EDUC208B
Curriculum Construction

Project Weightlifter:
A Project-Based Unit on Simple Machines

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ODUCTION

ct Weightlifter is a project-based curriculum on the applications of simple machines, designed for Secondary 1 al (Technical) students (equivalent to Grade 7) who will be admitted into a new secondary school to be set up ir pore. Known provisionally as the Specialized School for Normal Technical (SSNT), the school will begin operati ary 2013. The curriculum unit will be conducted over a period of five weeks, comprising two hours of instruction

KGROUND

Normal (Technical) Stream

nts in Singapore are tracked after six years of primary school education. Based on their score in the Primary Sc ng Examination (PSLE), they are tracked into one of three streams:

- The highest performing 6th graders (around 61% of the cohort) are assigned to the Express stream.
- The next 25% or so are assigned to the Normal (Academic) stream.
- The lowest performing 13% or so are assigned to the Normal (Technical), or N(T), stream.

nts in the Express stream follow a 4-year course leading to the GCE 'O' Level examination. In comparison, stuc N(A) or N(T) stream follow a 4-year programme leading to the GCE 'N(A)' and 'N(T)' Level examinations ctively. A 5th year leading to the GCE 'O' Level examination is available to N(A) students who perform well in th 'N' Levels. Students can move from one stream to another based on their performance and the assessment of t pal and teachers.

I(T) curriculum covers significantly less content compared to the other streams. The curriculum is geared toward gthening students' proficiency in English and Mathematics, and prepares them for a technical-vocational educat stitute of Technical Education (ITE). The ITE is a post-secondary education institute in Singapore and serves as ple provider of career and technical education.

SITE – Specialized School for Normal (Technical) (SSNT)

T aims to take a whole-school approach towards improving student learning and engagement for its students. So
es of the SSNT are as follows:

- The average class size will be about 20 students.
- The school will have a close partnership with ITE and industry partners to develop its curriculum and programs and to provide opportunities for internships.
- In addition to academic subjects, students will also be able to take industry-focused modules and classes in a range of areas, such as “Basic Retail Services” or “Fundamentals on Air Conditioning and Electrical Services”.
- SSNT will adopt a strong focus on interactive, practice-oriented, and Information and Communication Technol (ICT) enabled teaching methods.
- To provide students with a holistic education, there will also be modules on Aesthetics and Physical Education well as special programs to address students’ socio-emotional needs, personal development, and the learning life skills.
- Teaching staff will include secondary school teachers, ITE lecturers and individuals with relevant industry experience.

RICULUM RATIONALE

culum Ideology

rgirding our curriculum is John Dewey’s ideology of **progressivism**, with its focus on (i) experience and the iential continuum; and (ii) collateral learning.

ience. On experience and the experiential continuum, Dewey (1938) writes:

> “Everything depends on the *quality* of the experience which is had... the central problem of an education bas on experience is to select the kind of present experiences that live fruitfully and creatively in subsequent experiences” (p.16).

> "...if an experience arouses curiosity, strengthens initiative, and sets up desires and purposes that are suffic intense to carry a person over dead places in the future, continuity works in a very different way. Every experience is a moving force. Its value can be judged only on the ground of what it moves toward and into" (p.31).

urriculum pays particular attention to where the students have come from (e.g. a history of academic failure, low economic status), and their potential futures (including future educational experiences, vocations, and aspiration ıtent is that the situations and interactions experienced by students through our curriculum propel them into mo l learning experiences in the future.

eral learning. An explicit goal of our curriculum is what Dewey (1938) referred to as collateral learning:

> "Collateral learning in the way of formation of enduring attitudes, of likes and dislikes, may be and often is m more important than the... lesson... For these attitudes are fundamentally what count in the future. The most important attitude that can be formed is that of desire to go on learning" (p.49).

urriculum aims to help students develop the attitudes and dispositions to successfully approach subsequent iences and future learning, such as a positive attitude towards hard work and learning that also transfers to othe cts and other areas of their lives.

so hope to help students develop the skills, strategies and attitudes that will support self-directed learning, and wer them with the confidence to seek answers to new questions arising from their own curiosity.

eatures

n Thinking. In addition to anchoring the curriculum in progressivism, we have also incorporated key elements o n Thinking. The curriculum contains activities involving need-finding and understanding the perspective of the u ınecting students to real users, the curriculum grounds its activities in a real-world context. These exercises in thy also provide students with skills on how to interact with co-workers, managers, and customers in the future.

onally, students experience an entire design process, moving from need-finding to problem definition, brainstorı
yping, and testing. This will provide students with an immersive, authentic experience where their designs and
s concretely benefit another person, lending meaning to the educational enterprise.

ll, rather than striving to teach the jargon of design thinking, we aim to emphasize the user-centered, iterative n
design process and focus on the process skills learned.

rstanding by Design (UbD). In designing the curriculum, we adopted the principles of Backward Design (Wiggir
ghe, 2005). We first identified and clarified the outcomes and understandings that students would ideally derive
urriculum, before determining which types of assessments would provide sufficient evidence of students' learnin
, activities were created and developed. This curriculum design process starts with the end in mind, allowing fo
o follow function.
s ok here

gogical Approaches

ng on John Dewey's ideology of progressivism, the curriculum will be designed with the following pedagogical
aches in mind, identified by the Singapore's Ministry of Education as being effective for teaching N(T) students:

- Experiential learning, e.g. learning journeys, hands-on activities
- Authentic learning, e.g. authentic problems, transfer and application in different contexts
- Scaffolding, e.g. building on little successes.

fically, the curriculum will apply a project-based learning approach where students complete a group project to
n a workable solution to a real-world problem that will be presented to users at its completion. This will help to
op their confidence and teach transferable skills that will assist them in their future vocations (e.g. empathizing v
needs, diagnostic or trouble-shooting skills). There will also be opportunities for individual work and reflection.

ICULUM OUTCOMES

nal Standards

tarting point was the Lower Secondary Science Syllabus for Normal (Technical) (Ministry of Education, Singapo
. The relevant extract is shown below:

nowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
he advantages of using simple nines (levers, inclined planes, ys, wheel and axle, and gears) give everyday examples of their	Investigate the effort used when the following is used to raise a load and communicate findings: ● Lever ● Inclined plane ● Pulley Investigate how the following works to make objects move and communicate findings ● Wheel and axle ● Gears	Appreciate that technology deve response to human needs and w Value teamwork and individual e

ring Understandings

nment with the national standards set out above, Project Weightlifter aims to establish the following enduring
standings:-

Many everyday objects work well because they take advantage of scientific principles (e.g. the use of simple machines like levers).

Curiosity drives discovery, and there are strategies I can use to learn more about things I am curious about (e. asking questions, consulting more knowledgeable peers and adults).

d Outcomes

roader level, our hope is that other science units in SSNT's four-year science curriculum will be designed using ideology and similar pedagogical approaches, and that they will also be sensitive to the student profile and alig

ne school's overarching aims. We envision this series of units as helping students achieve the outcomes outline
, in the domains of Content Mastery, Skills Mastery and Attitude Development:-

ntent Mastery

Understand the scientific principles covered and how they relate to their lives

lls Mastery

Be able to identify problems in everyday life that can be addressed with scientific solutions
Develop skills related to general scientific and technological literacy which they can apply to address or solve everyday problems, and to their understanding of the world
Develop transferable work skills such as basic project management (e.g. goal-setting and planning) and interpersonal and collaborative skills

itude Development

Develop a sense of personal agency, such that they will be motivated individuals with aspirations and a sense purpose in life
Develop intellectual curiosity about how the world works
Develop a positive attitude towards learning, so that they will be prepared for successful learning in post-secor education and life beyond school

RVIEW OF CURRICULUM

son	Title	Overview
	Play	This lesson serves as an introduction to the project-based unit on "Applications of Si Machines." ● Students play Circle of Pong, a team building exercise. ● Students additionally go through another structured, mini design exercise invol moving a heavy load (similar to their actual project). ● Throughout the activities, students also review what they had learned about fo in previous lessons.

	Empathize & Define	This lesson comprises three parts: ● Students develop questions to ask the panel of users. ● Students then have a Question and Answer (Q&A) session with a panel of use of whom face the same problem of transporting heavy items from one floor to another. ● Student teams then proceed to choose a user and define their problem.
	Learn: Levers	Having defined the context of the problem, students learn tools to help solve the prob of the users. This lesson introduces simple machines and the principles of a lever, on the simple machines that can be used. ● Students are given examples of simple machines in everyday life and asked to identify key features of 4 types of simple machines (lever, inclined plane, whee axle and pulley) through a classification activity. ● Students differentiate between the 'load', 'fulcrum' and 'effort' of the lever. ● Students conduct both a physical and virtual experiment to learn the principle how levers function. ● As a form of formative assessment, groups brainstorm solutions for the define problem using the "lever" as a tool and students draw an everyday example of lever and label the 'load', 'fulcrum' and 'effort'. They also suggest one improve that could make the lever more effective in reducing 'effort'.
	Learn: Inclined Planes and Wheel & Axles	Students learn the principles and advantages of the inclined plane and the wheel and ● Students are shown examples of the wheel and axle systems they had used in Lesson 1. Students should identify key features of the wheel and axle and brainstorm other examples. ● Using a jigsaw activity, students identify the principles of an inclined plane and wheel and axle system, and how they could be made more effective. ● Groups brainstorm solutions for the defined problem centered using the lever, inclined plane and wheel and axle system.
	Learn: Pulleys	Students learn to identify the common uses of pulleys, differentiate the different types pulleys and how each makes work easier. ● Students are asked to bring everyday examples of the three simple machines

		covered in Lesson 3 or 4 and share them with their group as a form of revision the previous lesson. • Students identify everyday examples of pulley systems. • Students differentiate between the two types of pulley systems and try activitie which would help them learn the mechanical advantages of using the pulley sy • Summative assessments of concepts learned in Lessons 3-5 are presented in form of a game show and group challenge.
	Brainstorm	Having chosen their target user and clarified the problem on which to focus, • Students brainstorm as many possible solutions to the problem as possible • Students sketch out their ideas onto paper: What do the design(s) look like? H might users interact with the new device(s)? • Student briefly work with another group to provide feedback on each other's solutions: What questions or concerns arise? Do the solutions address the rea need?
	Prototype	This lesson is focused on bringing the ideas and solutions into the tangible world. • Students learn that prototypes may not always look like the original sketches; they create, students discover what does and does not work. • Students focus on ensuring that the prototype should allow people to *experien* idea/solution. • Students are reminded to consider the perspective of the user: How will the us interact with the device?
	Test and Refine	Students will have the opportunity to finish building, test, and refine their solution -- o quick cycle of a highly iterative design process. • Students finish building their prototypes • Teams pair up with other groups to test each other's designs and solutions • Students prepare for presentations for the next lesson
	Present	Students present their solutions to users as part of a mini-Expo • Students present and demonstrate their projects to users • Awards are given to each group to affirm good performance in a specific area,

		teamwork, creativity ● Teacher and user provide comments on students' work including both product process in three areas: (i) Content mastery, (ii) Skills mastery, and (iii) Attitude development.
	Reflect	Students reflect on the design process and their learning thus far ● Students reflect on their experiences during the curriculum unit ● Students create a digital artifact to capture their reflections

sons 1, 3, 7 and 9 have been fully developed and are presented in greater detail than the others. All lesson rces (e.g. PowerPoint slides, worksheets) are provided for these four lessons. All other lessons contain sufficien to be used by the teacher.

PONENTS OF THE CURRICULUM

on Plans

lesson plan begins with an **Overview** of the lesson and suggested **Venue**. This is followed by a set of 2-3 **Goal** e goals are not restricted to the Specific Instructional Objectives listed in the MOE N(T) Science syllabus (i.e. nt-related goals; rather, our broader goals reflect our holistic approach and our desire for students to engage in eral learning.

lesson also has 2-3 associated **Key Questions**, which reflect the curriculum outcomes outlined above and are d at focusing teachers' attentions onto the "essence" of each lesson. Teachers are encouraged to make use of t uestions as debrief questions during the last 5 minutes of every lesson, as a form of formative assessment.gooc

ming from our adoption of Progressivism as an underlying ideology, our lesson plans include a section on **Prior ent Experiences**. This section ideally takes into account a student's past experiences and reflects our intention urriculum to serve as an experiential continuum that will set students on a trajectory towards future learning. gre

esson plans also include a column labeled "**Outcomes (WHERETO)**". Wiggins & McTighe (2005) recommend th f the WHERETO elements (described in the table below) as a check of whether the learning experiences and ction enable students to achieve desired results. In this column, the intentions behind every learning activity are explicit. Fits well with your student population. Good choice

e	Description
	Help the students know **W**here the unit is going and **W**hat is expected? Help the teacher know **W**here the stu are coming from (prior knowledge, interest)?
	Hook all students and **H**old their interest?
	Equip students, help them **E**xperience the key ideas and **E**xplore the issues?
	Provide opportunities to **R**ethink and **R**evise their understandings and work?
	Allow students to **E**valuate their work and its implications?
	Be **T**ailored (personalized) to the different needs, interests, and abilities of learners?
	Be **O**rganized to maximize initial and sustained engagement as well as effective learning?

ework and Assessment

unit, homework will not take the form of worksheet assignments. Instead, tasks assigned to students come in t of scaffolded activities designed to guide students through the project (e.g. generating interview questions), as w sks to reinforce conceptual understanding (e.g. collecting examples of simple machines).

Parking Lot" is a portion of the class notice board for students to post questions about their science lessons on s
. The teacher refers to the Parking Lot regularly as a source of feedback from students and tries to address stuc
ions in subsequent lessons. Other than being a type of formative assessment yes!, the Parking Lot is also a too
ght the importance of curiosity and questioning. According to Eisner (2002), "the most intellectually demanding t
t so much in solving problems as in posing questions..., an intellectual context designed to promote student gro
must surely give students an opportunity to pose questions...." (p.579-580). Used well, the Parking Lot will
nstrate to students how their questions can lead to learning for everyone – including their teachers. The last five
es of all odd-numbered lessons will make use of the Parking Lot, and it is recommended that teachers spend th
ew introductory minutes of even-numbered lessons to address some of these Parking Lot questions.

ne lessons (e.g. Lesson 6), students are asked to express their answers to key questions in a variety of ways (e
nessages, emails, blog posts). Assessment has been embedded into the curriculum in several other ways, such
gh the use of individual whiteboards in Lesson 3 and a game show in Lesson 5.

native assessment takes place during the mini-expo in Lesson 9, through the use of a rubric that assesses stud
ee areas: content mastery, skills mastery, and attitude development.

ction

ction is an important component of the curriculum, as it allows students to process their experiences, consolidat
earning, and come to some conclusions for themselves. Although Lesson 10 is dedicated to reflection, students
l to document their processes from Lesson 1, using a camera and the class blog. The open-ended nature of the
ions in every lesson, and the use of the Parking Lot also encourages continual reflection. Eventually, students v
se from a variety of digital media (e.g. class blog, Comic Life) to present their reflections.

ences

y, J. (1938). *Experience and Education.* New York: Collier Books.

r, E. (2002). The Kind of Schools We Need. *The Phi Delta Kappan, Vol. 83,* No. 8, pp. 576-583. Retrieved from
http://www.jstor.org/stable/20440204?origin=JSTOR-pdf

ry of Education, Singapore. (2010). *Curriculum Framework for the Specialised Schools for Normal (Technical)*

[SSNT] Students. (Internal document from site).

ry of Education, Singapore. (2008). *Lower Secondary Science Syllabus for Normal (Technical).* Retrieved from http://www.moe.gov.sg/education/syllabuses/sciences/files/science-lower-secondary-nt-2008.pdf

ech Museum of Innovation. *Circle of Pong.* Retrieved from http://www.thetech.org/sites/default/files/pdfs/CircleOfPong_2003.pdf

ns, G., & McTighe, J. (2005). *Understanding by Design.* (Expanded 2nd edition). Alexandria, VA: Association fo Supervision and Curriculum Development.

ON 1: PLAY

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erview

s lesson serves as an introduction to the project-based unit on “Applications of Simple Machines.”

Students play Circle of Pong, a team building exercise.

Students additionally go through another structured, mini design exercise involving moving a heavy load (sim their actual project).

Throughout the activities, students also review what they had learned about forces in previous lessons.

apted from The Tech Museum of Innovation’s online lesson plan.

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to Teachers

teacher can use some of the photos taken in today’s lesson as examples of simple machines in lessons 3-5. By ent-provided resources, the teacher affirms their role in the co-construction of knowledge.

is point, the scientific accuracy of students’ answers and their correct use of scientific terms are not as importan ng students to think about their experiences, since these will be addressed in Lessons 3 - 5. However, teachers ld correct students if they deem it necessary to address any misconceptions immediately.

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e

Any open space (e.g. shaded part of the parade square, sheltered basketball court)

s

To understand that working well as a team requires good communication and listening to each others’ ideas.

To understand that problem solving and design are iterative processes - solutions can constantly be refined, w great ideas and the right tools.

Questions

What does good teamwork look like?

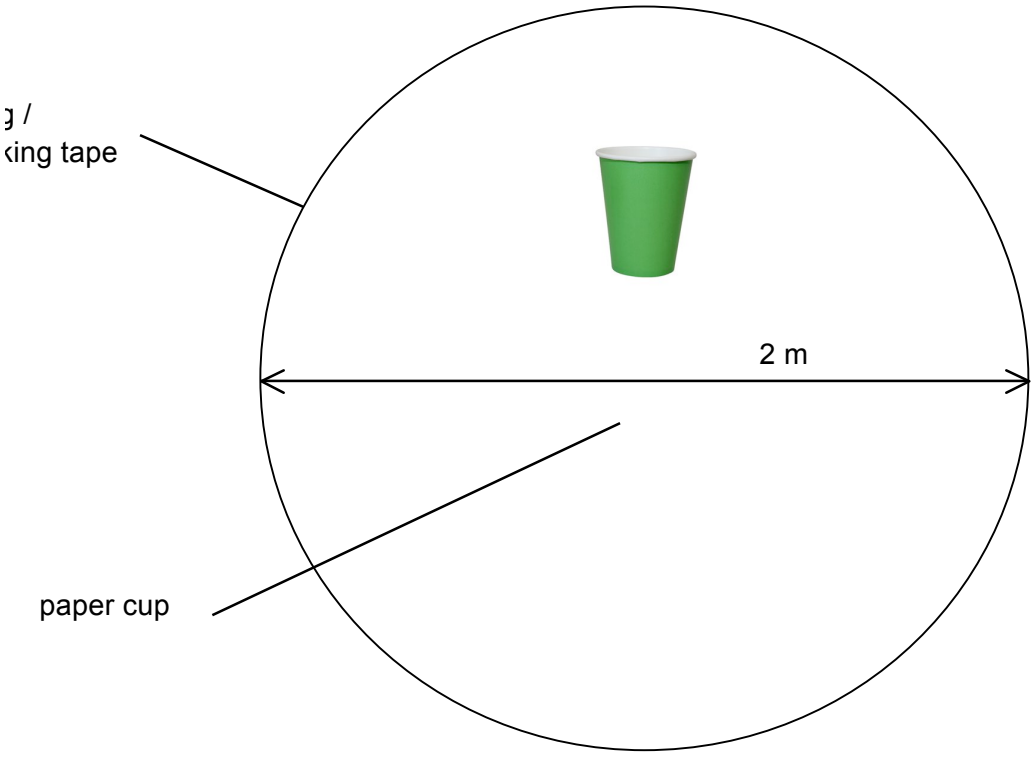
What does good problem solving and design look like?

Student Experience

Students understand that a force can be a push or a pull.
Students understand that forces can change the shape, size, and state of motion of a body.

rials / Resources

ty 1: Circle of Pong
2m-diameter circle marked out with string/masking tape with a paper cup securely taped in the center (see figu
1).



(Figure 1 – Circle of Pong)

eam:
- 5 cm of masking tape
- 30 cm of string
- 4 rubber bands
- 1 paper cup
- 1 sheet of paper
- 2 paperclips
- 1 ping pong ball
- 1 small paper bag, which holds all of the above materials

ity 2: Mini-Design Exercise
- Start and end points (5 lanes) marked out with masking tape
- 5 boxes filled with 20 kg of weight (placed at the start points of each lane)
- 5 lengths of rope (5m long)
- 5 sets of wheels and axles (10 wheels, 5 axles - axles should be longer than the length of the boxes)

on Outline

e	Activity	Description	Outcomes
	Circle of Pong instructions	Split the class into 5 teams of 4 students each. Determine team compositions to ensure a mix of races and genders*. These teams will likely remain the same throughout the next 5 weeks. It is up to the teacher's discretion to change team compositions, if necessary or preferred. Challenge the teams to devise a way to deposit a ping pong ball	H: *Hook* students *hold* their interest through a fun phys activity

		into the paper cup, with the following constraints: ● Every person must be actively involved in the placement of the ball. ● The ball must start outside the circle and must end up inside the paper cup. ● Students may not touch the ball. ● No part of anyone's body may extend past the circle. ● Only materials provided can be used. ● Ball cannot be damaged. ** This is a common practice in Singapore schools to encourage interaction between students of different races.*	
	Discussion and design	Give teams 10 minutes to discuss and to come up with a solution. May need more time for designing here? you can test out how much time it takes with a focus group…	H: *Hook* students a *hold* their interest through a fun phys activity E1: Give students a opportunity to *experience* working together in their pr teams for the first t
	Demonstration of design	Have teams demonstrate their solutions, one at a time. (It is alright if teams do not manage to place the ball in the cup.)	H: *Hook* students *hold* their interest through a fun phys activity
	Debrief	Conduct a debrief, focusing on aspects of working in a team (e.g. communication, listening, conflict resolution). Ask students:	E1: *Equip* student and help them *exp* the dynamics of th respective teams

		● Was working with your teammates easy or difficult? How so? ● Was there a clear leader in your team? Was that helpful? ● Did you listen to all of your teammates' ideas? Did anyone's ideas get shot down? ● Did anyone get into an argument? How did you deal with it? Conclude by reiterating the main points discussed. Highlight the importance of listening to each other, and of allowing everyone's contributions to be heard. If none of the teams succeed, and time allows, show students one possible solution. It is important that the focus is not on this one solution, as many possible solutions exist – hopefully exemplified by the students' work. Possible solution: The string, rubber bands, sheet of paper (ripped into long strips), paper clips, and possibly even paper bag (also ripped into long strips) are all attached end-to-end. The paper cup with ping pong ball are situated in the middle of this chain (using masking tape). Two students from each team hold onto the ends of the chain and carefully carry the cup, ball, and chain over the circle, heading towards the center, and deposit the ball into the center cup.	
	Introduction of camera	Inform students that this lesson marks the beginning of Project Weightlifter, which they will be working on for the next five weeks. The next exercise will give them a taste of what the project will be like. Brief students on the use of the camera: ● Throughout the project, each team will be issued a camera	W: Let students kn *where* the lesson i going and *what* is expected.

		during science lessons to help them document the process of working through the project. ● At the end of the project, every student will be required to reflect on their experiences, and to communicate this in a form of their choice (e.g. blog, Comic Life). ● Not only will these photos help them refresh their memories, those that capture significant points along the process and represent lessons learnt can also be used as part of their reflections. ● Teams may either appoint an official photographer, or members can take turns. ● All photos will be uploaded on a class Picasa album (to be shown to class in Lesson 2). ● Distribute cameras for students to begin taking photos.	
	Mini-Design Exercise Part 1	Assign teams to lanes and boxes. Instruct teams to move the box from the start point to the end point, without using any tools. Teams may use different methods (e.g. push box along ground, lift box and carry it). When the teams are done, ask the class to identify the forces that were acting on the box, including the direction of the forces (e.g. friction, gravity, push).	H: *Hook* students *hold* their interest through a fun phys activity E1: Give students opportunity to *experience* the pro for themselves. R: Give students a opportunity to *reth* their understandin forces and *revise* if necessary
	Mini-Design Exercise Part 2	Distribute a length of rope, and 1 set of wheels and axle to each team. Instruct them to use the materials provided to move the	H: *Hook* students *hold* their interest

		box to the other end, under the following conditions: ● Only 1 person can move the box. ● He/she can only use 1 arm. ● Teams have 10 min. Ask the class how the additional materials made moving the box easier (e.g. better grip, reduced surface area in contact with ground, less friction). Point out the fact that they had made use of simple machines, and it had made their work easier.	through a fun phy activity E1: Give students opportunity to *experience* how t use of simple ma make work easier *explore* possible solutions.
	Closing	Ask the class how many different solutions were developed. Highlight that there can be more than one way to solve a problem. Ask teams if they were satisfied with their solutions, and what they would do to improve them if they had more time and more resources. Emphasize that problem solving and designing a product often are not 100% successful the first time round. It usually takes many rounds of trying over and over again, making improvements continually, before a great solution is developed. Introduce the project to the class: ● Today, they experienced moving a heavy load from one point to another on the same level. ● Introduce the panel of users to students (people who face difficulties moving heavy objects from one level to another), and briefly state their respective problems. Students will meet the panel in class at the next lesson. ● Explain that the project they will be working on for the next 5 weeks will be to design and produce something to help solve their problem.	E1: Allow student *explore* issues in design process. E2: Encourage students to *evalu* their solutions. W: Let students k *where* the unit is go and *what* is expect

		Distribute and run through the rubrics for the project and mini-expo. A copy should also be displayed in the Parking Lot. Assign task for the next lesson: Think of questions to ask panel of users. They should post all the questions they think of between now and the next lesson on the Parking Lot.	

ON 2: EMPATHIZE AND DEFINE

erview

s lesson comprises three parts:

Students develop questions to ask the panel of users.
Students then have a Question and Answer (Q&A) session with a panel of users, all of whom face the same problem of transporting heavy items from one floor to another.
Student teams then proceed to choose a user and define their problem.

to Teachers

panel should be organized and coordinated by the teacher at least 2 weeks before the lesson. The panel should e up of 4 or 5 other members of the school community such as other teachers, the Operations Manager, school dants, laboratory technicians and canteen operators. The teacher should also brief the panel prior to the lesson to expect (e.g. by giving them a sample list of questions). If any of the users prefer to speak in Chinese or Mala her should ensure that there is a translator present, if he/she is unable to translate.

e

Classroom

s

To appreciate the importance of empathy in meeting the needs of others.
To appreciate the importance of active listening and asking good questions to understand a problem.

Questions

In what ways can “walking around in someone else’s skin” be valuable?
How can I go about trying to understand a problem?

Student Experience

In the previous lesson, students would have experienced moving a heavy object for themselves.
Students should also have posted questions for the panel on the Parking Lot.

ials / Equipment Required

4 or 5 additional chairs, arranged at the front of the classroom for the panel
"Defining the Problem" worksheet

on Outline

e	Activity	Description	Outcomes
	Introduction	Remind students of their experience in moving a heavy load in the previous lesson. In this lesson, they will be meeting and interviewing a group of people who have to move heavy loads as part of their jobs. (The names and occupations of the panel members should be written on the whiteboard.) Inform the class that the purpose of meeting the users is to understand the problems they face as fully as possible. Introduce the following quote from Harper Lee's To Kill A Mockingbird: "You never really understand a person until you consider things from his point of view - until you climb into his skin and walk around in it." Ask students what they think it means to climb into someone else's skin. Discuss the meaning of the phrase, and think about the definition of "empathy." Challenge them to try considering things from the users' points of view during the Q&A session, as they will then be spending the next 4 weeks designing and developing a solution for a user of their choice, in their teams. Instruct students to sit together with their teammates. Remind students about taking photos to document their work, and distribute cameras to the teams.	W: Let students kn *where* the lesson is going and *what* is expected.

	Question Generation	Inform students that at the beginning of the Q&A lesson, each user will briefly describe his/her own perspective and need. Subsequently, the panel will take questions from students. The purpose of the questions is to understand the needs better. Hence, they should be relevant. Ask 3 students to share some of their questions, and have them write the questions on the board. Discuss the questions with the class. Do these questions suffice? If not, how can they be improved? Come to a consensus on whether the 3 questions are good ones to ask. Examples of questions: • What do you find most difficult about transporting this heavy item? • Have you tried any solutions? Were they effective? Why or why not? Distribute Worksheet 1 to students. Give the teams some time to decide on 5 questions that they want to ask the panel, and to write them down on the worksheet. It is fine for teams to have overlapping questions. Walk around to offer teams suggestions and advice. Teams may work standing around the Parking Lot if they wish. Advise students to listen carefully to the users, and write down key points (space is provided in the worksheet for students to take notes). During the Q&A lesson, students may think of new questions (that are not on their list) and ask them. However, there may not be time for them to ask all their questions.	E1: Let students *e* the issues.
	Q&A Session with Panel of	Invite panel into the classroom.	E1: *Equip* student understanding of t

	Users	Each user will briefly describe his/her need and/or problem of moving something from one level to another. When every user is done, the floor will be open for students to ask their questions. Questions will be asked team by team, in turn, unless a team has a follow-up question to a user's response. If teams have similar questions, these should not be asked repeatedly. Unless otherwise specified by the team, questions will be considered directed towards all users. Thank users for coming.	problem.
	Defining the Problem	Give instructions on how to define the problem (with the aid of the worksheet). ● Teams should decide on the user whom they wish to help. It is okay if more than 1 team chooses the same user. ● Teams should come up with one sentence that summarizes the problem faced by their selected user. ● They should also list at least three important features about the problem, based on what they heard from the user, so as to describe the problem in greater detail.	O: Provide scaffol for students to *org* users' inputs. T: Giving students choice of which us help allows them t *tailor* their own experiences, acco to their interests.
	Closing	Collect worksheet. Ask students if they felt the Q&A lesson was useful. ● Why do you think I invited the panel to join our lesson today? ● What if we hadn't had the Q&A lesson? Would you have understood the problem as well? ● Which questions were the most effective? ● Why is listening important?	E2: Let students *Evaluate* the usefu of the Q&A sessio W: Let students k *where* the unit is and *what* is expe

		Emphasize that it is important to remember the user's perspective. Good designers try to step into the shoes of their end users when they design products. Similarly, when serving a specific audience, it is also important to understand what their needs really are. Students must address the users' needs. Introduce the class Project Weightlifter blog and class Picasa album to students. Explain that the blog is another tool to help keep a record of their experiences. Blog entries can be in the form of photos (uploaded from Picasa) with attached comments. They can also be purely textual. Show an example of an entry (created by the teacher using a photo taken in Lesson 1). Each entry should be tagged by team. Encourage students to blog regularly, as it will be a good resource for their final reflection. Brief students on how they can get access to computers in school. Inform students that during the next 3 lessons, they will be gaining knowledge about simple machines that will help them develop a solution to the problem.	

WORKSHEET 1: DEFINING THE PROBLEM

Top 5 Questions To Ask Panel:

1. _____
2. _____
3. _____
4. _____
5. _____

Notes from Q&A Session:

Selected User:

Our team would like to help

_____.

Problem Statement:

Features of the Problem:

- _____
- _____
- _____
- _____
- _____

ON 3: LEARN: LEVERS

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rview

ng defined the context of the problem, students learn tools to help solve the problems of the users. This lesson duces simple machines and the principles of a lever, one of the simple machines that can be used.

Students are given examples of simple machines in everyday life and asked to identify key features of 4 types simple machines (lever, inclined plane, wheel and axle and pulley) through a classification activity.
Students differentiate between the 'load', 'fulcrum' and 'effort' of the lever.
Students conduct both a physical and virtual experiment to learn the principle behind how levers function.

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e

Classroom

s

To understand that simple machines make work easier and there are different types of simple machines.
To understand how levers function to make work easier.

- Identify everyday examples of levers.
- Identify the different parts of the lever.
- Understand the principle behind how levers function.

Questions

Why do we use simple machines?
What are everyday examples of simple machines?
What are some everyday examples of the lever?
How do levers work?

Student Experience

Students understand the effects of forces and how it can change the movement or direction of an object.

rials / Equipment Required

uction

Laptop and projector
Powerpoint file for teacher-led discussion for Lesson 3.

Photographs of students using rope and wheel and axle systems in the mini-Design exercise.

ty 1

5 sets of 8 photographs of everyday examples of simple machines. Each set of 8 photographs should contain photographs of each simple machine (lever, inclined plane, wheel and axle and pulley).
Large sheet of butcher paper to be placed on the wall.
Masking tape

ty 2

5 photographs of a class 3 lever
20 Individual whiteboard and markers (If unavailable, you could laminate a sheet of A4 paper)

ty 3

5 laptops or iPads
5 staplers

ng

Exit cards.
Additional weblinks: http://edtech.kennesaw.edu/web/simmach.html

on Outline

	Activity	Description	Outcomes
	Introduction	Remind students that during Lesson 1, they were given different tools such as rope and wheel and axle systems to make their job of moving the load from the start point to the end point easier. Show students pictures of how they solved the mini-Design exercises and ask students to suggest other tools which could have made their task easier. Try to lead students to suggest that the use of "machines" makes work easier. When this happens, use this as a segue to discuss "simple machines" with the students and ask the following questions:	H: *Hook* and *hold* students' attention by relating the lesson to prior experience. W: Help the students know *where* the unit is going and *what* is expected.

	● What do you understand by the term “machine”? ● Why do we use machines? (All machines are designed to make work easier.) Students can share their answers and write their answers in Lesson 3 Worksheet 1. Explain that for the next 3 lessons, the class would be learning about 4 simple machines that could be incorporated into their design to solve the problem for their user. Present the agenda and key questions of the lesson. Address some questions generated on the parking lot from the previous lesson.	
Activity 1: Introduction to simple machines	Divide students into teams of 4. Distribute 2 sets of 4 photographs of everyday examples of simple machines to each team (each set containing an example of a lever, inclined plane, wheel and axle, pulley). All 8 photographs should differ. Each student should receive 2 random cards. Group work: Ask the students to work in their teams to answer the following questions and record their answers on the worksheet provided. 1. Look at the examples of simple machines provided and classify them into four different groups. 2. Explain how you classified them by stating one common characteristic of the simple machines in each group. 3. Suggest a name for each category of simple machines.nice constructive activity	E1: Have students *experience* and *explo* everyday examples th they have encountere

	Students can write their answers in Lesson 3 Worksheet 1. *Differentiation: If students need more scaffolding, provide the definitions for each of the four simple machines and ask the students to sort them into the categories. To increase the difficulty level, students could be given photographs of everyday examples which are more difficult to identify, or examples which comprise of more than one simple machine component and asked to draw a Venn diagram to classify them.* *Note to teacher: It would be useful to use examples which the students can find readily at home or in school and are of interest them.* Class sharing and Concept mapping: Get a few volunteers to share the categories that they have identified. At this point, you may wish to introduce the actual names and descriptions of the 4 simple machines. Ask student volunteer to start a graphic organizer containing the four examples of simple machines (Lever, inclined plane, wheel and axle, pulley) on a sheet of butcher paper on the class wall. You could ask students in class to contribute a few more examples. Guided practice: Have students complete Lesson 3 Worksheet 2, Question 1. Inform the class that while the class will be focusing on the first four simple machines highlighted, there are two other simple machines which can be found on websites: the screw and wedge.	

	Inform the class that they will be focusing on “levers” for the day. *Note to teacher: Although the syllabus only requires that the students are taught the first four simple machines, it would be preferable to introduce the students to all six simple machines as they would encounter them on websites.* Additional resources: http://www.edheads.org/activities/simple-machines/index.shtml http://www.edheads.org/activities/lesson_plans/pdf/sm_04.pdf (Examples of simple machines that the students can discover. Site also explains how each everyday item functions as a simple machine.) http://www.beaconlearningcenter.com/WebLessons/MoveOurPrincipal/principal001.htm (Activities which requires students to move their Principal, and introduces students to how each simple machine works.) http://www.mikids.com/Smachines.htm (Website which provides examples of each simple machine and theory behind how they work.)	
Activity 2: Types and parts of levers	Teacher-led discussion: Ask students to pick out the examples of “levers” out of the 8 cards which their group had been assigned (class 1 and 2). Teacher to distribute one more example of a lever (class 3). *Note to teacher: This ensures that students would encounter all three types of levers. More information about different classes of levers:* *http://www.enchantedlearning.com/physics/machines/Levers.shtml*	E1: *Equip* students wi an understanding of t mechanics of a lever. T: *Tailor* the lesson to the different needs, interests, and abilities learners.

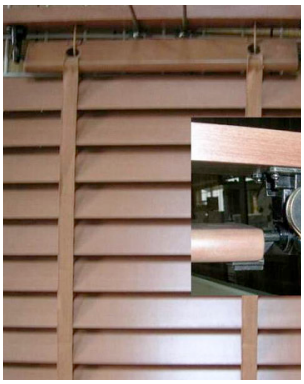
		Explain that levers are a type of simple machine and help students to identify the 'load', 'effort' and 'fulcrum' of the lever. Give at least an example for each type of lever. Formative assessment: Give each student an individual whiteboard and whiteboard marker. Ask students to label the parts of three examples of levers in Lesson 3 Powerpoint, Slide 7. They should write their answers on their whiteboard and compare their answers with their teammates. If there are differences in answers, they should be given 2 minutes to decide which is the correct answer. They can write their answers on Lesson 3 Worksheet 2. *Differentiation: As an extension to the activity, students could also be taught differences between the classes 1 to 3 of levers explicitly. You could explain that in each class of lever, the Fulcrum, Load and Effort are in the centre respectively. A mnemonic FLE could be use to help them remember the differences.* Ask students to identify the differences between the three types of levers they are holding, and ask students to suggest the two different types of advantages of a lever (force or movement multiplier). They may write their answers in Lesson 3 Worksheet 2.	
	Activity 3: How does a lever work?	Give each team a laptop or iPad and a stapler. Ask the students to identify the fulcrum, load and effort of the stapler. Ask the students to staple a stack of 5 sheets of papers using just their index finger at three different points of the stapler. (Refer to Lesson 3 Powerpoint Slide 10. Remind the students to be careful	E1: Enable students t *experience* the impac their actions on a leve and draw conclusions from there.

	not to hurt themselves. Ask the students to decide which point required the most effort and which required the least effort and share their answers with a partner. Based on their findings of Activity 3, ask the students to formulate a hypothesis and suggest the distance of the fulcrum to allow the load to be lifted in the following: http://sunshine.chpc.utah.edu/javalabs/java12/machine/act1/lab2.htm (An applet which allows students to change the distance of the fulcrum and observe its effect on load) If there is time, show students the following video to reinforce learning. http://www.youtube.com/watch?NR=1&feature=endscreen&v=tavCa6hLHpg Students can be asked to suggest other examples that have made use of such principles. They can write their answers in Lesson 3 Worksheet 3.	
Activity 4: Solving everyday problems with simple machines	Explain that students will be incorporating what they learned today to solve the problem for the user (from Lesson 2). Remind students of the basic design principles and define *brainstorm*: “a group discussion to produce ideas and ways of solving problems” (from Google Dictionary) Discuss brainstorming principles with the students ● Withhold judgment ● Encourage wild and exaggerated ideas ● Quantity counts, not quality	E1: Allow students to *explore* the concepts through application.

	● Build on ideas put forth by others ● Every person and idea has equal worth (http://www.brainstorming.co.uk/tutorials/brainstormingrules.html) Have teams brainstorm solutions for their problem from Lesson 2, applying the concept of levers. They can draw their suggestions on a sheet of butcher paper that could be posted up on the class wall.	
Closing	Ask students to draw an example of a lever on exit cards that they pin up on the class wall. Students should label the fulcrum, effort and load, suggest if it is a force or movement multiplier and suggest one way to make it more effective. This is ambitious but good assessment Students should also ask one question that they might have on a sticky note and place it in the “parking lot”. Ask students to use the team camera to collect photographs of everyday examples of each type of simple machine for the next lesson. They should collect 4 examples of each simple machine. Stipulate that they should not have the same picture or example as anyone in their team.	O: *Organize* their thoughts for more effective learning.

ɔn 3 Activity 1&2 Materials

ɔute 2 sets of 4 photographs of everyday examples of simple machines to each team (each set containing an ple of a lever, inclined plane, wheel and axle, pulley). All 8 photographs should differ. Each student should rece m cards.

			
			
	*(Picture of tongs are to be distributed only for Activity 2)*		

on 3 Worksheet 1

---

ay's questions

do we use simple machines?
t are different everyday examples of simple machines?
t are some everyday examples of the one of the types of machines?
do how do they work?

---

duction

at do you understand by the term "machine"?

---

y do we use machines?

---

ity 1

Look at the examples of simple machines provided and classify them into four different groups.
Explain how you classified them by stating one common characteristic of the simple machines in each group.
Suggest a name for each category of simple machines. Group the 8 simple machines you have been given an
state the characteristic which you used to distinguish them.

p name			
t makes this group special?			
yday example			
yday example			

ɔn 3 Worksheet 2

ɜw lines to match the simple machine with its description.

Lever	• It is a wheel with a groove around its edge.
ined plane	• A bar that is free to turn about a fixed point. It has three parts, namely the load, the effort a the fulcrum.
Wheel and Axle	• A slanted surface connecting a higher surface to a lower surface.
Pulley	• It is made up of a lever that turns in a circle around a centre point or fulcrum.

ɔel these examples of _____ with the correct parts: _____, _____ and _____.

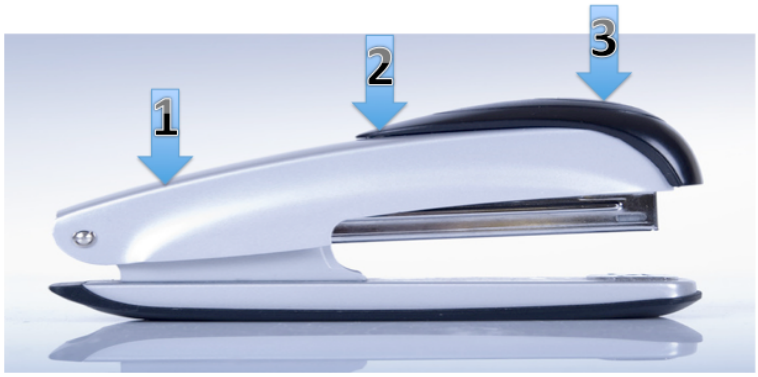
ɜat are two advantages of a lever?

_____

_____

on 3 Worksheet 3

the diagram below, label the load, fulcrum and effort of the stapler.



ple 5 sheets of paper using just your index finger at points 1, 2, and 3.

n point required the most effort?____ Which point required the least effort? ___

plore the website provided. http://sunshine.chpc.utah.edu/javalabs/java12/machine/act1/lab2.htm

ct how lifting the block onto the cart can be made easier.

nclusion: It would be easier to lift the block if the fulcrum is

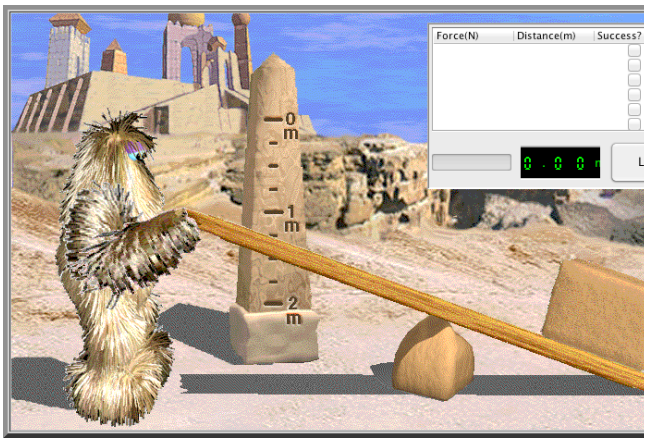
_____ (further away from/ nearer) the effort.

s an example of a _____ (force/movement) multiplier.

scribe another example that makes use of this principle.

_____

_____



ON 4: LEARN: INCLINED PLANES AND WHEEL & AXLES

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rview

ents learn the principles and advantages of the inclined plane and the wheel and axle.

Students are shown examples of the wheel and axle systems they had used in Lesson 1. Students should ide key features of the wheel and axle and brainstorm other examples.

Using a jigsaw activity, students identify the principles of an inclined plane and a wheel and axle system, and they could be made more effective.

Groups brainstorm solutions for the defined problem centered using the lever, inclined plane and wheel and a system.

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e

Classroom

s

To equip students with a conceptual understanding of how inclined planes and wheel and axle systems functio make work easier.

- Identify everyday examples of inclined planes and wheel and axle systems.
- Understand the principles behind how they function.

Questions

What are some everyday examples of the inclined plane and wheel and axle?

What are the mechanical principles to explain how these simple machines function?

What are advantages of using these simple machines?

Student Experience

Students understand the effects of push and pull forces.

Students understand the principles of how levers function.

Brainstorm and design principles.

rials / Equipment Required

ty 1

Photographs of examples of how wheel and axle systems were used in Lesson 1.
Laptop and projector

ty 2
Laptops for 3 groups
Straw and a spool of thread
Spring balance or rubberbands, 1 kg mass, long ruler and a stack of books of 25 cm height.

on Outline

e	Activity	Description	Outcome
	Introduction	Address any questions that were raised in the previous session. Recap the previous lesson by asking students explain how the lever could be used to solve the problem defined in Lesson 2.when you say problem from lever 2 – you mean their main problem based on their user, right? Collect examples of each type of simple machine from the students for preparation of class quiz in Lesson 5. Explain that more tools will be provided to help them solve the problem. Ask students if they can recall what the other three types of simple machines. Explain that the class will focus on inclined planes and wheel and axle systems today. Present the agenda and key questions of the lesson.	W: Let students *where* the lesso going and *what* expected.
	Activity 1: Everyday examples of	Show pictures of the solutions students designed in the mini-design exercise in Lesson 1.	H: *Hook* and *ho* students' attent relating the less

	inclined planes and wheel and axle systems as simple machines	Facilitate the discussion to help students remember why they had used the wheel and axle systems: to make work easier! Lead the discussion to ask students if an inclined plane could also help to make their work easier.	a prior experien
	Activity 2: How inclined planes and wheel and axle systems work	Jig-saw: Number off students in each team to form 4 groups of 4-5. Each group engages in at least two of the following activities. ● Activity A: Students should be shown the following video: http://www.youtube.com/watch?v=oWiZ_5qvs7I and asked the following question: What is a disadvantage of using the inclined plane compared to a lever to lift an object to the same height? *Note: This concept is useful for their design, but if the concept of mechanical advantage is too difficult for the students, an alternative video that can be used is: http://www.youtube.com/watch?v=28Fth_pWguk&feature=related. Students can be asked to explain an inclined plane works taking into account work and distance.* ● Activity B: Students should be shown this video http://www.youtube.com/watch?v=0xiQtmUQ4yI and asked the following questions. What are some other examples of wheel and axle systems? How is the wheel and axle similar to the lever? If they were required to design a wheel and axle system that would require as little effort as possible, what features would it have? ● Activity C: A long part of a flexible straw is inserted and fixed into the hole of a spool of thread. Each of the spools of thread are rolled along the edge of the table. For each spool, one is rolled by turning it at the axle, while the other is rolled by turning it at the wheel. Students are asked to determine and explain if it was	E1: Let student*experience* solv real-life problen*explore* how sin machines work.

		easier to roll the spool of thread using the wheel or the axle. Students should relate this experience with that of a lever and derive the principles of the wheel and axle through this activity. ● Activity D: A 1 kg mass is attached to spring balance and held vertically through a height of 25 cm. The reading is compared to a 1 kg mass held on an inclined plane at the height of 25 cm. In place of a spring balance, students could also use linked rubberbands and measure the length of the rubberband. Students are asked to determine it was easier to move an object up an inclined plane or to lift the object vertically. Students are also asked to determine if a larger or smaller effort is required to pull or push a load up a longer distance. Students should derive the principle behind the inclined plane through this activity. Ask students to relate this experience to cycling up a steep slope versus a gentler slope. If time permits, each team could be given an iPad or laptop to explore the following website: http://jersey.uoregon.edu/vlab/friction/Friction.html They should draw the conclusion that a steeper slope would result in less time required for them to descend the hill. Ask them to relate an experience they might have with inclined planes. Have students re-group in their teams and share their findings with each other. Have students identify key features of both simple machines and give them some time to brainstorm examples of inclined plane and wheel and axle systems in the school. Write these on the board and ask students to suggest explanations why they make work easier.	
Solving everyday	Remind students of basic design and brainstorm principles.	R: Provide opportunities to

	problems with simple machines	Groups should brainstorm solutions for their problem from Lesson 2 using a combination of levers, incline planes and wheel and axle systems.	*Rethink* and *Re* their solution gi more tools
	Closing	Ask students to summarize the main learning points of the lesson. Ask students to draw and label an everyday example of a wheel and axle system and park it on the class wall.	O: *Organize* the thoughts for mo effective learnir

ON 5: LEARN: PULLEYS

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rview

ents learn to identify the common uses of pulleys, differentiate the different types of pulleys and how each make
easier.

Students are asked to bring everyday examples of the three simple machines covered in Lesson 3 or 4 and s
them with their group as a form of revision for the previous lesson.
Students identify everyday examples of pulley systems.
Students differentiate between the two types of pulley systems and and try activities which would help them l
the mechanical advantages of using the pulley system.
Summative assessments of concepts learned in Lessons 3-5 are presented in the form of a game show and g
challenge.

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e

Classroom and school grounds which contain examples of pulley systems.

s

To be equip students with a conceptual understanding of how pulley systems function to make work easier.

- Identify everyday examples of pulley systems.
- Differentiate between the different types of pulley systems.
- Understand the principles behind how they function.

Questions

What are some everyday examples of pulley systems?
What are the different types of pulley systems?
What are the advantages of using pulley systems?

Student Experience

Students should be able to differentiate between effort and load.

ials / Equipment Required

ty 2
- Laptop and projector
- Examples of 2 types of pulley systems
- Worksheet to show direction of load and effort

ty 3
- Quiz show questions of how simple machines work (photographs provided by students prior to this lesson).
- Problem cards of situations requiring simple machines.

ng
- Sticky notes

on Outline

e	Activity	Description	Outcomes
	Introduction	Recap of previous lessons by asking the students to help fill out the concept map placed on the class wall in Lesson 3. Explain that the class will focus on pulley systems today. Present the agenda and key questions of the lesson.	W: Let students k *where* the lesson going and *what* is expected.
	Activity 1: Everyday examples of pulley systems as simple machines	Think-pair share: Recap some of the brainstormed solutions at the end of Lesson 4 using a lever, inclined plane or wheel and axle system. Ask students what other solutions were available. Teacher-led discussion: Referring to the alternative solutions, lead students to identify features and examples of a pulley system. (E.g. If no group comes up with the suggestion of a pulley, teacher could ask how the students could make the process easier, perhaps make	E1: Give student to *Explore* how th can incorporate v they have learnt design a solution problem.

		reference to the flag pole).	
	Activity 2: How simple machines work	Show students the following video: http://www.youtube.com/watch?v=I8q_V5LHj-U&feature=related Suggested questions: Is it better to use a single or a double pulley? Why is that so? http://www.youtube.com/watch?v=TlPWy7qW7oM *[Note: You might need to explain that "screw" is another simple machine that you have not covered]* Suggested group discussion questions: What are some everyday examples of pulley systems? What are the two types of pulleys described? How can you alter a pulley system to gain more mechanical advantage? Ask students to design a pulley that is able to maximise mechanical advantage. Think-pair share: Let students experiment with two contrasting examples of a pulley system (fixed pulley and movable pulley) and ask students to differentiate between them. They should discuss this in pairs. Lead a discussion to recap the principles and confirms differences between the two pulley systems (Fixed pulley - effort and load move in opposite directions; movable pulley, effort and load move in similar directions.) Guided practice: Students fill in a worksheet to show the direction of load and effort.	H: *Hook* and *Hol* students by enga them in understa how they can ma their designs bet

	Activity 3: Identifying simple machines	Game show: Using the photographs of everyday examples which the students had taken after Lesson 3 to create a game-show using the program on http://almorale.com/gsdl.html. It could be designed to require other students to identify which of the four simple machines are used, and the parts of the machine where applicable. (E.g. fulcrum, effort, load, axle, wheel). An individual component should be included. Group challenge: Students are given a problem card containing scenarios that could be made easier using a simple machine (lever, inclined plane, wheel and axle and pulley). Students are asked to discuss share what devices could make that problem easier. You could end the lesson by giving a few examples of complex machines to show how it comprises of more than one simple machine and explaining that their final product could comprise of a combination of machines.	H: *Hook* and *Hol* student interest b having students c their own game-s to assess their pe
	Closing	Teacher asks students to summarize the main points of the day's lessons and generate questions, which are placed in the 'parking lot'. Ask students to think about how they can use each simple machine or a combination of machines as a tool to solve their problem, and consider how to design the system to maximize the mechanical advantage. Inform them that the design process will begin in the next lesson.	O: *Organize* thei thoughts for mor effective learning

LESSON 6: BRAINSTORM

rview

ng chosen their target user and defined the problem on which to focus, students will:

- Brainstorm as many possible solutions to the problem as possible.
- Sketch out their ideas onto paper: What do the designs look like? How might users interact with the solutions
- Briefly work with another group to provide feedback on each other's solutions: What questions or concerns ar
- Do the solutions address the real need?

to Teachers

ons 6, 7, and 8 roughly follow the Design Thinking methodology. This process has been modified to better fit th
g, goals, and learners of this curriculum. While the curriculum generally follows the stages of the process, the
rtance lies not in the exact steps or terminology but in the iterative, human-centered focus of the methodology.
mmon process of any designer in any field (educators, engineers, graphic artists, etc), and it will be helpful for
ents to understand how it helps them create a solution for their user's needs. For more background information,
//dschool.stanford.edu/use-our-methods/

e

Classroom, ideally with open areas for group collaboration. Each team should have a team project space, whe
they can safely keep their materials and work-in-progress. This area can serve as their team "workshop," label
with team names and decorated with their sketches and designs.

s

To go through the design process and flesh out their design ideas and potential solutions by brainstorming, drawing, collaborating with others, and constructive peer feedback.

To become comfortable asking key questions in order to keep designs and solutions focused.

Questions

How does the perspective of your user influence your solutions and ideas?

Does a visual representation of your idea(s) help clarify the designs? Why or why not?

How does constructive feedback aid in the development of your ideas?

Student Experience

Familiarity with the process of brainstorming (as introduced and covered in Lesson 3; referenced from http://www.brainstorming.co.uk/tutorials/brainstormingrules.html and modified from Stanford University's d.sch School)

- Withhold judgment
- Encourage wild and exaggerated ideas
- Quantity counts, not quality
- Build on ideas put forth by others
- Every person and idea has equal worth

Experience with sketching

- Sketch big, sketch fast
- Explore the visual element of your ideas: how would it look?
- Sketching allows students to "show" their ideas, instead of verbally explaining them

Familiarity with giving and receiving peer feedback (see worksheet for more information and guidelines)

ials / Equipment Required

paper, blank: preferably big sheets (at least 8" x 10")
pencils
assortment of pens or markers
sticky notes, at least 10 per student
Peer Feedback worksheet (included after this lesson)

e	Activity	Description	Outcomes
n	Overview	Provide a quick overview of what students will be doing today: ● Brainstorming solutions to their defined problem (after Lesson 2's user panel) ● Fleshing out their designs and solutions, by using their acquired knowledge of simple machines from the past 3 lessons, sketching, and peer feedback ● Choosing 1-2 key ideas which with to move forward.	W: Let students *where* the lesso going and *what* expected.

		Have students work together in their teams (assigned in Lesson 1). It may be helpful to designate one person as the timekeeper; this role can switch to other team members in upcoming lessons. Inform students that this entire design process (lessons 6, 7, and 8) will seem rushed. This is okay! This pace is not to frustrate them; rather, time constraints can sometimes spark new ideas, and along with space and material constraints, real-life design projects often have a limited amount of time.	
2	Brainstorming	Review brainstorming (refer to guidelines from Lesson 3, also noted above). Have students gather in their teams with all necessary materials, including pens, pencils, markers, sticky notes, and their worksheets that contain the defined problem. Provide students with approximately 10 minutes to brainstorm as many wild ideas as possible. Idea headlines should be written on sticky notes and stuck onto the wall for all team members to see and build off of.	E1: *Equip* stude with the skill of brainstorming, allowing them t *experience* the design process *explore* their ide
	From Flare to Focus	Have teams take a few minutes to read through all of their generated ideas. Each team member should notate their top 3 individual ideas, and together, they should choose their team's overall top 3 ideas.	R: Encourage students to collaborate with members to *ref* and create a coherent set of solution ideas.
	Sketch	Teams should sketch out their top 3 ideas. Sketch big, sketch fast! Use the full sheet of paper, instead of drawing small doodles in the corners.	E1: *Equip* stude with drawing sk and encourage

		Have teams think about: What do the designs look like? How might users interact with the device/tool/solution? Allow group members to sketch separately, then bring ideas together; or the whole group can collectively and collaboratively draw out a potential design solution. Have 2-3 designs ready to present to their peer feedback groups. Walk around the classroom, from group to group, and help them stay focused by asking key questions.	to *experience* m the collaborativ project process drawing and wo together.
า	Overview of Peer Feedback	Explain how peer feedback should operate. See worksheet for more information.	W: Introduce *wh* expected during time for peer feedback.
	Peer Feedback between teams	Two teams should pair up, to provide each other with peer feedback on the current draft of ideas. Each team has 5 minutes to review the other team's 2-3 designs and provide feedback. Help facilitate peer feedback, if necessary.	E2: Encourage students to take advantage of th opportunity to p *evaluate* their w thus far.
า	Debrief	Review the key questions • How does the perspective of your user influence your solutions and ideas? • Does a visual representation of your idea(s) help clarify the designs? Why or why not? • How does constructive feedback aid in the development of your ideas? And have students answer them in a variety of ways: • Short headline answers on sticky notes, which are then	E2: Set aside ti and space for students to *eva* their work so fa reflect on their successes and frustrations, and review their wor T: *Tailor* the del

		displayed on a wall • Private text messages or short emails to the teacher • Blog posts, tagged with team name and individual name Choose one of these above reflection methods for all students in this lesson. Methods may change for the next reflection opportunity.	to the students' and interests. A them to choose to reflect best.

FEEDBACK (Lesson 6 worksheet)

Questions:

looking at the designed solution, or interacting with it, what questions or concerns arise?
e solutions address the real need of the user, as defined by the problem statement?

elines:

When one group is talking, the other team should listen quietly, take notes, ask 1-2 clarifying questions if necessary, and thank them for their thoughts.
Be constructive. This opportunity for peer feedback is not to criticize or make the other team feel bad. Help the improve their ideas and solutions!
Determine which team will provide feedback first, then switch.

edure:

Spend a few minutes reviewing the designs. Ask questions, only if necessary. There should be a limited amou talking and explanation. The team whose designs are being reviewed should *show, not tell!*
Offer 1-2 pieces of positive feedback showcasing elements at both the big-picture and detailed levels. Also consider how different senses react to the design. Some examples of good ways to start positive feedback:

- "I like how you ____"
- "This aspect really shows ___"
- "This makes me feel ____"

Offer 1-2 pieces of constructive feedback, always remembering to include a suggestion or question along with critique. Some examples of good ways to start constructive feedback:

- "You might want to consider this _____"
- "How about trying ____"
- "Don't forget about ____" nice scaffolding feedback here

LESSON 7: PROTOTYPE

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rview:

lesson will be focused on bringing the ideas and solutions into the tangible world.

Prototypes may not always look like the original sketches; as they create, students will learn and discover wh does and does not work.

The prototype should allow people to *experience* the idea/solution.

Remember to consider the perspective of the user: how will the user interact with the device?

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Classroom, ideally with open areas for group collaboration. Each team should have a team project space, whe they can safely keep their materials and work-in-progress. This area can serve as their team "workshop," label with team names and decorated with their sketches and designs.

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To evolve their designs from 2D sketches to 3D creations

To become comfortable asking key questions in order to keep designs and solutions focused.

Questions

Does a tangible, 3D version of your solution change your original design intentions? How?

How will the user interact with this device?

Student Experience

Familiarity with all tools and equipment

- Including safety precautions, such as use of safety glasses, gloves when necessary, and pulled-back h
- Including proper use of all equipment

rials / Resources required

Bring in a prototype (made of wood, cardboard, or similar materials) from a different project, to show students "rough" nature of what a prototype may look like.

It may be helpful for teachers to explain that students may use any materials available in the classroom, but th will not be additional resources purchased. Teams must work together to share materials.

For the actual prototype, students may choose from a variety of materials, including:

- markers, pens, pencils
- cardboard (single- or double-walled)
- tape (duct tape, scotch tape, masking tape)
- glue (hot glue, liquid glue, glue sticks)
- hot glue guns
- balsa wood
- box cutters, Xacto knives
- rulers
- scissors
- hammers
- screwdrivers
- nails
- screws
- wood
- etc
- paper
- sticky notes
- PVC pipes, elbows, and T connectors
- rope, twine
- wheels, axles
- pulleys
- casters
- aluminum foil

e	Activity	Description	Outcome (WHERET
	Overview	Provide an overview of the lesson: ● Quickly review what was accomplished yesterday ● Explain the plan for today's lesson on prototyping ● Remind students of the outcomes and goals for the lesson	W: Let students *where* the lesso going and *what* expected.
n	Introduction to Prototyping	Define *prototype*: "a first, preliminary model of something" (from Google Dictionary) Show an example of a prototype from a past project (ideally unrelated to this project) to provide students with an idea of how a prototype might look. Discuss the purpose of a prototype: To tangibly and physically create what you designed, bringing the idea from 2D to 3D, in order for the user (and	E1: *Equip* stude with the skill of prototyping, allo them to *experie* the design proc and *explore* the ideas. R: This is also a

		designers) to better interact with it, test it, and refine it. Quickly review materials and equipment available for use. Prepare students: ● It's okay if the 3D models look nothing like what you sketched, or imagined. ● It's okay if the design changes. ● Remember to think about how the user will *use* this device.	opportunity for students to *reth* and *revise* their designs and pla depending on th peer feedback f the previous les and their learnir from the prototy process. O: *Organize* materials to opt time and use.
	Prototype, build, and create	Have teams create at least one prototype. Ideally, teams can create one prototype per solution, or even multiple versions of one solution. During this time, rotate around the room and move from the group to group, in order to: ● Confirm that solution designs are feasible for prototyping ● Ensure that tools, materials, and equipment are being used properly and safely ● Check-in on team dynamics and progress	E1: *Equip* stude with prototyping process skills a encourage them *experience* the stages of the collaborative de process: buildin
	Clean-up and debrief	Have students clean up and organize their work areas. Review the key questions: ● Does a tangible, 3D version of your solution change your original design intentions? How? ● How will the user interact with this device? Spend at least 5 minutes having students contribute questions to the	E2: Set aside ti and space for students to *eva* their work so fa reflect on their successes and frustrations, and review their wor

		parking lot. Encourage students to think about how their projects and work relate to their own lives. Promote an inquisitive attitude, and relate project work back to previous lessons on teamwork, empathy, and how simple machines make work easier.	T: *Tailor* the del to the students' and interests. A them to choose to reflect best.

LESSON 8: TEST AND REFINE

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ents will have the opportunity to finish building, test, and refine their solution -- one quick cycle of a highly iterati
gn process. Remember to focus on what they've learned through this process.

Finish building; prototypes are meant to be rough!
Pair up with another group and allow them to test the solution by interacting with the prototype.
Prepare for presentations during the next lesson!

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Classroom, ideally with open areas for group collaboration. Each team should have a team project space, whe
they can safely keep their materials and work-in-progress. This area can serve as their team "workshop," label
with team names and decorated with their sketches and designs.

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To complete one cycle of the design process, which concludes with user testing.
To become comfortable allowing others to use and test their product in a real-life situation, learn from user comments, and prepare for a final presentation.

Questions

How does it feel to put your work "out there" for others to use and test?
In real life, do users speak with, or interact with, the original designers of a product before using it? How does affect a user's experience?

Student Experience

Familiarity with all tools and equipment

- Including safety precautions, such as use of safety glasses, gloves when necessary, and pulled-back ha
- Including proper use of all equipment

rials / Resources required

It may be helpful for teachers to explain that students may use any materials available in the classroom, but th
will not be additional resources purchased. Teams must work together to share materials.
For the actual prototype, students may choose from a variety of materials, including:

- markers, pens, pencils
- cardboard (single- or double-walled)
- tape (duct tape, scotch tape, masking tape)
- glue (hot glue, liquid glue, glue sticks)
- hot glue guns
- balsa wood
- box cutters, Xacto knives
- rulers
- scissors
- hammers
- screwdrivers
- nails
- screws
- wood
- etc
- paper
- sticky notes
- PVC pipes, elbows, and T connectors
- rope, twine
- wheels, axles
- pulleys
- casters
- aluminum foil

e	Activity	Description	Outcome (WHERET
n	Introduction to Testing	Provide an overview of the day, in addition to key points that students should remember as they test. Emphasize to students that the goal for today's lesson is to finish building prototype(s), test them, and prepare for the next lesson's presentation and mini-expo. Remind students: ● The goal of testing is **not** to receive perfect positive reactions or scores ● The goal of testing is to consider the user's perspective and how he/she is inclined to use the product	W: Let students *where* the lesso going and *what* expected.
0	Finish building the prototype	Have students put the finishing touches on their prototype(s) and prepare to let users test them out.	E1: Allow stude *experience* the

			steps of the prototyping proc
	Testing, Round 1	Have teams pair up with another team. One team will test another team's product by interacting with the prototype, provide peer feedback in the last 2-5 minutes, and then switch roles. As with the previous peer feedback lesson, teams should listen and speak respectfully. As the team doing the testing, students should imagine stepping into user's shoes, interact with the prototype, and help the partnering team refine their product. As the team whose prototype is being tested, students should watch and listen carefully to the testers and his/her reactions (both vocal and physical) to the product. Remind students that they should remember to show, don't tell! Users should be able to figure out how to interact with the solution, without much (if any) preface or explanation. This is an impt point that might be made even clearer up above when you mention it (ie I wasn't sure what you meant by show not tell the first time I read it above) Move from group to group, helping to facilitate testing and interactions between groups.	E2: This is an opportunity for students to *eva* their work, by te it with other pot users.
	Testing, Round 2	Have teams pair up with another team. One team will test another team's product by interacting with the prototype, provide peer feedback in the last 2-5 minutes, and then switch roles. As with the previous peer feedback lesson, teams should listen and speak respectfully. As the team doing the testing, students should imagine stepping into user's shoes, interact with the prototype, and help the partnering team refine their product. As the team whose prototype is being tested, students should watch and listen carefully to the testers and his/her reactions (both vocal and physical) to the product.	E2: This is an opportunity for students to *eva* their work, by te it with other pot users.

		Remind students that they should remember to show, don't tell! Users should be able to figure out how to interact with the solution, without much (if any) preface or explanation. Move from group to group, helping to facilitate testing and interactions between groups.	
	Presentation Preparation and Debrief	After testing is complete, tell teams to come together, review notes, and prepare for the presentation tomorrow. If time allows, refinements may be made. If not, teams should reflect on the feedback received from testing and record what next steps they would take, if they had additional time. These "next steps" can be included in their presentation, in order to show how they would refine their work based on feedback. Students should clean up and organize their work areas. Review the essential questions ● How does it feel to put your work "out there" for others to use and test? ● In real life, do users speak with, or interact with, the original designers of a product before using it? How does this affect a user's experience? And have students answer them in a variety of ways: ● Short headline answers on sticky notes, which are then displayed on a wall ● Private text messages or short emails to the teacher ● Blog posts, tagged with team name and individual name Choose one of these above reflection methods for all students in this lesson. Methods may change for the next reflection opportunity.	E2: Set aside ti and space for students to *eva* their work so fa reflect on their successes and frustrations, and review their wor T: *Tailor* the del to the students' and interests. A them to choose to reflect best.

LESSON 9: PRESENTATION AND EXPO

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entation and Mini-Expo

Users from Lesson 2 invited back to view solutions
Students present and demonstrate their projects to users who provide feedback
Each student in the group is required to present / demonstrate
Awards are given to each group to affirm good performance in a specific area, e.g. teamwork, creativity
After Expo, teacher and user provide detailed comments on students' work including both product and proces
three areas: (i) Content mastery, (ii) Skills mastery, and (iii) Attitude development.

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Workshop and locations for User Needs

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To have students demonstrate and articulate empathy and user-focus in their solutions to user needs
To have students demonstrate application of scientific principles through applying simple machines in their pro
To have students reflect on process of working in a group, and be able to identify their own strengths and contributions

Questions

Has your solution met the needs of your user?
What simple machines did you use in your project, and why?
Did your group work together effectively? Why?

Student Experience

Presentation skills, perhaps in second language (depending on user)

rials / Equipment Required

Teachers' Assessment Rubric
Student projects
Notepads or paper + pens for users to take notes

Small prizes e.g. candy

ɛ /	Activity	Description	Outcomes (WHERETO
ıin	Introduction + Setup	Introduce the aims for the lesson ● User testing of solution ● Checking for understanding and application of simple machine concepts ● Students should be able to explain how they worked together to produce the solution. ● Rehearsal for Expo to be held after school hours 1 week after the end of the unit ○ Every Secondary One class to be involved ○ Parents, users, school staff invited Students set up their project demonstrations Users arrive and are oriented by the teacher.	W: This will orient students as *what* is expected, and *where* unit is going
ıin ɳ X ps)	Presentations	Have groups demonstrate solutions ● Demonstrations carried out authentically, i.e. with actual loads and objects, operated by actual users, and in actual locations Have groups do 5 minute presentation after demonstration ● Other groups listen and pose questions Assessment ● Assess projects and presentations according to rubric (please see Teacher's Assessment Rubric), asking guiding questions to get students to demonstrate their understanding	E2: The presentations allow students to *evaluate* their pro and presentation skills E1: Through making their presentations to the use peers, students *experience* meeting client needs. W: The assessment would als communicate to students in d *what* is expected of their proje

		○ Special focus on getting students to explicitly use scientific terms and concepts ● Facilitate users in assessing effectiveness of solution (Please see Teacher's Guiding Questions for Users)	
า	Prize Giving	Have students regroup at Workshop Awards every group a prize - ah good ● E.g. "Best teamwork", "Most imaginative Solution" ● Special attention to be paid to groups whose prototypes are not successful. Teacher can affirm their effort with a special recognition in other areas. Good pt ● Teacher reminds students to refine their prototypes and presentations based on feedback received, in preparation for the level-wide Expo.	R: Allows students to *rethink* approach and facilitates their efforts to *revise* their work T: Prizes can be *tailored* to af the individual strengths of gro and students
า	Debrief	Review the key questions ● Has your solution met the needs of your user? ● What simple machines did you use in your project, and why? ● Did your group work together effectively? Why? Have students answer them in a variety of ways: ● Short headline answers on sticky notes, which are then displayed on a wall ● Private text messages or short emails to the teacher Students may also contribute their own questions to the parking lot.	E2: Set aside time and space students to *evaluate* their wor far, reflect on their successes frustrations, and review their T: *Tailor* the debrief to the stu pace and interests. Allow ther choose how to reflect best.

Teacher Assessment Rubric

s is good. Having read this, I think you want to scaffold a bit more for student presentations to meet the standard this rubric? Will the students see the rubric ahead of time ? (that would be good)

Product	
rototype addresses specific needs of the user	Not obser Obser Outsta
rototype is functional (not necessary for prototype to be **successful** at its task) – nice pt – how to define nctional – some are easier to use than others, should this matter?	Not obser Obser Outsta
Presentation	
tudents are able to use the correct scientific terms to describe the operation of their solution, e.g. “fulcrum”, oad”, “effort” (Content)	Not obser Obser Outsta
tudents are able answer prepared questions posed by teacher based on the design of their solution (Content)	Not obser Obser Outsta

tudents are able to discuss each of the stages of the design process (Skills)	Not obser Obser Outsta
tudents are able to discuss further improvements they could make to the design and how these improvements ould benefit the user (Skills)	Not obser Obser Outsta
ach student is able to describe his/her contributions in working on the project (Attitude)	Not obser Obser Outsta
ach student is able to talk about one thing they have learned that they are good at doing (Attitude)	Not obser Obser Outsta

Teacher's Guiding Questions for Users

1. What features of the design address your needs?
2. What do you like best about the design?
3. Would you use this solution regularly? Why or Why not?
4. How could the students further improve on the design to meet your needs?

LESSON 10: REFLECT

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rview

Students reflect on the design process and their learning thus far
- Teachers assist to structure and guide reflections where necessary

Students are provided with a range of digital technology tools (e.g. cameras, video cameras, Comic Life! softv laptops), and asked to choose a medium for sharing their reflections

Students comment on the future of the project e.g. another iteration to fix existing problems, scaling up soluti

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Computer Lab

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To have students reflect on their experiences, and draw out learning from the design process, especially in ter work strategies and life skills

To recap key ideas in content and how these ideas apply to real world problems

Questions

What have you learned from working on this project that you could apply to your life?

How can you apply the simple machines that you learned to assist you in achieving real-life goals?

Student Experience

Familiarity with digital tools, e.g. cameras, Powerpoint, etc

rials / Equipment Required

A range of digital technology tools (e.g. cameras, video cameras, Comic Life! software, laptops)

Project Weightlifter blog

e /	Activity	Description	Outcomes (WHER
n	Introduction	Recap previous lesson ● Elicit students' responses to experience of user-testing and presentation Provide overview of reflection activity	W: Teacher's recap intended to unearth *where* students are coming from, in terr their experiences ar thoughts from the la lesson. W: It will also help t orientate students, a start them recalling previous experience the unit.
	Reflection Activity	Instruct students to select appropriate material from blog, e.g. entries, photos Have students select medium for reflection (e.g. Powerpoint, Comic Life, or journal entry. Have students storyboard their reflection project on paper Instruct students to complete reflection project on their own (1 week) ● Beginning the following week, students will share 2 reflections at the end of every lesson until all students have presented. ● Digital reflections can be archived, and added to students' portfolios. These could also be used in parent-teacher meetings to discuss students' progress.	W: The reflection ta intended to unearth *where* students are coming from, in terr their experiences ar thoughts from the u a whole. W: It will also help t orientate students, a start them recalling previous experience the unit.

	Debrief	Review the key questions ● What have you learned from working on this project that you could apply to your life? ● How can you apply the simple machines that you learned to assist you in achieving real-life goals? Teacher will also take time to address issues raised in previous lessons in the parking lot. Have students respond to key questions and /or the parking lot items and answer them in a variety of ways: ● Short headline answers on sticky notes, which are then displayed on a wall ● Private text messages or short emails to the teacher	