic learning, but it may not be sufficient, since students minds must be engaged as well. For example, it may not make much sense to ask ESL or special needs students to 'build' atoms, even though it is an important scientific concept, since it might not be at a student's level of understanding - students cannot see, feel or touch atoms. This is true for any student, not just ESL/special needs. Thus, trying to visualize atoms might be particularly difficult (understanding them might be even harder) considering that many students (and teachers) have a hard time understanding even the visible concepts, such as moon phases or seasonal changes. In order to engage the minds of ESL and special needs students, the hands-on activities must instigate students previous knowledge about a particular subject and this could help the students build new knowledge and acquire new skills. Throughout each hands-on activity ESL/special needs students could be guided/assisted by teachers/presenter or their more active peers in order to ensure that their minds stay focused and engaged in all activities. Like all teaching, hands-on science should be subjected to further research, evaluation, and improvement.

EXPERIENCES AT *LET'S TALK SCIENCE*

Organization of the in-class workshops: Hands-on science programs at *Let's Talk Science* include life and physical sciences, engineering, mathematics and technology. (For more detailed description of LTS see web site www.letstalkscience.uwo.ca). LTS offers 60-150 minutes, in-class science workshops to elementary schools that provide fun, innovative hands-on learning for all students. The in-class workshops are rich with activities that are hands-on, and performed in groups of 4-6 students. The practical, and the major component of the workshop, consists of several stations (usually 3- 4). Each student has the opportunity to take different roles, and perform different tasks during the hands-on activities. The major focus of all workshops is to help students acquire different skills (e.g. observation, data-collection, critical thinking, teamwork, communication etc.) and to emphasize the applications of each hands-on activity. Emphasizing the applications allows each student to see the relevance of each hands-on activity.

Furthermore, LTS also supports inclusion; all students regardless of their condition will be presented the same science content. ESL and special needs students benefit by being integrated into regular science classes, rather than being excluded. They have the opportunity to acquire the same skills as other students. Hands-on science workshops could be designed to motivate all students, and engage everyone in hands-on learning. The LTS presenters need to take in consideration the physical layout of each workstation in order to provide the environment where ESL/special needs students can engage their minds in hands-on activities. The workstations need to have space for both individual and group work; the work areas need to be marked so that a student can find his/her own way; the workstations need to contain all work materials in a centralized area, and the instructions for each activity must be simple, and easy to follow (i.e. in a flow chart style).

Before the start of hands-on activities: At the beginning of all workshops students are introduced to the word '**Science**', and they are asked by the LTS presenter to name different science-related fields. Chemistry, physics, astronomy, marine biology, oceanography and paleontology are science fields that are named by a few, eager and

energetic students in elementary schools. However, many students, especially ESL are shy and may not know these fields by name. For example, ESL students many not know what 'paleontology' means, but they know about dinosaurs and bones. Often when ESL students hear words that they don't understand, they may become intimidated and very quiet. In this case the presenters need to use simpler language, and when other students in the class call out the names of some science-related fields, the presenters need to immediately simplify the language. For instance, when a student calls out 'oceanography', the presenter would immediately say: "This is the science of under water world - fish, and anything else that is under the largest bodies of water on our planet." In order to further engage the minds of shy ESL/special needs students, the teachers could ask all students to write down a science-related field that they like. The LTS presenters could then read clearly and loudly the different science fields that students like. This gives quiet students a chance to tell the class their most exciting science field(s). It is also important to provide verbal, and visual cues to ESL and special needs students in order to motivate them, and to get them involved with the rest of the class. In order to engage ESL/special needs students, the teacher/presenter needs to direct the students' thinking. One way to direct ESL/special needs student's thinking is to ask questions in plain terms. For example, instead of asking: "What science field do you like," a teacher/presenter could ask: "Do you like dinosaurs, or fish, or stars?" while at the same time pointing to the visual cues with these words (i.e. a picture of a dinosaur, a fish, a star, etc.) If ESL/special needs students look like they do not understand, the teacher/presenter needs to make them feel comfortable by letting them know that it is okay not to know something. Talking about science, and science activities in precise and credible terms is particularly important for ESL and special needs students, since it helps to build their self-esteem, and their 'science confidence.' We are aware that many students have diverse interests, but one commonality is that all students make science personal. Boys might like chemistry with explosions, while girls might like more 'softer sciences', such as marine biology or zoology. This is true for ESL/special needs students, too, but it doesn't mean that no boys like 'softer sciences', and that no girls like chemistry.

In addition, most students in elementary schools have misconceptions as to who scientists are, and what they look like. Students think that a scientist is a male

(Caucasian) in a white lab coat, with gray, messy hair and taped-up, black-frame glasses. However, most students find it empowering to know that they, too, can be scientists, and that a scientist is not what they might think. It is important that instructors of hands-on science mention names of scientists from diverse cultural backgrounds, genders, and races, who have made a special contribution to our society. By doing so we promote admiration by all students for the accomplishment of people of many different backgrounds, and also different physical abilities. For example, students could be asked if they knew that Thomas Edison, the inventor of the light bulb, had a learning disability. This could make special needs students feel more 'science-confident.' Teachers/presenters could tell all students that people with learning disabilities can climb to the greatest heights of success, and there are many who have done that. Students need to be aware of science as a diverse field, not only in content, but also in kinds of people who pursue it.

Science education researchers always explore different ways to make the hands-on science even more practical and interactive for all students. We know the nature of hands-on science, and the organization of LTS workshops, but how do we maximally engage the minds of ESL and special needs students, and help them maintain attentiveness throughout the practical activities? A few suggestions have been already stated, but we will explore these, and other issues, more throughout the rest of this document.

Preparing everyone before an in-class workshop: LTS encounters ESL and special needs students in the hands-on science workshops on many occasions. The teachers inform the LTS presenters ahead of time if there are any ESL or special needs students in the class. This is very helpful, because it gives the LTS presenters a chance to better prepare prior to their visit. In preparation they could simplify their own vocabulary, prepare direct, short and simple step-by-step instructions, and think about the space needed for the hands-on activities. In addition, to better prepare a class, the LTS presenter could provide the teachers with a vocabulary list, along with short definitions or pictorial illustrations of the key words/concepts that will be encountered in the hands-on workshop. Teachers could then incorporate the vocabulary list *not only* in the science

class, but also in English class, or in any other class. The integration of science, English, and other disciplines results in better language development for all students, especially ESL and special needs.

Since we live in an increasingly multicultural society, the vocabulary can also be expressed in students' native languages. This requires that hands-on instructors obtain the list of native languages of ESL students in order to translate ahead of time the key 'hands-on workshop' words. It might be too much to ask of LTS (or any other outreach organization) but if the schools make the policy of this approach, it might be do-able. On this note, LTS could develop a resource which listed common scientific terms in different languages which were likely to be represented in the classroom. This extra document can help ESL students fully understand the meaning of all key words. ESL students mostly have a language problem, which if addressed appropriately, can be improved, and solved quickly.

In addition, it is very useful to prepare a schedule ahead of time, because it gives the presenters a framework in order to effectively facilitate students with each hands-on activity. Schedules are a part of classroom structure, and are often helpful for ESL/special needs students. A schedule, indicating duration of each work session and break times, could be given to the teachers ahead of the visit. The teachers could carefully review the up-coming events of their adventurous, 'hands-on day'. This ensures that all students will anticipate the science-day, and it might help teachers/presenters to better prepare a class before the hands-on activities. It also increases the probability that students' minds will be more engaged throughout the workshops, since we hope that students will be excited and will let their minds jump into fun activities. In addition, all presenters should be prepared to alter their original presentation format if necessary.

Engaging the minds of ESL/special needs students during the hands-on science activities: Hands-on science workshops can be made very interactive, and thus more practical, if the students within each group have varying interests, levels of abilities, intellectual capacities, and have approximately equal ratios of boys to girls. This diverse mixing allows more interactions at various levels within a group. ESL and special needs

students have more opportunity to interact with other students, and to improve their communication and inter-personal skills. The minds of the ESL/special needs students could be more involved if there is someone in the group who could help them with whatever they might not understand. The presenters/teachers could encourage very active students, or even the students who might be/look bored, to assist their ESL/special needs peers. The concept of PALS (Peer-Assisted Learning and Support) should be promoted by teachers and presenters during every hands-on activity. PALS allows for enhanced learning for all students. It could be especially beneficial for better engagement of ESL/special needs students, since cooperative learning might prove to be more effective for ESL/special needs students than individual learning.

During a typical hands-on activity students are involved at different science stations. They might be doing finger-printing, chemical analysis, hand-writing analysis or chromatography (e.g. LTS Crime Lab Workshop). In certain instances some students may finish a particular station faster than others. As a result of that, they might lose attentiveness, and become impatient and distracting to other students. In comparison, ESL students might be slower, and special needs students might need extra help with finger-printing. These, and many more situations are encountered during hands-on workshops. The presenters/teachers must show personal interest in assisting the students in all situations, and directing them towards the completion of the activities' goals. The presenters/teachers need to constantly check for students' understanding by asking simple questions. For example, an ESL student/special need student could be asked by the presenter/teacher to explain in their own words what they are doing, or the presenter/teacher could give them brief, simple, and redundant explanations of the applications of each activity to real life. It is very important to stress applications of each activity, since it promotes learning by associating practical experiences to real life situations. Furthermore, students' minds are not 'blank slates'; they can form new concepts by building on old ones. For example, many students know how to tell what the weather is like outside (e.g. cold, hot, rainy, windy, etc.), and thus they have this prior experience, and knowledge. However, many of them don't know how meteorologists measure weather conditions such as wind speeds, or temperature. By allowing students to build an anemometer and measure their own wind speeds, students can build new

knowledge/skills on the already existing knowledge about weather. Thus, to engage ESL/special needs students activities must be introduced (at the right age, and in logical order), where students can build new knowledge by recognizing patterns, find possible explanations, predict outcomes, and obtain positive values, beliefs and attitudes for learning science. Simple entertainment, which is the core of hands-on science for youth, eliminates the pain associated with learning 'too much' science. Instead, it introduces pleasure into learning; therefore it engages the minds of all students. Students learn and remember from the fun experiences that LTS presenters could offer them.

For many years it has been known that lack of attentiveness, irrespective of the reason, is a clear potential of disruption of learning efficiency (Swift and Spivack, 1975). What does this mean for ESL/special needs students? Many would agree that if the students' minds are absent throughout an activity (i.e. they wander, distract other students, etc.), then the chances are that they will not learn, or will learn poorly. ESL/special needs students often become inattentive due to language difficulties, or a learning disability (sometimes a few learning disabilities per student). If ESL/special needs students become inattentive, that should quickly press the instructors for a reaction, and the inattentive students should be made active participants. For example, students could be given more choices in the activities, and/or they could be asked to repeat the same activity. Repetition of an activity, if time allows, is often helpful, and many times it improves the learning experience. We want to mobilize the minds of ESL/special needs students, and the mobilization often requires presenters/teachers to monitor the students' comprehension and to open up channels in their minds to receive positive experiences from hands-on learning. By positive experiences we imply that students gain usable skills and they can recognize, explain and further question the applications of each activity to real life. Opening the channels to their minds might require constant repetition of new ideas, concepts, skills, and applications, as well as allowing time for the positive experiences to 'sink-in.'

Furthermore, during workshops ESL students (and many other students) encounter words that they do not understand. For example, when asked to calculate the wind velocities and complete a worksheet, a few students in grade five did not understand the meaning of 'revolution,' and 'circumference'. Many times a student cannot

understand language as well as a teacher/presenter believes he/she can. In this case, alternate words could be used, such as 'spinning' or 'distance around a circle'. It is important that LTS presenters review the worksheets and check for any words that ESL/special needs might not understand. Whenever a new word is encountered, the presenter could ask the entire class to repeat the word out loud. This re-energizes a class, and makes everyone more attentive. Most ESL/special needs students are less shy to pronounce a new word if they hear the whole class say it loudly. The word could also be written on the black board by a student or teacher to serve as a reminder for all students. It can also help enrich the class vocabulary list.

The directions to perform each hands-on activity need to be clear, and arranged in a flow chart method. LTS makes a great use of flow-charts to guide the students through each hands-on activity. Presenter could complement instructions in the flow-chart with pictorial illustrations, and bold every key word. (One must be careful not to give students visual cues that are too distracting). The pictorial illustrations allow ESL/special needs students to think more carefully about what they are doing. Their minds can remain focused on the activities rather than on cluttered, incomprehensible instructions, which are often found in many science textbooks throughout a child's formal science education. Also, placing materials in the setting where they will be used can also help ESL/special needs students follow directions and complete task more successfully. This is particularly helpful for special needs students, since some might have difficulties reaching the required materials, and when this happens they become disoriented, confused and uninvolved. For example, having a beaker with cold water (labeled 'cold water') and a beaker with warm water (labeled 'warm water'), next to food-colouring, and a medicine dropper, are cues to all students as to what tasks should be done, and what materials to use. ESL/special needs students can see what is in front of them, and such visual prompts can start the thinking process, and engage their minds in the activity. Many students, especially special needs, have difficulties holding details together; therefore, presenters/teachers should rely on one thought/instruction at a time, and present materials in small steps. Furthermore, presenters/teachers can use samples or pictures of finished products to show ESL/special needs students (and all other students) what needs to be done, or what the finished product should look like. Finished models can often be very

helpful for ESL/special needs students, since most ESL/special needs students rely on visual cues to help them complete a task. Special needs students with physical handicap might require physical assistance and appropriate guidance to complete a required task.

All students should be encouraged to describe in their own words what they are doing. This, as stated earlier, checks for students' understanding. It is also very important to encourage all students to ask questions, and it is not embarrassing not to know something. If Sir Isaac Newton didn't question why an apple fell on his head, he wouldn't have defined gravity, no matter how silly his question might have been to him, or others. A science classroom is a place where all students learn to ask questions. A true test of comprehension involves posing questions, as well as finding answers to the questions. Students need to know that their questions are always interesting, and have a lot of meaning. Students could be encouraged to write down their questions; in this way, even the shy ESL students can get their questions across.

Continuing the learning after workshops: The teachers have the pivotal role in continuing the learning of his/her class after the hands-on science workshops. It is always important to reflect with the students on the activities that they performed. All workshops should be followed by brief in-class discussions, which check for students' understanding, as well as for different experiences that students had throughout a particular activity. This would help ESL/special needs students to hear what the rest of the class experienced. A presenter/teacher could ask a question to an ESL or a special needs student, and also remind them that we all can be scientists, and that science is not just for smart, nerdy boys. In addition, it is most rewarding for the students when an activity has a final product that they could take home. Having a product, which the students can take home, such as a thermometer to measure temperature, or slime to illustrate a polymer, increases the probability that students will continue to talk about their product, and consequently most other activities performed during a workshop. A supplementary list of simple exercises could be provided to students to help them continue the learning after a workshop. For example, a simple, half-page paragraph with missing words, which students have to fill out from a list of words that would be

provided to them prior to any workshops. Also, all students should be encouraged to self-evaluate, and enter journal entries describing what they have done, and learned, from the hands-on activities. For ESL and special needs students, if writing skills are weak, there are alternative strategies, such as drawing, or giving oral presentations to the rest of the class. Teachers must focus on one skill development at a time, and sometimes, a student might need to master one skill before acquiring the next one.

The hands-on, in-class science workshop offer a fun experience to all children, and is a great means of getting students' attention and motivating students to explore science. All presenters should be aware of the diversity of all students, and that certain activities might require more attention than others. The presenters must always put scientific knowledge in a comprehensible context with relevance to students' lives, which will increase the chances that students will continue to want to learn science on their own.

Summary of tips for teachers/presenters of hands-on science when they encounter ESL/special needs students in the workshops

- ❑ Enforce applications of science concepts, and various skills to real life situations.
- ❑ Do not treat ESL/special needs students as different; include all students and present everyone with the same materials.
- ❑ Use the kinesthetic approach to learning as the means to introduce ESL/special needs students to new concepts and skills.
- ❑ Be specific, consistent, and systematic in expectations and actions in each hands-on activity.
- ❑ Ensure that there is enough space for individual, as well as group work, at each workstation.
- ❑ Read orally all instructions to the class, and stress the key words in each activity.
- ❑ Review the key words on the vocabulary list, which would be provided to the teachers prior to LTS visit.
- ❑ Check that ESL/special needs students understand all key words, and instructions to successfully complete each activity.
- ❑ Change the volume of the tone of your voice to emphasize important points in the activity, especially the applications of each activity.

- Provide visual and verbal cues to ESL/special needs students throughout the activities.
- Help build 'science-confidence' by promoting admiration for the accomplishments of people/scientists of many different backgrounds, physical and mental abilities, genders and races.
- Increase interest by helping ESL/special needs students, and encourage the active students to assist their peers, or to be PALS.
- Ensure mastery of new material through repetition, and check for students understanding by asking simple questions.
- Encourage ESL/special needs students to describe in their own words what they have learned or experienced in each activity.
- Allow students to ask questions to the instructors, as well as to their peers.
- Ensure that students have some final product to take home, and to be able to discuss, briefly, with their parents what they have learned.
- Supply a supplementary, one page, exercise (ie. fill-in the blanks exercise) could be used to help students review the information learned in each workshop, and consequently continue the learning after the fun workshops.

SUMMARY

When teaching science, one should always look for most innovative, interesting and fun approaches. Hands-on science offers many teachers, and other science educators a practical way of presenting science to all students; however, it might not be enough since students' minds need to be engaged as well. Since we strive to improve scientific literacy of all students, the hands-on approach puts all students in the center of action for all activities. The emphasis, and major objective is to engage all students and encourage development of new skills that will guide students (esp. ESL/special needs) through future education. ESL and special needs students can benefit from kinesthetic learning, since the teachers can always incorporate language development along with Science learning. Encouraging the skills to think for oneself, and giving choices to all students

can further the development of students' education. In order to continue the learning, the teachers need to encourage students to express activities in their own words, write journal logs, give individual and/or group presentations, and support each other by continuing to be PALS.

ACKNOWLEDGEMENTS

I gratefully acknowledge the support of Dr. John R. Percy, Let's Talk Science and Ontario-Work Study Program.

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