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TEACHING INTEGRATED SCIENCE THROUGH THE USE OF INTERACTIVE WORKSHEETS

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In this work, interactive worksheets were used to teach a unit of integrated science to a group of 32 lower secondary school science students in Trinidad and Tobago. Observational checklists, students' journals, and perception opinionnaires were used to: (1) explore what effect interactive worksheets had on students' levels of participation during classroom learning, and (2) solicit students' views about the effectiveness of interactive worksheets to teach science. The findings revealed high levels of student participation and an overall expression of enjoyment among students when science was presented to them via this method. Students indicated that the experience was a meaningful one to them and suggested that interactive worksheets were effective in facilitating their understandings of the science content that was taught in the unit.

Introduction and Background

Research in methods of delivery in science instruction suggests that rote delivery "turns-off" students and contributes to the development of resentment for the science discipline (Anderson, George, & Herbert, 2009; Kinchin, 2004). Given that science is by nature a hands-on discipline it is not easily understood why teachers opt to choose traditional passive methods of delivery over more practical, interactive strategies. Hake (1997) suggests that interactive instructional techniques not only stimulate student learning in the classroom but that they impact on overall student performance in the long term. A number of interactive methods have been used to promote active participation and interactivity in the science classroom, including peer instruction tutorials (Mazur, 1996); ranking tasks (O'kuma, Maloney, & Heiggelke, 2004); and in-class worksheets (Heuvelen, 1997). What all these have in common is a use and design format that allows for students to hold a certain degree of autonomy for their learning in their hands.

In general, these methods are quite attractive and offer science teachers a non-traditional approach to achieve learning in their classrooms. They have found a great deal of acceptance among teachers in all of the science disciplines—biology, chemistry, physics, earth science, and agricultural science—because they can be used effectively

in classes of all sizes and do not require teachers to make drastic changes to their course content (Johnson & Dasgupta, 2005).

The Trinidad and Tobago Context

In Trinidad and Tobago, students enter the secondary school system at an average age of 12 years, and as part of the prescribed curriculum they are all required to pursue Integrated Science (a combination of biology, chemistry, and physics) for the first three years of secondary schooling—called lower secondary—in all instances. Their placement in secondary school is determined by the results of their performance on a national placement examination called the Secondary Entrance Assessment (SEA) examination, which is administered to them at the end of primary schooling. In this SEA, only skills in Language Arts, Mathematics, and Creative Writing are assessed. There is no science component even though science is taught at all levels in the primary system. Given the nature of the assessment in this placement examination, teachers in the primary schools do not place as much emphasis on the teaching of science—in both quantity and quality—as they do on the teaching of Language Arts, Mathematics, and Creative Writing. Wiggins (1993) has suggested that when there is a reduced emphasis on science teaching and learning at the primary school level it usually results in a situation in which students entering the secondary school system are either deficient in science content or disinterested in science, or both, because of their limited exposure to the discipline at the primary level.

Against this background, it is not surprising to find many lower secondary students in Trinidad and Tobago displaying varying degrees of disinterest when re-introduced to science at secondary school. As Watters and Ginns (2000) have said, limited prior exposure to science at primary school often manifests itself in low levels of participation and involvement in secondary school science classes. This, in fact, is an observation many lower secondary school science teachers in Trinidad and Tobago have made, and they have indicated that they feel challenged when attempting to deliver science instruction to non-responsive participants. They recognize that it is important for them to devise strategies and to adopt methods that will stimulate students' participation and promote meaningful learning in their science classrooms. As a result, some teachers have employed practical hands-on approaches and structured small group activities in an attempt to encourage student participation and promote interest in science. They feel, however, that they are unable to facilitate these approaches for all science topics when

class sizes are large, and when their classes are comprised of mixed ability students.

Teacher educators in science education programmes in Trinidad and Tobago have listened to and given consideration to the challenges faced by secondary school science teachers, and have introduced trainee science teachers to the concept of interactive worksheets as another more recent strategy that they can use to promote interactivity and participation in their science classrooms. Leslie-Pelecky (2000) has explained that well-designed interactive worksheets are highly versatile and flexible, and therefore have the potential to treat with the challenges faced by lower secondary science teachers. Teacher educators in many of the existing science teacher preparation programmes in Trinidad and Tobago have been making deliberate attempts to encourage science teachers to consider interactive worksheets as one possible strategy to assist them in delivering science instruction.

In this study, the use of interactive worksheets to teach a unit of integrated science to a group of Form 2 lower secondary students is investigated. The study is set in Central Trinidad, and participants include students and teachers from a government-controlled secondary school with a school population of 604 students. The overarching goal of this work is to reveal the effect of in-class interactive worksheet on the levels of student participation, and to gauge the students' views on the effectiveness of this strategy as a teaching/learning tool for integrated science. In this regard, therefore, the following two research questions shaped the approach adopted:

1. *What effect does the use of interactive worksheets in a form 2 integrated science class have on the levels of student participation in the science classroom?*
2. *What are students' views about the effectiveness of interactive worksheets to teach integrated scienc*e?

Interactive Worksheets

As mentioned, worksheets are very versatile and can be designed to meet any instructional objective in any topic, in any discipline. It is important to note that worksheets of any type—interactive or otherwise—will consist of questions, and that writing "good" questions—those that stimulate thought, encourage critical and creative thinking, and promote problem-solving skills—is not always an easy task. Furthermore, worksheet questions should also seek to identify students' misconceptions and allow for clarification of these as far as possible (Leslie-Pelecky, 2000). No matter what the type, worksheets for a given

topic must be very specific (to the topic), that is, devoid of ambiguity, in order to allow teachers to target the intended objectives of the lesson being presented to students.

Interactive worksheets can be of two types:

- Problem-solving worksheets are those that are designed to lead students through the specific steps for arriving at an algebraic or numerical solution. Questions on this type of worksheet can be worked on as sample problems during the lesson or can be used as stimulus material for structured classroom activities. Problem-solving worksheets can also be used as a formative assessment tool. Usually, questions on problem-solving worksheets require students to apply some learned theory, law, equation, or relationship to new situations in which the variables might be different from, but related to, those encountered in the learning experience (Gormally, Brickman, Hallar, & Armstrong, 2011).
- Conceptual worksheets are more focused on developing conceptual understanding and confronting students' perceptions and/or misconceptions, which are necessary for understanding subsequent material (Heuvelen, 1997).

The focus in this particular work is on exploring students' levels of participation through collaborative engagement in problem-solving exercises and activities. Their general perceptions of the effectiveness of problem-solving interactive worksheets in the teaching of integrated science will be sought, and to that end only problem-solving worksheets will be used in this work as these will adequately accomplish the aims of the research.

Literature Review

Underlying Theory

The Piagetian view of learning, which led to the shift from learning as "knowledge-acquisition" to learning as "knowledge-construction," has at its core the belief that students construct knowledge and understandings by negotiating past experiences with new experiences in socially interactive settings. It saw learning occurring through a learner-centred approach, in which the teacher becomes a cognitive guide of learner's learning and not a knowledge transmitter. This view of learning suggested that learning within a social context is facilitated through concepts such as modelling, observational learning, and imitation, and that children learned from observing and interacting with others by

engaging in structured, well-paced activities. In the late 20th century, the constructivist view of learning was reshaped by the rise of the perspective of "situated cognition and learning," which emphasized the significant role of context, particularly social interaction, in the learning process. In the new view, cognition and learning are understood as interactions between the individual and a situation; knowledge is considered as situated, and is a product of the activity, the context, and the culture in which it is formed and utilized. In this revised view, learning occurs through active participation and social negotiation (Lave; 1988; Rogoff, 2003; Vygotsky, 1997).

Science Learning, Interaction, and Interactive Worksheets

Science is often perceived as a difficult subject by many; some describe it as confusing and others suggest that it is boring (Maharaj-Sharma, 2011). Physics, in particular, seems to be deliberately avoided by a number of students pursuing higher-level science education, to the extent that, in Trinidad and Tobago, enrolment in physics at the secondary and tertiary levels is the lowest among the other science disciplines such as chemistry, biochemistry, botany, and zoology (Trinidad and Tobago, Central Statistical Office, 2008). Investigation into students' perceptions of science suggests that their dislike/avoidance of the subject is only remotely linked to what is taught in the science class, and instead is more directly related to how science teaching occurs in the classroom. Goldenberg (2011) suggests that students really do enjoy learning science, and that they are quite fascinated by the enquiry process and by discovery learning, but they feel stifled into having to conform to the regimented, passive methods of delivery. Watters & Ginns (2000) found that when the learning process is made enjoyable, by allowing students to express themselves through questioning, collaboration, and interactive discourse, science students not only perform at higher levels when assessed, but are motivated to pursue science at higher levels. The opportunity to actively participate in their learning seems to yield its own reward (Kinchin, 2004).

With particular reference to physics, Heuvelen (1997) designed, for the first time, and used in-class interactive worksheets in physics classes, and found that the worksheets were able to achieve much more than was originally expected. Not only did it tease out information about **when** students did not understand the physics, but it also revealed **why** they did not understand. Furthermore, the immediate student feedback that the in-class worksheets provided allowed for confrontation of both the **when and why** of students' lack of understanding. The worksheets also

allowed for better daily evaluation of students' learning and significantly improved students' participation in class. In addition to Heuvelen (1997), Hake (1997) used a number of interactive activities in the classroom, and found that the creation of interactive settings within the classroom prompted learners of all types to participate in class activities and created the optimum environment for science students to learn from each other. Later, Goldenberg (2011) revealed that students of the science disciplines were asking for more interactive approaches to be used in their science classes, and that even slow learners were identifying ways in which interactive methods of learning were impacting positively on their cognitive development.

Leslie-Pelecky (2000) suggested that while interactive worksheets in science classes are very effective at confronting students' lack of understanding/misunderstanding, and while they promote increased levels of student participation and a higher degree of student-teacher interaction in the classroom, they are not suitable for all topics in science. In addition, worksheets take a long time to prepare, and for some topics they cover less content material than would be covered in the same time using more traditional methods of delivery. These are issues that teachers who wish to use interactive worksheets must carefully consider before opting to use them.

Educators in the local context agree that there is an urgent need for teachers to make science learning a more rewarding experience for students and, in this regard, over the last two decades, more and more efforts have been made to shift to contemporary practices through the use of a number of creative, innovative, and hands-on strategies and approaches in science classrooms (Maharaj-Sharma, 2008). In keeping with this effort, in this work interactive worksheets will be used for the first time to deliver science instruction to science students in the local context—Trinidad and Tobago.

Methodology

Target Group

A group of 32 Form 2 lower secondary school science students participated in this work. Their ages ranged from 12-15 years and the class consisted of 15 boys and 17 girls. The group was a mixed one, in terms of ethnicity, geographical origin, and previous academic performance. The class was taught Integrated Science by one teacher, who saw the class three times per week for sessions lasting 50 minutes each. The teacher has been teaching Integrated Science for the past 6

years, and for the purposes of collecting data for this work she was assisted by a cooperating teacher. Because the intervention (interactive worksheets) is a new one in this context, convincing teachers and, by extension, their students to participate was not very easy. This particular teacher felt very encouraged by the potential benefits interactive worksheets could have for her students, and she encouraged her students to participate in the research.

Treatment — Pre-Implementation

The case study approach was adopted for this work. Structured interactive worksheets of the type(s) discussed herein are a somewhat new strategy that teacher educators are introducing to trainee teachers and encouraging them to adopt in their classrooms. In this specific case, the science teacher, being very enthusiastic about the strategy, volunteered herself and her Level 2 Integrated Science class to participate in the project. Parental permission was sought and obtained for all 32 participating students. In the study, the teacher delivered an integrated science unit entitled "Forces and Motion" to the students. The unit consisted of six 50-minute lessons in which interactive worksheets were used as the main teaching/learning strategy.

The unit of work was planned well in advance of the classroom delivery, and corresponding worksheets were designed for each lesson in the unit. The worksheets were reviewed, in conjunction with the lesson, by a teacher educator in the area of science education to verify consistency between the lessons' content and the worksheets' coverage, and to ensure that the worksheets were coherent and unambiguous. All stimulus materials, models, laboratory equipment, and readings needed for the lessons were prepared before teaching of the unit began.

Treatment — Implementation

The unit was taught over a period of two weeks; 3 lessons per week on Mondays, Wednesdays, and Fridays. The interactive worksheets were used primarily in the body of the lessons, except for the first lesson in which it was used at the end of the session. The worksheets were not graded, but were used formatively to allow the teacher to determine the extent to which students were able to apply learned material to solve problems or to explain observations and occurrences. The teaching session for each lesson consisted of three phases. In the first phase, students were taught some foundational content about the topic of the lesson and were presented with examples of applications of the content. In the second phase, they were presented with the worksheets and

instructed to work through them by engaging in group collaboration. For each question on the worksheet, the students were instructed to share what they each thought was a suitable answer and to explain to the group why they thought so. When members of a group had differing answers they had to decide on which answer to present on the worksheet. In making this decision, they were to collectively consult their class notes, handouts, and blackboard work, to arrive at consensus on what they would present as a suitable answer for the question. The worksheet exercises were designed to progressively move students from the cognitive levels of knowledge and comprehension up to analysis and synthesis, by prompting them to solve problems as they completed the sheet. In the final phase of the teaching session, each group presented by telling the class what problems they were presented with and the solutions they arrived at. In any one teaching session, each group worked on a different problem.

During the lessons, students' levels of participation were gauged by the use of a detailed teacher checklist. The observational checklist used was adopted, and suitably adapted, from work done by Wiggins (1993), in which students' levels of participation in science learning were explored. The cooperating teacher observed the lessons and completed the checklist while the class teacher taught. The checklist consisted of 15 descriptive items, which each sought to encapsulate the behaviours of students as they worked through the worksheets. Each item rated a particular behaviour as *high*, *moderate*, or *low* depending on the extent and the frequency (as described by Wiggins, 1993) with which the particular behaviour was observed among the students. The checklist focused on behaviours in the following areas:

- Students' willingness to freely volunteer answers to questions posed to them in the class
- Students' participation (oral and written) in group work/activities
- Students' engagement in peer assistance when working through the interactive worksheets

At the end of **each lesson**, students' perceptions about the effectiveness of the worksheets were captured by way of a short journal entry. They were asked to indicate in what ways the worksheets were helpful or useful to them in the lessons, and to say whether or not they thought the worksheets were effective in facilitating their learning. At the end of **the unit**, each student was asked to complete a short Likert-type opinionnaire, which sought to capture additional details about their levels

of participation as well as their overall perceptions of the effectiveness of the worksheets in facilitating learning in integrated science.

[The opinionnaire was designed initially by the researcher and went through three phases of piloting. The first phase sought to ensure that the statements were grammatically unambiguous and, as a result, was sent to the language department for review and critique. In the second piloting phase, the aim was to ensure that the statements targeted the key parameters for which information was being sought—levels of participation and perceptions of effectiveness. A measurement and evaluation specialist reviewed the opinionnaire, and feedback furnished was used to improve the validity and reliability of the instrument. In the final phase of the piloting process, the instrument was administered to 100 Form 2 students (none involved in this study). These students were from the same school at which the study took place but belonged to other Form 2 groupings. Their responses suggested that the instrument was clear and focused.]

Data and Data Analysis

Observational Checklists

The observational checklists focused on the activities students were engaged in during the learning process, and sought to capture students' levels of participation during each teaching session. The checklist allowed the cooperating teacher to record, from among the list of demonstrative behaviours on the checklist, which behaviours each student displayed during each lesson, and also to classify the behaviour as *strong*, *moderate*, or *weak*. The cooperating teacher observed the students as they worked through the activities using their interactive worksheets, and she completed the observational checklist to reflect the extent to which the students were participating in the lessons. Upon completion of the unit of work, these lists were collated, reviewed, and analysed quantitatively to determine the extent to which each of the behaviours observed was displayed by the students. Observed behaviours were further analysed to reveal the extent and nature of students' participation in terms of their willingness to provide and/or volunteer responses, their participation in group work through information sharing, and their willingness to provide peer assistance to others in the class.

Journals

Students were asked to make a short journal entry at the end of each lesson, in which they were encouraged to write about their views of the effectiveness of the interactive worksheets in facilitating their learning for that lesson. The entries were made under the cover of anonymity so that students could honestly and freely express their views in a non-intimidating setting. These journal entries were collected, reviewed, coded, and subsequently analysed qualitatively to give an indication of what students' views were in respect of the effectiveness of the interactive worksheets to teach science.

Perceptions Opinionnaire

Items on the perceptions opinionnaire were used to capture additional data about students' levels of participation when interactive worksheets were used in the classes, and students' perceptions of the effectiveness of interactive worksheets to teach science. Its use was to complement the data obtained from both the checklists and the journal entries. It consisted of 10 opinion statements presented via a Likert model, to which students responded that they *agreed*, *disagreed*, or were *uncertain*. Some of the items were linked to levels of participation and some sought to reveal students' perceptions of the effectiveness of the worksheets. These opinionnaires were analysed in conjunction with the data obtained from the checklists and the journal entries to present a more thorough picture of the effect that the use of interactive worksheets had on teaching and learning in the science classroom.

Findings

Students' Levels of Participation

Analysis of the data obtained from the observational checklists revealed that, in general, students were very involved when interactive worksheets were used during the teaching of the science lessons. Students were discussing ideas and solutions to problems on the interactive worksheets, and were explaining concepts to their peers, genuinely assisting them to work through the worksheets. When class questions were posed by the teacher there was an overwhelming willingness by the students to answer or to provide additional explanations. The science class was abuzz with interactivity—sharing and collaboration—as students attended to the tasks on the worksheets. Quantitative analysis of the observational checklist data revealed the following:

1. Students' levels of participation, as described by Bean and Peterson (1998), in terms of willingness to volunteer responses to oral questions, willingness to offer explanations, and readiness to make input in discussion was greater than 83% in each of the lessons of the unit.
2. In collaborative group work, while completing the interactive worksheets, more than 80% of the students were engaged in information sharing and discussions for each of the lessons.
3. Peer assistance by way of explanations of ideas and concepts to each other was observed in all the lessons and, based on analysis of the checklists data, 3 out of every 4 students indicated that they explained an idea to one or more of their peers, and 9 out of every 10 students indicated that an unclear or difficult idea was made understandable to them by one of their peers.

Students' Journals

When students' journals were analysed, it was revealed that their perceptions of the effectiveness of the interactive worksheets were overwhelmingly positive. Most students found the worksheets to be helpful in allowing them to work through a problem in a "stepwise" and "logical" manner. There was a strong indication that the interactive worksheets facilitated "flow" and "building" of ideas as the unit progressed from lesson to lesson. Students indicated, too, that the process was an enjoyable one as they were allowed to learn through collaboration and sharing of information with their peers. Many students said that working with their peers on completing the worksheets was an "*enjoyable*" experience, and that they "*liked explaining what they knew*" to their friends. Even though the shift from the traditional paradigm seemed to have found great acceptance among many of the students in this work, a few of the high performers in the class expressed, through their journals, less positive views about the use of interactive worksheets. But even while they cited the much slower pace with which the class progressed as their main area of dissatisfaction, they agreed that interactive worksheets were effective in facilitating science learning. Responses of this kind, however, were in a very small minority; less than 7% of the responses.

The following excerpts of journal responses captured, in a general sense, students' perceptions of the effectiveness of the interactive worksheets:

Student 1: …I did not get it at first….but when Amy explained it to me ….I was able to do the worksheet…

Student 2: the equations in straight line motion were difficult….but when I went through the steps in the worksheet with my friend it was easy to follow

Student 3: …it was fun explaining how a force works to the others in my group…

Student 4: The worksheets made the problem seem easy….and I was able to explain it…

Student 5: we really shared our learning….

Student 6: …the worksheets really helped me to understand effects of forces

Student 7: Comparing my answers with my friend … helped me to see my mistake….

Student 8: …the sharing and discussing was nice… it was different…

Student 9: the worksheets were very useful to me…

The Likert Perceptions Opinionnaire

[The 10-item Likert perceptions opinionnaire was administered to the class at the end of the unit, after the teaching of the six science lessons. The students were asked to indicate if they ***agreed****,* ***disagreed****, or were* ***uncertain*** *for each item.]*

Views on participation. Students' responses to items on the Likert perceptions opinionnaire that sought to elicit from them their views on the effect the interactive worksheets had on their levels of classroom participation indicated that, in general, students felt that the worksheets facilitated greater levels of peer-peer interactions and allowed for a high degree of student participation in the lessons. Students suggested that, in general, they were interacting with their peers more than they normally did in previous science classes. Their responses indicated that in using the approach, a great deal of information sharing occurred among the students, which allowed for a lot of learning from each other. Their overall response to the participation specific items is summarized below:

- The interactive worksheets encouraged me to share my knowledge with my friends.

  Agree – 83%; Disagree – 8%; Uncertain – 9%

- I was able to help my friends understand something using my worksheet.

  Agree – 89%; Disagree – 2%; Uncertain – 9%

- When using the worksheets, I interacted more with my peers than I did in lessons before.

  Agree – 85%; Disagree – 4%; Uncertain – 11%

Views on effectiveness. The other 7 items on the perceptions opinionnaire sought to reveal what were students' views on the effectiveness of the worksheets on their science learning. Students agreed overwhelmingly that the worksheets aided their understanding of content covered in the unit, and that it was a useful teaching/learning tool. Most of the students (90%) indicated that the worksheets were helpful to them as they helped them to link related ideas. All the students agreed that the worksheet design facilitated developmental understanding because the sheets started with simple ideas and gradually moved along to more challenging concepts and scenarios. All but two students agreed that the worksheet made learning the topic easy for them. These two students were high academic achievers in the class. They assisted their classmates on occasion, but seemed bored over the time it took for their peers to arrive at answers for questions on the worksheets. The majority of the class (92%) indicated that by using the interactive worksheets they were encouraged to think carefully as they worked through the problems to arrive at the final answers. In terms of the frequency with which they felt interactive worksheets should be used and its overall effectiveness in aiding learning in science, all but two of the students agreed that it should be used more often and that it was effective in helping them learn concepts in the topic.

Discussion

For the students, the use of interactive worksheets to teach integrated science in this work revealed that prior experience, learning context, social interaction, and suitably selected interactive approaches all contribute to meaningful and effective learning in the classroom. As was reported by Bean and Peterson (1998), the interactive worksheets used in this particular case encouraged students to learn science through collaboration by engaging in small group discussions, by sharing information and experiences, and by sequentially building knowledge and understandings. Learners of all types commended the strategy highly and expressed satisfaction with the experience. No comments of

intimidation or strong unease emerged from the data, which seems to suggest that, in general, learners of all types participated without inhibition.

Insights about when students did not understand a concept and, to a lesser extent, why they did not understand it were revealed through the interactive worksheets. Close examination of the completed worksheets submitted by the students indicated very clearly at what point the students encountered difficulties as they worked through the sequence of tasks on the interactive worksheets. For example, a common problem experienced by the teacher when teaching in the past had been students' difficulty in grasping the idea of distance moved in the direction in which a force acts when describing work done on an object. If the distance in the direction in which the force acts was given to students they were able to figure out what work was done very easily, but once they were required to examine either the wording of a problem or the diagram of a system to determine what was the distance moved in the direction in which the force acts, they ran into difficulties and were unable to solve the problem.

With the interactive worksheets, this problem was broken down into smaller problems/parts, which allowed, in this particular example, for students to identify, firstly, **where** the force was acting and what was the **magnitude** of the force. The next step in the worksheet asked students to **track/trace/explain the motion** of the object as a result of the force acting on it and to assign a **direction of motion**. In the third step they were asked to return to Step 1 and to indicate the **direction** in which the **force** was acting on the object. In Step 4 of the worksheet they had to look at the **direction in which the force was acting and the direction in which the object was moving,** and to determine whether they were the same or different and if they were different to explain how the directions were different. This stepwise approach allowed for students to see clearly the relationship between the direction in which the force acted and the direction in which the object moved and to determine the work done on the object. In this regard, therefore, the interactive worksheets allowed the teacher to see some of those areas where students were experiencing difficulties.

An unanticipated benefit of using the interactive worksheets, as articulated by the class teacher in informal discussions after the project was completed, was that the psychological distance between student and teacher, which is often present in large classes, seemed to have been practically eliminated. Students' names were visible on every worksheet; they were talking about the topic freely, helping each other, and sharing what they understood. They were speaking more frequently, openly, and

with greater levels of confidence to the teacher. The teacher indicated that the experience allowed for her to get to know "*more about many more of her students*."

Lessons Learned

Interactive worksheets are very effective in that they allow teachers to recognize students' preconceptions, misconceptions, and problem-solving challenges. They are very effective at facilitating class participation and at increasing both student-student and student-teacher interactions. The particular design of the worksheets can help teachers determine if the difficulty for the students is linked to problem solving or if it is conceptual. While opportunity for open responses in the worksheets can provide valuable information about what student learning has or has not occurred, if the responses are too vague it will make assessing the extent of learning a difficult task for teachers. It is important, therefore, to provide lots of writing space for students on the worksheets, as on many occasions they write/scribble before/during the thinking process. Not only students, but teachers too, can benefit from the responses students provide on their worksheets. These responses can point out weaknesses in a teacher's presentation of the topic and can indicate to teachers those areas/topics in which he or she needs to be more explicit in subsequent teaching.

Leslie-Peckley (2000) indicated, and it was verified by the teacher involved in this work, that preparing worksheets for classroom use can be a time-consuming exercise and it is a process that requires significant teacher foresight. Students' collective responses to the strategy emerging from this work, however, suggest that this challenge may be more than offset by the realization that students work much harder in the class, are more motivated and engaged in the learning process, and are developing essential cooperative and collaborative skills. In spite of the small number of participants in this work, the implications of outcomes such as those discussed in this paper cannot be disregarded. From the teacher's perspective, it is a useful tool to promote students' participation and to facilitate meaningful learning. From the student's viewpoint, it is effective in aiding understanding and promoting learning through collaboration. The teacher and the students involved in this work agreed almost unanimously that the interactive worksheet is a unique and useful teaching/learning tool, which can be tailored to focus on those particular skills or concepts the teacher deems to be most important.

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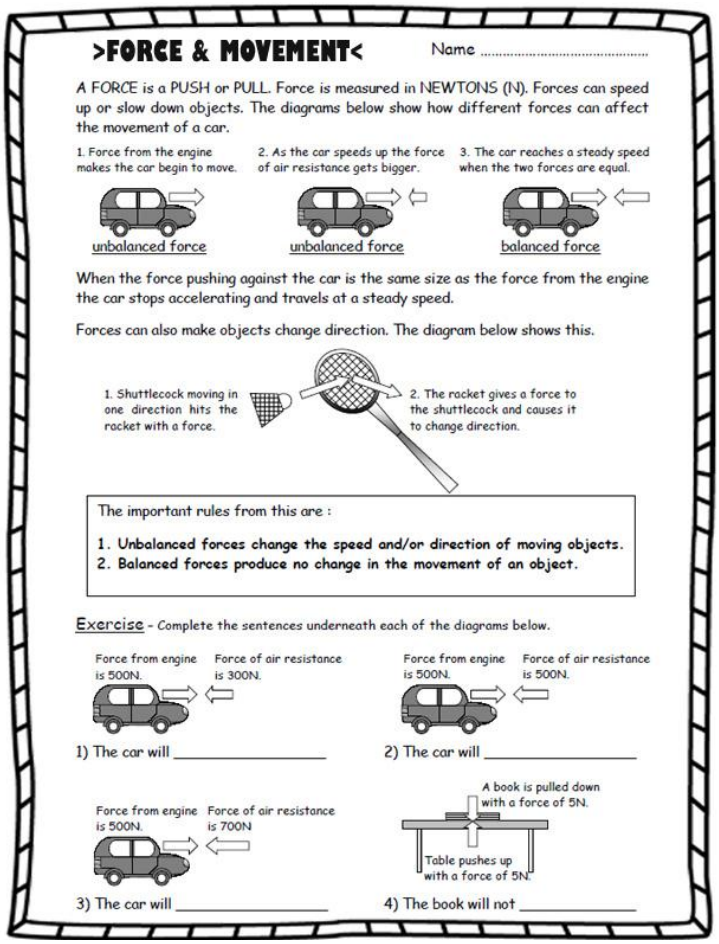
Appendix A – Sample Interactive Worksheet



>FORCE & MOVEMENT< Name .....

A FORCE is a PUSH or PULL. Force is measured in NEWTONS (N). Forces can speed up or slow down objects. The diagrams below show how different forces can affect the movement of a car.

1. Force from the engine makes the car begin to move. — unbalanced force
2. As the car speeds up the force of air resistance gets bigger. — unbalanced force
3. The car reaches a steady speed when the two forces are equal. — balanced force

When the force pushing against the car is the same size as the force from the engine the car stops accelerating and travels at a steady speed.

Forces can also make objects change direction. The diagram below shows this.

1. Shuttlecock moving in one direction hits the racket with a force.
2. The racket gives a force to the shuttlecock and causes it to change direction.

The important rules from this are :

1. **Unbalanced forces change the speed and/or direction of moving objects.**
2. **Balanced forces produce no change in the movement of an object.**

Exercise - Complete the sentences underneath each of the diagrams below.

Force from engine is 500N. Force of air resistance is 300N.

1) The car will _____

Force from engine is 500N. Force of air resistance is 500N.

2) The car will _____

Force from engine is 500N. Force of air resistance is 700N

3) The car will _____

A book is pulled down with a force of 5N.

Table pushes up with a force of 5N.

4) The book will not _____

Appendix B – 10-Item Likert Perceptions Opinionnaire

Please read the statements carefully and tick the box which best reflects your opinion about the statement (SA=Strongly Agree; A=Agree; U=Undecided; D=Disagree; SD=Strongly Disagree).

Statement	A	U	D
1. The interactive worksheets encouraged me to share my knowledge with my friends			
2. I was able to help my friends understand something using my worksheet			
3. When using the worksheets, I interact more with my peers than I did in lessons before			
4. The worksheets helped me to understand the topic that was taught in class			
5. The worksheets helped me to see how ideas are related so I could link things			
6. The questions on the interactive worksheet moved from simple to difficult and this made it easy for me to follow			
7. The worksheets made learning the topic easy for me			
8. The worksheet questions prompted me to think carefully about the answer I was giving			
9. Interactive worksheets should be used more often to teach science			
10. Overall, I would say that the interactive worksheets were effective in helping me to learn about the topic.			