DESIGN DOCUMENT FOR INCORPORATING INSTRUCTIONAL MATERIALS FOR THE WIND TUNNEL EXHIBIT AT THE IMAGINATION STATION

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Executive Summary

Imagination Station is the only hands-on family science center in the Greater Lafayette area. It provides interactive exhibits ranging from computers, to dinosaurs, to simulators. The Wind Tunnel exhibit is an interactive display whose purpose is to help learners gain an understanding of the aerodynamic concept called *drag.*

The Engine team has identified that more effective operating instructions and concept explanation/description would increase effectiveness at teaching the aerodynamic concept of drag to elementary and middle school students by their interactions with the Wind Tunnel exhibit. Based on discussions with the users of the exhibit, parents, teachers, administrators of Imagination Station, as well as research, we followed a systematic approach to conduct our design tasks.

We analyzed the learning context, the learner characteristics, the learning task, and the assessment, and we set as our primary goal that: after observing and/or interacting with the Wind Tunnel, together with the instructional materials, the learner will be able to make cognitive connections integrating these observations, skills, and concepts with the newly-acquired concepts of cause/effect, airflow and drag. Finally, before we begin the development of instructional materials, we would like to provide our complete design document for review.

Context Analysis

For our instructional design activity, the design group *Engine* will be creating instructional materials for the Wind Tunnel exhibit, an interactive simulator that is intended to demonstrate the aerodynamic concept of drag. It is a fairly large, self-contained unit run by 110V AC current. It employs a centrifugal fan that moves a large volume of air through a plexiglass tunnel to demonstrate the effects of drag on objects that are attached to weak springs inside of the tunnel. When the air flows through the tunnel, its maximum velocity reaches about 35 mph, which is enough to cause movement of the objects inside. Currently, the objects inside the tunnel are riding on frictionless carts, and these objects will react to the airflow by moving in the same direction as the wind against spring pressure. If the objects have largely different drag characteristics, they will move different amounts. The object that has the shape with the highest coefficient of drag will move the furthest.

The airflow is drawn into the tunnel from the left side (when viewed from the proper position) through the silver airhorn. It is then exhausted out of the unit through an opening on the top of the cabinet, which can be controlled by a handle connected to a door. The further the door is held open, the more air flows through the test section and exits the machine through this opening. In essence, the amount of air flowing through the tunnel is controlled by the user who manipulates the handle. Diagrams of the Wind Tunnel and its parts are shown below.

The parts of the Wind Tunnel are:

1 – Inlet
2 – Test Section
3 – Dampener Handle (Reverse)
4 – Dampener Exit
5 – Blower
6 – Cabinet (Reverse)
7 – Power Switch
8 – Module Location

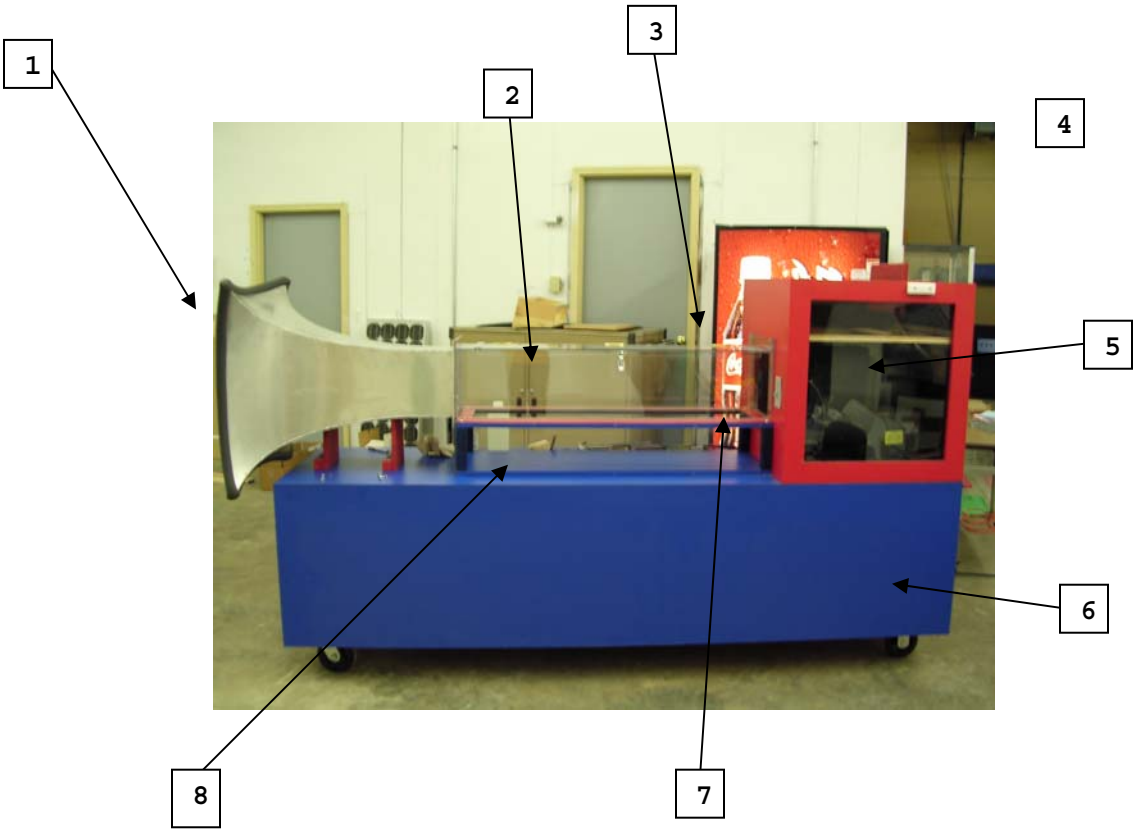


Figure 1. The Wind Tunnel and its parts

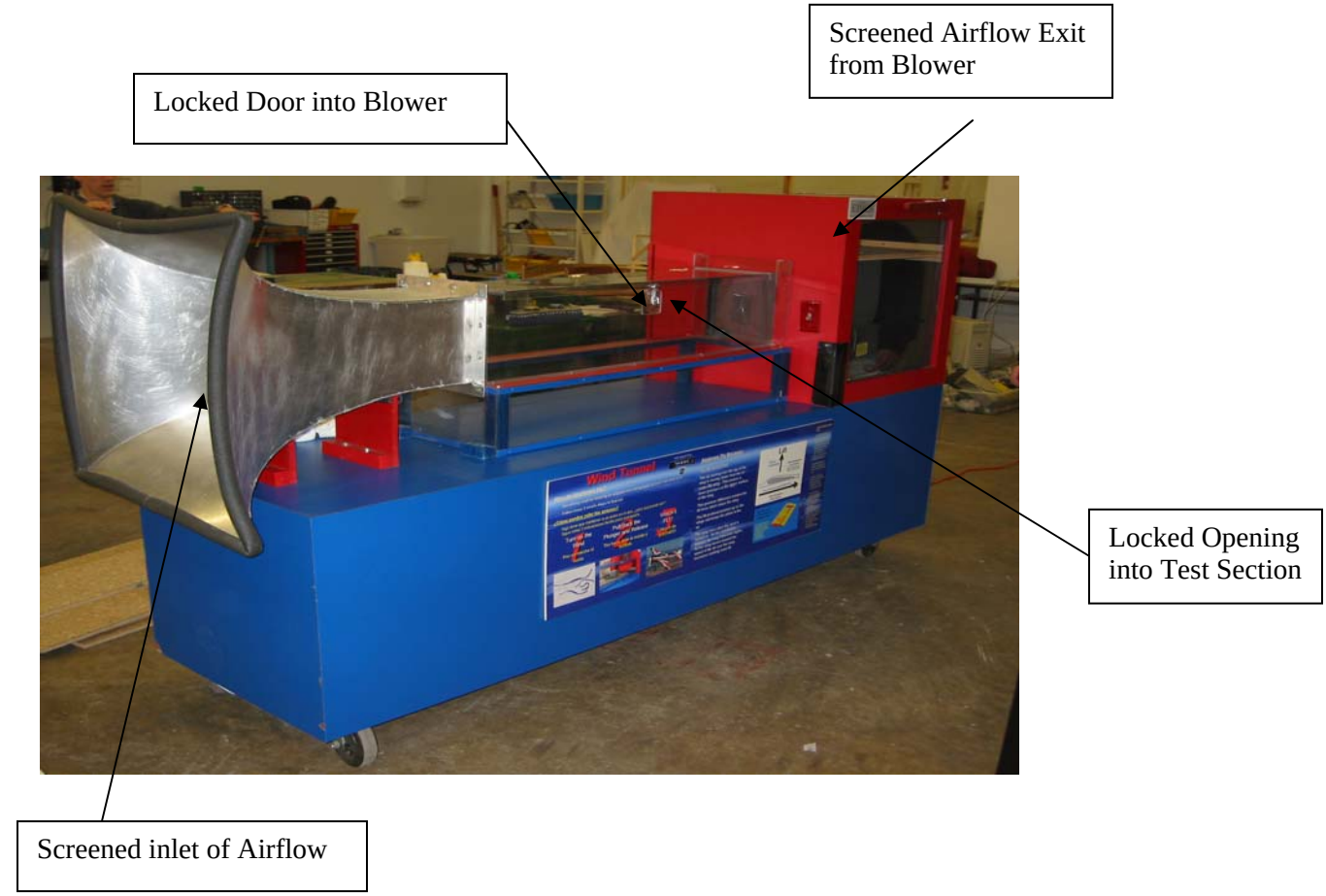


Figure 2. The Wind Tunnel

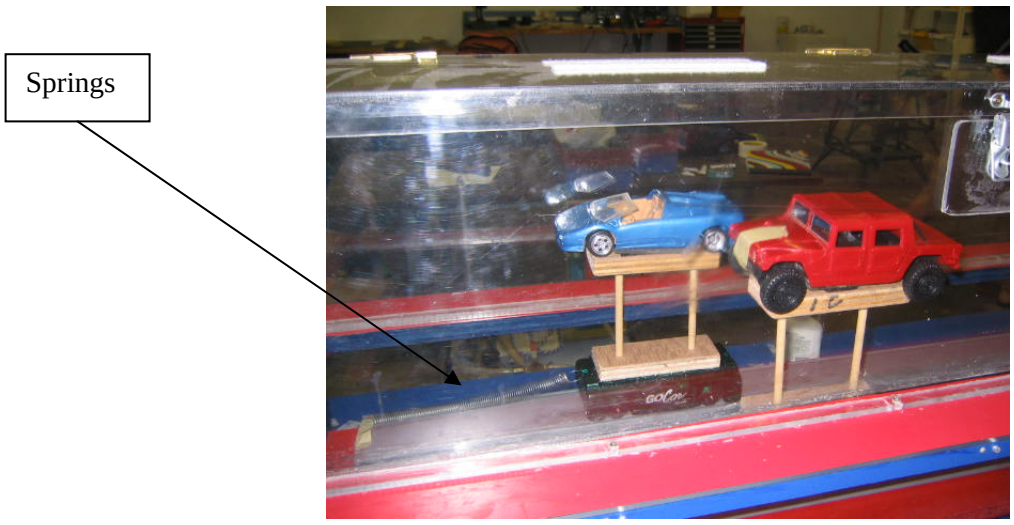
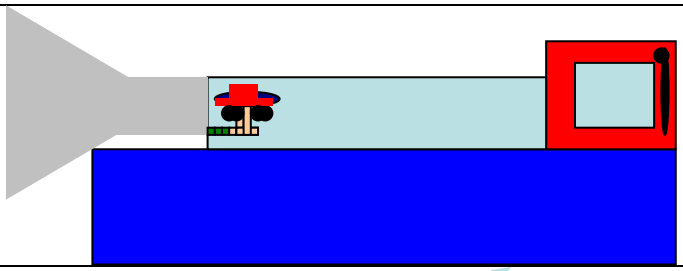
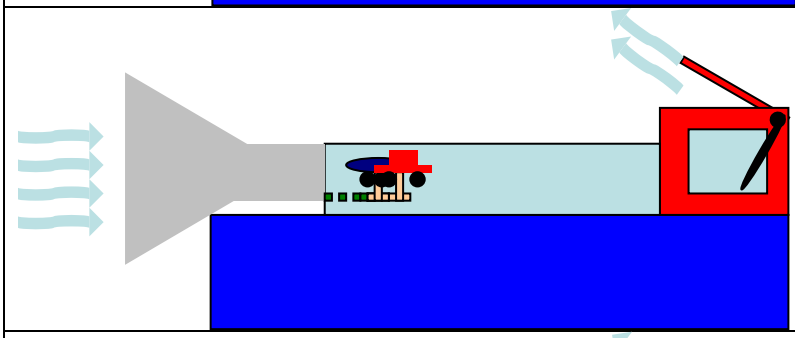
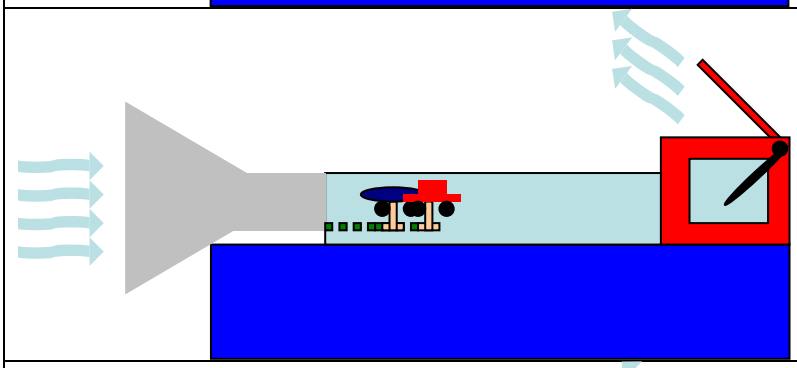
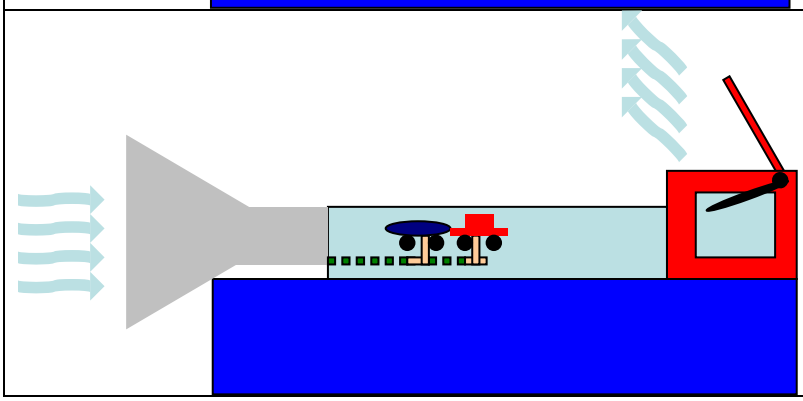


Figure 3. The objects (cars) inside the wind tunnel

Scenario

	This is the initial position. The cars will not move unless the dampener is open.
	The airflow is controlled by the dampener. As it is opened, more airflow is pushing the cars.
	The more the cars are pushed, the more they are separated from each other. The blue one, which has the better aerodynamic shape, is always closer to the air inlet.
	This is the final position, the dampener is wide open and the maximum speed is 35m/hr. The springs are stretched.

This learning exhibit is important in part because of its close proximity to Purdue University, which has the 4th highest-rated aeronautical engineering program in the country. It is located in Imagination Station, the only hands-on family science center in the greater Lafayette, Indiana area. Imagination Station boasts interactive learning exhibits ranging from computers to dinosaurs to simulators.

The Wind Tunnel is still under evaluation and modification by the EPICS (Engineering Projects in Community Service) team that developed it from Purdue University. Based on our team's observations, we have detected that the learners are confused with the design of the Wind Tunnel, and so the EPICS team has decided to make modifications in order to incorporate more hands-on and visual learning. This new incorporation is highly desired because the exhibit will be more in line with the mission of Imagination Station, which is to provide hands-on science, space, and technology experiences that stimulate young minds. This new revision by the engineering team will allow the Wind Tunnel to more effectively demonstrate the concept of drag. Additionally, the EPICS team is developing interchangeable modules that will demonstrate the effects of both *drag* and *lift*. However, for this instructional design project, we will be focusing on the module that demonstrates *drag* due to the fact that the successive modules are still in development.

The problem with the Wind Tunnel exhibit in its current form is that it is not effective at relating the aerodynamic concept of drag to the Wind Tunnel exhibit. More effective operating instructions and concept explanation/description would increase its effectiveness to teaching elementary and middle school students

The target audience for the Wind Tunnel is the primary visitors to Imagination Station, who are, according to the facilitators there, between 2 and 12 years of age. However, tests with observers of the Wind Tunnel have suggested that students are not fully interested in the Wind Tunnel and the concept is not easily understood. The information provided to the observer at the exhibit may not be sufficient to show what the Wind Tunnel's learning goals are.

Based on our discussions with the administrators of Imagination Station, the EPICS team, and our own observations of the Wind Tunnel, our group has detected the following needs:

- Students need to be able to interact with the exhibit without help from adults. This is important because if the students cannot operate the exhibit effectively, it will not be useful to them.
- Students need to be able to identify and describe aspects of *drag* after using the Wind Tunnel. If the students can't demonstrate a better understanding of *drag* after interacting with the Wind Tunnel than before, the exhibit will not have met its objective.
- Students need a certain amount of pre-knowledge before being able to effectively use the Wind Tunnel. We would like to be able to provide this pre-requisite knowledge to all students in a convenient and self-directed medium.

These needs can be met by adding several new components to the Wind Tunnel. These can include:

1.) Instructional material that could be used by the teacher or instructor before the visit. Instructors/parents may want to take an active role in facilitating the students' learning of *drag*—particularly for the younger students who may not grasp the concept on their own.

2.) A display (graphics combined with text) with an explanation of how drag works, as well as a description of how the Wind Tunnel should be operated. This is necessitated by

evidence that students don't currently operate the machine correctly, nor do they spend enough time at the display to be able to describe *drag* any differently than before they used the machine.

3.) Publish a version of the printed material above on the Imagination Station website. This will help the instructors and learners be prepared for what they find at the Wind Tunnel exhibit, which doesn't happen currently.

4.) A guide for parents and instructors containing a description of how drag works, how the Wind Tunnel is related to and simulates drag, and a step-by-step description of how the Wind Tunnel should be used.

The major considerations for the instructional design team are the learners' vast age range and prior knowledge. *Drag* is a concept that can't be seen—only the effects of it can. Therefore, our challenge is to design instructional materials that: 1) facilitate the students' ability to use the machine properly; 2) help the students to be able to learn more about *drag* by interacting with the exhibit; 3) Show how the exhibit works. The exhibit cannot teach drag by itself, as is evidenced from observing users of it. It is, therefore, necessary to supplement the exhibit with instructional materials for both the student and teacher that will allow them to fully utilize the ability of the exhibit to *demonstrate* the principle of *drag.* This will be our challenge.

Finally, after the instructional design group finishes producing the learning materials, these materials are going to be administered by the Imagination Station personnel who will also be in charge of replacing the signage when the product life has finished. Additionally, the information on the website will not require further maintenance than the website is having at this moment.

Audience Analysis

Most of the exhibits at the Imagination Station, including the Wind Tunnel exhibit, primarily target children between the ages of 2 to 12. As the first step of learner analysis, our design team decided to define the primary target audience to be sixth grade children by referring to the Indiana Academic Standards. We found the following statements from the academic standards that apply to this learning exhibit:

- Explain how technologies can influence all living things
- Inspect, disassemble, and reassemble simple mechanical devices and describe what the various parts are for. Estimate what the effect of making a change in one part of a system is likely to have on the system as a whole.
- Describe that a system is composed of subsystems

These statements present information showing that sixth grade students may be a good candidate for the Wind Tunnel exhibit because they are equipped with the necessary logical thinking ability.

Sixth grade students have not had prior curriculum training about how an airplane flies or in the aerodynamic concept of drag. However, according to the Indiana state standards, they have some skills that will help them understand *drag*. During the fifth grade, according to the standard #3, students were introduced to *forces of nature* concepts—being able to investigate and describe how changes in speed, direction, or motion of an object are caused by forces. They should be able to understand that the greater the force, the greater the change in motion and the more massive an object, the less effect a given force will have, which is important to help understand the working mechanism of the Wind Tunnel. The sixth grade students should be

familiar with using computers to retrieve information online as well. Oblinger and Oblinger (2005) described some general characteristics of the current generation of young people, sometimes referred to as “Net Gen”, as shown in the following:

- Net Gen learners tend to be more visually literate than previous generations. They are able to weave together images, text, and sound in a natural way. Their ability to move between the real and the virtual is instantaneous. Because of the availability of visual media, their text literacy may be less well developed than previous cohorts.
- Net Gen learners tend to learn by doing rather than by being told what to do. Net Gen students tend to learn well through discovery—by exploring for themselves or with their peers. This exploratory style enables them to better retain information and use it in creative, meaningful ways.
- Net Gen learners tend to be more comfortable in image-rich environments than with text. Researchers report Net Gen learners tend to refuse to read large amounts of text, whether it involves a long reading assignment or lengthy instructions. Net Gen learners’ experiential nature means they tend to like doing things, not just thinking or talking about things.

In addition, when we design the instructional material for the Wind Tunnel exhibit, we also take into consideration the parents and teachers as an important secondary target audience. They are also serving as learners in this setting and effective instructional material will help them better teach/instruct their children or their students, respectively. We will talk about them in this learner analysis as well.

"Stages of Intellectual Development in Children and Teenagers" by Myers (n.d.) gives an overview of the intellectual development theory by Jean Piaget (1969), who is one of the foremost researchers in the field of cognitive development. According to this theory, sixth grade students are most likely in the formal operational stage. They are able to formulate hypotheses and systematically test them to arrive at an answer to a problem. The individual in the formal stage is also able to think abstractly and to understand the form or structure of a mathematical problem. Another characteristic for persons in this stage is their ability to reason from the fact. That is, if they are given a statement and asked to use it as the basis of an argument; they are capable of accomplishing the task.

Sixth grade students have generally acquired a certain amount of knowledge along with the ability to sort information and to think abstractly. The challenge for the teacher by the sixth grade is to provide more and interactive activities that help students to use existing knowledge with new materials and that encourages the use of their problem solving skills. Two fundamental thrusts of the sixth grade curriculum are creative thinking and problem solving. Sixth grade science programs focus on "…interrelationship and interdependence inherent in the functioning of systems in the natural world. Students work on observation, prediction, analysis, comparison, recording information, problem solving, and vocabulary and research skills" (Grade Six Curriculum, n.d.).

Types and conditions of learning for sixth grade students

Gagne (1985) as cited in Smith & Ragan (2005), summarized sixth grade students' intellectual skills in general as follows: students are able to recall in verbatim, paraphrased or summarized form facts, lists, names, and organized information in general. They are able to

differentiate between two stimuli they have learned and are capable of making discriminations. They can identify examples of concepts and classify previously un-encountered examples and non-examples of the concepts. They are able to identify relational rules (if-then) and to identify procedures.

We tried to get the specific samples to derive types and conditions of learning on sixth grade learners in the Imagination Station learning context. We were able to conduct observations on two learners interacting with the exhibit and found that they do not understand the instructions placed on the wind tunnel exhibit and do not know what is happening inside. They would like it to be described more clearly.

As we identified previously, parents and instructors are viewed as an important secondary target audience of the Wind Tunnel exhibit. Their experience will help their children or students' learning. We take them into our consideration in the learner analysis for this reason. Our group conducted conversations with several parents and four local elementary educators from the Lafayette/West Lafayette area and it is clear that their concerns revolved around assurance that educators and educational experiences in the area meet or exceed the Indiana academic standards. They would like to see the learning interactions be composed of three stages:

- Pre-visit – They all agreed that well-designed instructional materials for in-class instruction prior to visiting IS would make the experience more meaningful. They suggested that the materials should be specific to the learning principles that will be introduced to the students during their visit. When given the example of the Wind Tunnel they agreed that instructional materials should give clear explanations and specific opportunities to experience the principles and applications of the exhibit.

- During the visit – The teachers stressed the importance of clearly stated objectives for the exhibit. What is the educational purpose for the exhibit? How will it enhance the student's knowledge of the principles and concepts featured in the exhibit?
- Post-visit – They would like to see some form of follow-up learning materials that 'test' and reinforce the learning experience for the students. They would like to be able to assess what the student has learned during the visit.

Implications for Design

How to demonstrate the aerodynamic concept of drag is a challenging task and it has to be made comprehensible by sixth grade children. A combined image and text description of related aerodynamics concepts will be provided accompanying the exhibit. The practical reasons of how the concept is applied in the real life (such as airplane design, etc.) will also be described to provide learning motivations. Instructional material design can take advantage of the web resource to offer additional support for the extended learning before and after the student's visit.

Learning Task Analysis

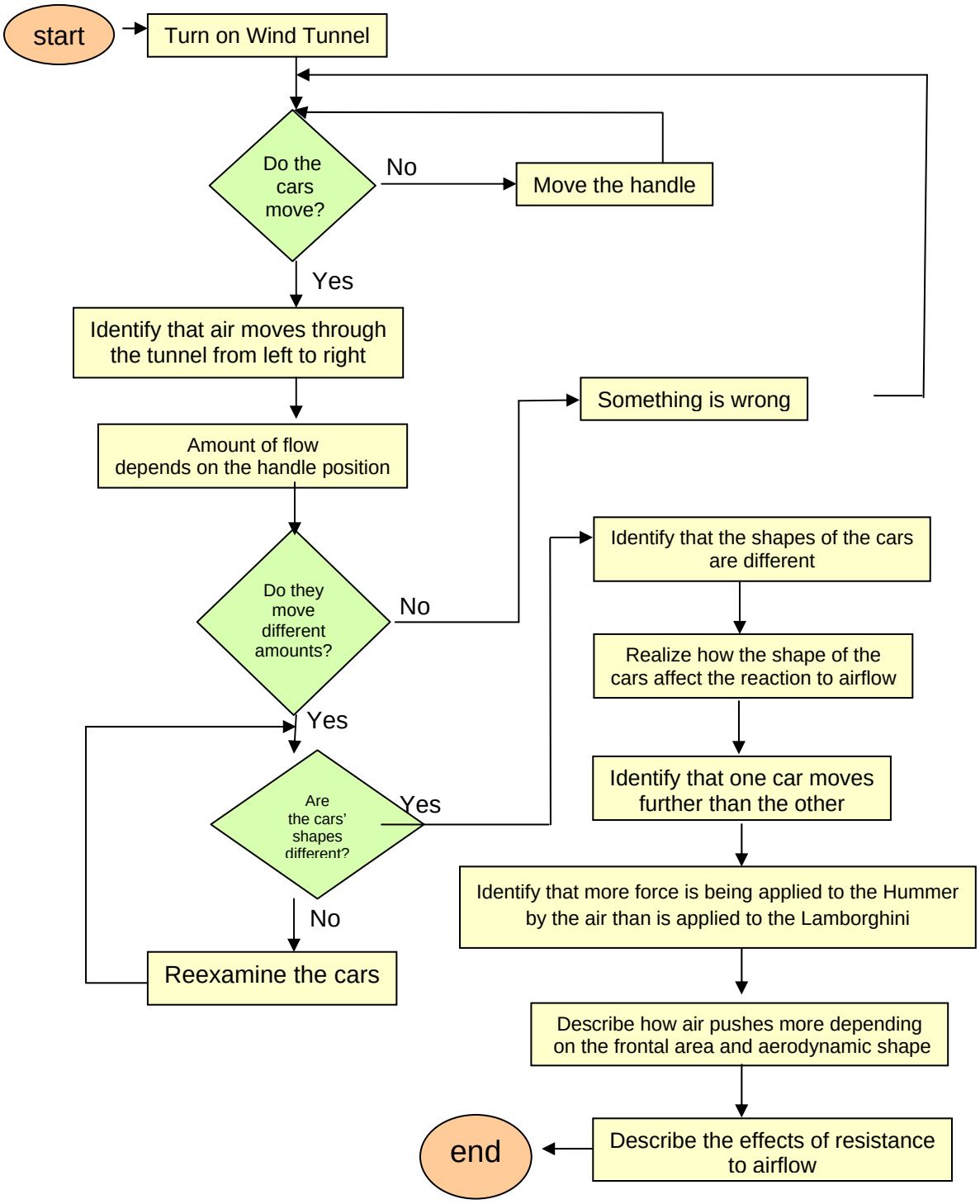
OBJECTIVE: By interacting with the Wind Tunnel, the learner will be able to describe the effects of drag on objects of different aerodynamic shapes and sizes.

In order to develop effective learning materials we are going to focus on children of sixth-grade level, usually about 12 years of age. The types of learning reflected by the learning goal mentioned above include intellectual skills (specifically, concepts and principles) and

cognitive strategies in the form of those used for basic learning tasks and complex learning tasks that tie new information to prior knowledge.

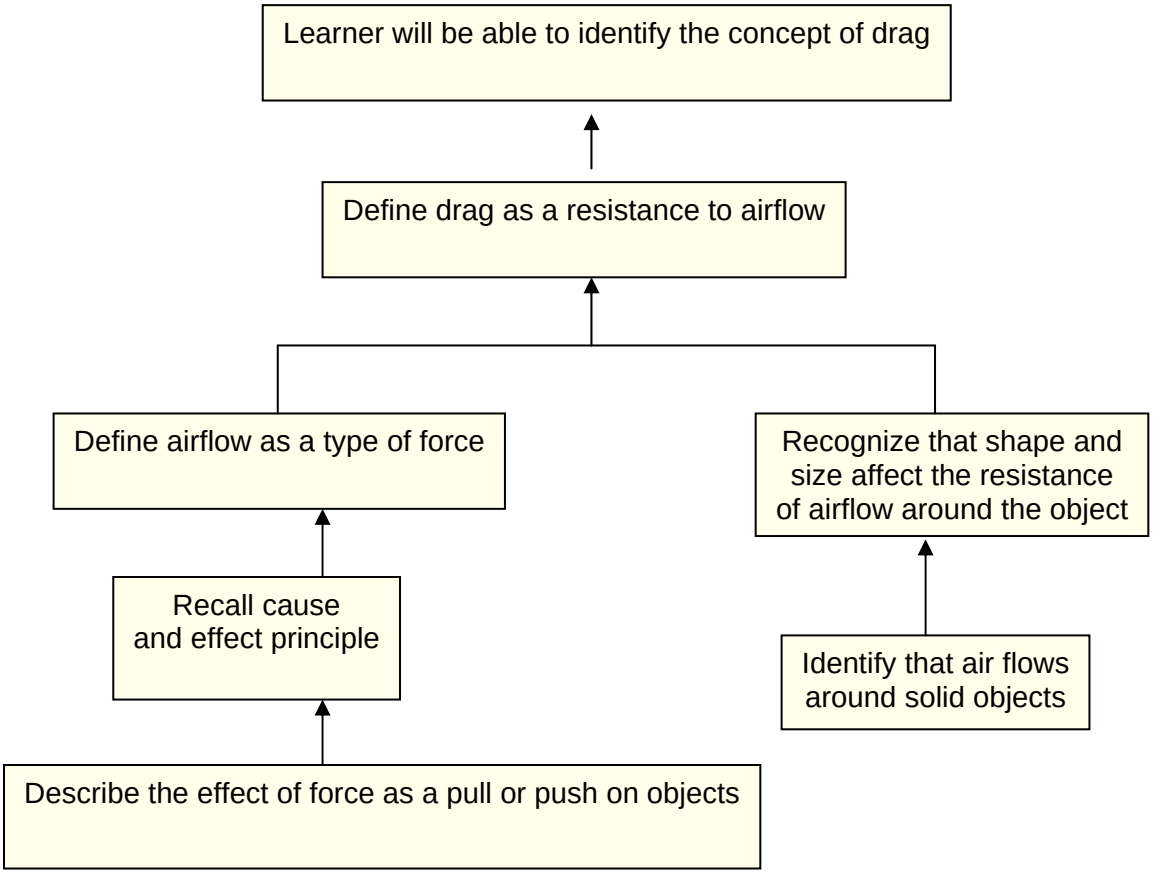
First, by accessing the instructional materials that are available on the Imagination Station web site or at the exhibit through the printed materials, the learner should be able to identify concepts such as force, motion, airflow, cause/effect, and aerodynamic features of shapes/size. With the help of these identified concepts and interaction with the Wind Tunnel exhibit, learners will be able to learn the concept of drag in an effective way. The interaction process that learners of the Wind Tunnel exhibit will follow is as follows: 1) The learner, by using the instructional materials will be able to start the Wind Tunnel. 2) Then, the learner should identify and describe that air flows from left to right inside the tunnel, (when viewed from the front of the exhibit), and that the airflow acts on the objects within the tunnel. It is also important that the learners identify the effect of moving the handle in relation to the movement of the objects. 3) Finally, after observing and/or interacting with the Wind Tunnel, together with the instructional materials, the learner will be able to make cognitive connections integrating these observations, skills, and concepts with the newly-acquired concepts of cause/effect, airflow and drag.

Information Processing Analysis

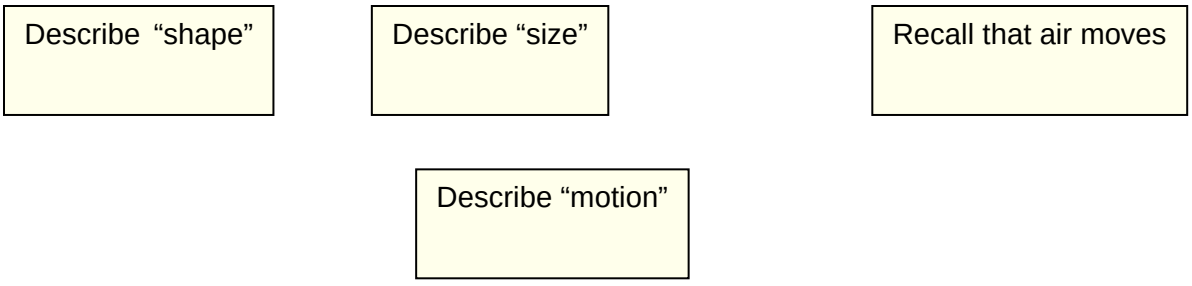


Prerequisite Analysis

Concept Map



Prerequisite skills



Terminal Objective

By interacting with the Wind Tunnel, the learner will be able to describe the effects of drag on objects of different aerodynamic shapes and sizes.

Enabling Objectives

1. Learners will be able to describe what happens when force is applied to an object.
2. Learners will identify what type of forces airflow is generating on the object.
3. By following steps displayed in a pictorial diagram, learners will be able to operate the Wind Tunnel and describe how it works.
4. Given the scenario of wind blowing against an object, learners will be able to describe a cause and effect relationship between wind and the object.
5. Learners will be able to describe how airflow acts in opposition of the spring force.
6. Given two objects of different shapes and size, the learner will be able to identify the object that exhibits more drag.

Assessment

In order to validate the effectiveness of the learning materials, and at the same time to assess if the learners have achieved the learning goals, we will conduct an assessment.

The assessment will take the form of an informal task that can be observed and evaluated with a series of tools including a web-based multiple choice questionnaire and an open question in the parental/instructor guide. In addition, hands-on activities will be identified that may help the observer to better witness and evaluate the learners' level of understanding of the concept.

Assessment Procedures

The assessment of this instructional unit will focus on gathering information about the ability of the instructional materials together with this exhibit to present the learner with the opportunity to increase his/her understanding about the effects of drag.

Because these assessments are directed towards the individual learner, they will be of an informal and indirect nature, and will be optional.

The assessment of the individual learner will consist of two forms. One will be carried out once the instruction has been done; it will be supported by the parental/instructor guide (open question(s), and will only assess the terminal objective.

The second one will be conducted through the website (multiple-choice questionnaire); it will assess the terminal objective as well as the enabling objectives.

Assessment Specifications

In order to ensure that learners have learned what they are expected to learn, it is important to have clearly defined terminal and enabling objectives. The terminal objective will be used to frame the questions for the parent/instructor guide and the website questions will come from the enabling objectives. The following are examples of terminal and enabling objectives for the Wind Tunnel project.

Terminal Objective

By interactive experience of the Wind Tunnel, the learner will be able to describe the effects of drag on objects of different aerodynamic shapes and sizes.

Assessment Form

Assessments will be an interactive discussion experience initiated by questions that will be included in the Wind Tunnel parental/instructor guide.

Sample Item

Why are the objects moving when the Wind Tunnel is activated and the handle is in the open position?

Answer: Because the airflow is blowing through the tunnel and pushing against the cars.

Question Characteristics

The Parent's Guide will contain the correct answers along with an explanation. For example: The airflow is exerting a push force on the vehicles. It exerts more force on the object with more resistance to airflow (the larger object). This resistance to airflow is called drag.

Response Characteristics

Learners are expected to be able to identify the correct answer. In the event that they are not able, additional discussion and examples may follow to clarify the correct answer.

Criteria

One question will be asked to asses the terminal objective. If the learner should answer incorrectly, the parent or instructor will give them immediate feedback to ensure that the concept is understood. The website will provide feedback to reinforce the learning.

Enabling Objective

Objective #1 - Learner will be able to describe what happens when force is applied to an objective.

Assessment Form

Website: Multiple-choice questions

Sample Item

Which of the following is a characteristic of force on an object?

A. A force, such as wind, has no affect on the velocity of an object.
B. Force has no direction.
C. Forces on an object may cause movement.

Answer – C

Question Characteristics

These questions will attempt to lead the learner through a collection of facts that define and clarify the meaning of force. To avoid problems with reinforcement of the incorrect answers, it will be important to include the correct answer and topic information to support the answer in order to reinforce the correct definition for the learner.

Response Characteristics

Learners will recognize and select the correct answer when given a set of definitions and/or descriptions.

Criteria

There will be 2-4 questions related to this objective. The web application will include feedback with the correct information for the learner in the event that the answer is incorrect.

Enabling Objective

Objective #2 - Learners will identify what type of forces airflow is generating on the object.

Assessment Form

Website: Multiple-choice questions

Sample Item

In the Wind Tunnel exhibit, what causes the object to move backward?

A. The pushing force of the airflow is greater then the pulling force of the spring when the spring is not stretched.
B. The object is moving backward only because of the drag force
C. The thrust force
D. None of the above

Answer: A

Question Characteristics

The learner needs to recognize the correct answer from a group of alternative answers. Limitations may come in the form of the learner's pre-knowledge of the concept.

Response Characteristics

The learner must choose the letter corresponding with the correct definition. This ability to match the definition will depend on the learner's ability to recall that force is composed of mass and acceleration.

Criteria

1 to 3 questions will be asked in order to assess this enabling objective. The web application will include feedback with the correct information for the learner in the event that the answer is incorrect.

Instructional Strategy Design

We have selected a supplantive instructional strategy for developing the instructional materials for the Wind Tunnel exhibit. This decision has been made based on the following factors we have detected through the task analysis, context analysis, and learner analysis:

a) From our task analysis, we have concluded that the starting point is quite complex and that learners require more support in processing the information. Our analysis supports that a key factor in the successful learning of the concept of drag through the Wind Tunnel exhibit is the learners' existing or prior knowledge.

b) From the learner analysis, it has been found that there exists a need to review—and, in some cases, provide in its entirety—the prerequisite knowledge. In fact, some of the required concepts are introduced in the 5th grade but it may require us to provide some scaffolding in order for the learner to recall them. It has also been suggested that learners exhibit low levels of motivation and interest regarding this particular exhibit.

c) From the context analysis, it has been determined that the instructional time is limited.

The cognitive processing activities along with the instructional strategies that will leverage our learning objectives are:

Type	Material	Content	Media	Events of instruction involved	Learning objective involved
during-visit materials	Handout	-Introductory concepts and warm-up -Step by step diagram of how the Wind Tunnel works and how it should be operated -Leading questions focused on relating the Wind Tunnel with the principle of drag -Conclusion or summary of what has been learned -Additional informational resources (the IS website)	Text, Graphics and diagrams	-Gaining attention -Providing learning guidance -Eliciting performance -Summarize and review -Enhance transfer	-Objective 1 -Objective 2 -Objective 3

	Parent Guide	-Introductory concepts (review of previous knowledge) and warm-up -Step by step diagram of how the Wind Tunnel works and how it should be operated -Explanation of what the concept of drag is and how it is represented through the Wind Tunnel -Leading questions to be asked by the parent of the learner focused on relating the Wind Tunnel with the principle of drag and with their corresponding answers -Additional informational resources (the IS website)"	Text, Graphics and diagrams	-Gaining attention -Informing the parent the objective -Stimulating recall of prerequisite learning -Providing learning guidance -Eliciting performance -Providing feedback -Summarize and review -Enhance transfer	-Objective 1 -Objective 2 -Objective 3 -Objective 4 -Objective 5 -Objective 6
	Display	-Images of other applications of the principle of drag -diagram of how the Wind Tunnel works -step by step of how to operate it(briefly)	Text, Graphics and diagrams	-Gaining attention -Providing learning guidance -Eliciting performance	-Objective 1 -Objective 3
pre-visit and post-visit materials	**Web Page**	-Several images, animations and/or videos of other applications of the principle of drag with a brief explanation -Introductory concepts and review of previous knowledge with examples, images and explanation -Step by step diagram of how the Wind Tunnel works. -Video and/or animation of how the Wind Tunnel works. -Leading questions to be asked of the learner with multiple choice answers -Evaluation of the answers and provide feedback -Additional informational resources classified as: experiments, more complex examples that show/explain the concept, etc.	Text, Graphics, diagrams, animation and video	-Gaining attention - Prerequisite learning -Presenting stimulus materials -Providing learning guidance -Providing feedback -Summarize and review -Enhance transfer	-Objective 1 -Objective 2 -Objective 3 -Objective 4 -Objective 5 -Objective 6

Enabling Objective #1: Learners will be able to describe what happens when force is applied to an object.

One of the more difficult problems associated with this learning objective is identifying a way to effectively define and describe the concept of force on an object. This goal is complicated by the fact that force is difficult to see. The challenge is finding a way to provide visitors to the Wind Tunnel exhibit with a way to experience force that is engaging and motivational.

In order to accomplish this task, we have broken the experience into two learning activities that, at first glance, will be used for *Attending* and *Motivation*. First, we will provide a basic definition for the concept of force. It is important that these definitions are presented in a way that motivates the learners to look deeper in to the subject. This will also cover the most

important part of *Prior Knowledge*. Motivation will be addressed by showing the learner the importance of the concept of drag, and at the same time we will present familiar examples that illustrate the concept.

Having given the learner a set of working definitions for drag in the pre-visit materials, we can now shift our attention to the second learning activity: describing the concept of force in a way that will hold the attention of the learner. There are a number of different ways to enhance the learner's interest such as including the use of digital and video images. Using these kinds of tools can help the learner visualize the concept and associate the definition with an action.

Enabling Objective #2 Learners will identify what type of forces airflow is generating on the object.

By correctly identifying the relationship between drag/lift and airflow force, we make it easier for the learner to stay focused.

We will provide instructional material both online or on–site to show the relevance of airflow force to real-life applications that at the same time are familiar to the learner. This will take the form of images and videos representing the same concept, such as on airplane. By this way, we intend to positively impact the learner's *motivation* to reach the objective.

Objective 2 is also an important foundation for the learner to relate the Wind Tunnel exhibit with the aerodynamic concept of drag.

Enabling Objective #3: By following steps displayed in a pictorial diagram, the learner will be able to operate the Wind Tunnel and describe how it works.

Objective 3 will be used in the *processing of information* activity. The instructional materials will include a pictorial diagram of the Wind Tunnel that will show step by step how it should be operated and at the same time how it works. After looking at the pictorial diagram the visitors should also recognize the various components of the Wind Tunnel. It is very important to understand how the Wind Tunnel works and specifically what the direction of the airflow is in order to identify the concept of drag.

Enabling Objective #4: Given the scenario of wind blowing against an object, the learner will be able to describe a cause/effect relationship between the wind and the object.

This objective is used in several cognitive processing activities. But they, just like objectives 5 and 6, are a lower priority. This is due to the fact that these objectives cannot be met or mastered until the ones prior to them are met. Therefore, the cognitive processing activities associated with objectives 4, 5, and 6 are ones that are on a higher order of thinking than some of the earlier ones.

Objective 4 is used by the *Learning Strategies* activity in that the parents of the learner can elicit a “think-aloud” technique. By discussing and describing the cause/effect relationship between the wind and the object, the learner will have to link this cause/effect relationship to one he/she already knows. It would be appropriate for the learner to give other examples that illustrate the principle, as there are many common cause/effect relationships beyond that of wind blowing against an object.

Objective 4 is also met with a *Practice* activity. Although its use is more limited than some of the other cognitive processing activities, Objective 4 will generally require the learner to

use and manipulate the Wind Tunnel on repeated occasions in order to be able to predict and explain the cause/effect relationship between the wind and the object.

Objective 4 should also be met with a *Feedback* activity, but this will require the participation and interaction of the teacher and/or parent. The learner may be able to describe the cause/effect relationship on display in the exhibit, but if he/she receives no feedback from someone more knowledgeable, the learning will not be concrete – it will still be conjecture to the learner. More effective and lasting learning takes place when the learner is able to receive feedback on his/her learning efforts.

Previous knowledge will have to be recalled in order to meet Objective 4 because there are many prerequisites to an understanding of a cause/effect relationship. The question will have to be asked by (or of) the learner, "What is the cause, and what is the effect?"

Enabling Objective #5: The learner will describe how airflow acts in opposition of the spring force.

Objective 5 may use the *Learning Strategies* activity, depending on how interactive the parents/instructors are with the learner. A question/answer guided session will be very helpful in getting the learner to describe how the airflow acts in opposition of the spring force applied to the object in the Wind Tunnel. This is tied closely to the *Practice* activity in that the more the learner answers the questions about how the airflow acts, the better his/her understanding of it will be, and the more accurate and thoughtful will be the description. Incidentally, the question/answer session by the teacher/parent is part of the *Feedback* activity, as well. The feedback (in the form of answers from the parent/teacher) reinforces the learner's correct understanding of the airflow's opposition to spring force.

Enabling Objective #6: Given two objects of different shapes and size, the learner will be able to identify the object that exhibits more drag.

Objective 6 is the capstone of the enabling objectives. It will only be accomplished by successful completion of the prior five objectives, and it uses nearly every one of the cognitive processing activities. In essence, objective 6 is an information synthesis, where all the concepts learned and objectives met to this point culminate in a proper understanding of drag to the point where the learner is able to understand all concepts leading up to this point, and in addition, make inferences about how those concepts translate to different objects. *Learning Strategies, Practice, Feedback, and Transfer* are all used based on the premise that the learner is asking questions of his/herself and others, receiving the feedback from those questions, and then applying this new understanding to other situations that incorporate the same concepts.

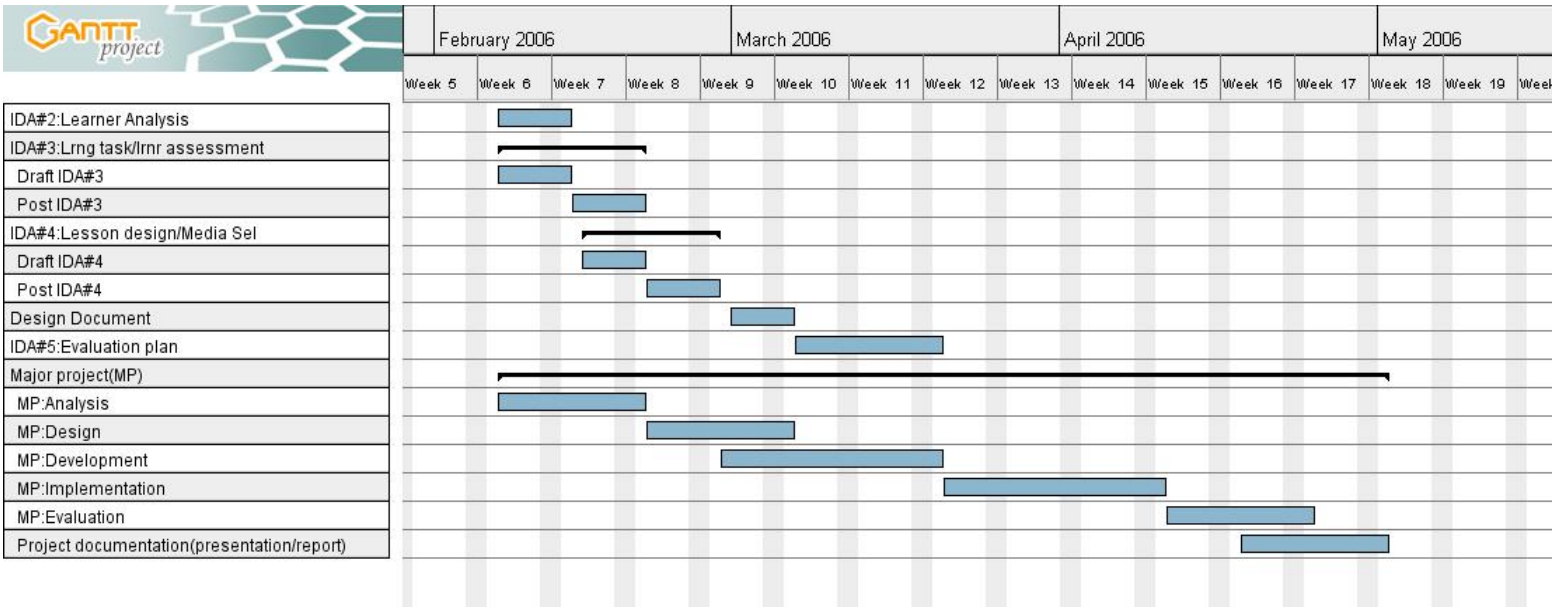
The media for presenting the instructional materials will incorporate text, graphics, diagrams, animations and video. The primary delivery mode will be through the web site of Imagination Station for both pre-visit and post-visit information. Instructional materials will also be presented at Imagination Station in the form of displays, a parent guide, and a handout.

There are three learning objectives that are partially covered at the exhibit through the existing instructional materials, but we will enhance and complement those materials. The two learning objectives that are partially covered are:

- Objective 3—at the exhibit there is information that describes how the Wind Tunnel works, the definition of drag and a short explanation. This material covers the cognitive activities of processing information.

- Objective 4 and 5 are also partially covered by the displays at the exhibit and through the exhibit itself, but in this case the cognitive activity employed is *inquiry* because the learner has to infer the concept of drag by interacting with the Wind Tunnel.

Gantt Chart


GANTT project
February 2006
March 2006
April 2006
May 2006
Week 5
Week 6
Week 7
Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
Week 15
Week 16
Week 17
Week 18
Week 19
IDA#2:Learner Analysis
IDA#3:Lrng task/lrnr assessment
Draft IDA#3
Post IDA#3
IDA#4:Lesson design/Media Sel
Draft IDA#4
Post IDA#4
Design Document
IDA#5:Evaluation plan
Major project(MP)
MP:Analysis
MP:Design
MP:Development
MP:Implementation
MP:Evaluation
Project documentation(presentation/report)

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