What’s next?

Riflessioni su:

VETTORI + CINEMATICA + DINAMICA

TEOREMA GAUSS – USO DI MODALITA’ INNOVATIVA o TRADIZIONALE?

CALORIMETRIA e TERMODINAMICA

Argomenti

Tools per l'Insegnamento della Fisica

Cinematica
Dinamica
Energia
Fluidodinamica
Calorimetria/termodinamica
Ottica
Elettrostatica
Magnetismo
Elettromagnetismo
Meccanica quantistica
Relatività speciale e generale

Early Physics
Multiple Representations in Physics
Historical approaches
Problem-solving; Jeopardy problems
Physics of everyday Thinking
Project Based Education
Modelling instruction
Simulation for Educational Physics
ISLE - Investigative Science Learning Environment
IBSE - Inquiry Based Science Education
Bayesian updating method
On line educational tool-kit

Investigative Science Learning Environment

(ISLE approach)

OBSERVATIONAL EXPERIMENT

TESTING EXPERIMENT

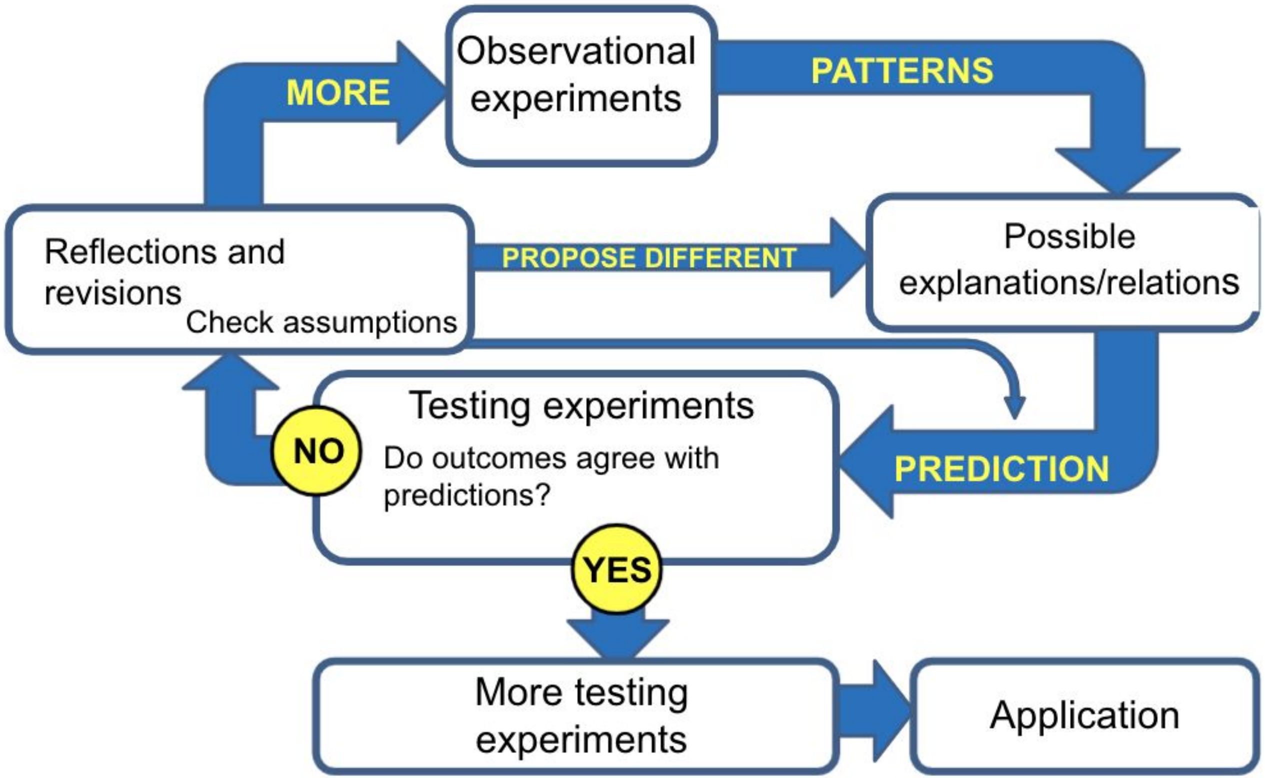
ISLE approach involves students' development of their own ideas by

- Observing phenomena and looking for patterns,
- Developing explanations for these patterns,
- Using these explanations to make predictions about the outcomes of testing experiments,
- Deciding if the outcomes of the testing experiments are consistent with the predictions,
- Revising the explanations if necessary,
- Encouraging students to represent physical processes in multiple ways.

(Etkina et all, 2007-2010-2019)

The combination of these features is applied to every conceptual unit in the ISLE learning system, thus helping them develop productive representations for qualitative reasoning and for problem solving.

Investigative Science Learning Environment - ISLE cycle



Etkina, 2015

Esperimenti di osservazione: cosa sono?

Esperimenti nei quali gli studenti investigano un fenomeno nuovo.
Gli studenti non effettuano previsioni circa i risultati dell’esperimento, ma osservano e descrivono: raccolgono dati, li analizzano e trovano delle relazioni ricorrenti (“*patterns*”) in essi.
Essi sono portati a elaborare una spiegazione per le relazioni trovate e/o a costruire una relazione qualitativa o quantitativa.

Esperimenti di osservazione: perché usarli?

Gli studenti:

- riceveranno esperienze *concrete* come parte del ciclo di apprendimento
- imparano ad interpretare i dati senza sapere se sono giusti o sbagliati (*open-mind*)
- imparano a effettuare *scelte* su come rappresentare i dati e su quali relazioni cercare
- procedono in situazioni dove non c'è una risposta giusta o sbagliata, imparando modi produttivi per investigare fenomeni complessi (*cognizione epistemica*)
- imparano a trattare la complessità di *dati reali*

Esperimenti di osservazione: come e dove usarli?

- a lezione: per sviluppare idee su un argomento nuovo. L'esperimento può essere svolto dal docente e gli studenti dovranno raccogliere ed elaborare i dati, decidere quali variabili sono importanti e trovare *patterns*. I dati o la loro analisi possono essere già forniti da terzi: in questo caso gli studenti dovranno solo trovare un pattern e fornire una spiegazione a riguardo;
- in laboratorio: dove gli studenti raccolgono ed elaborano i dati, trovano pattern e costruiscono spiegazioni o relazioni matematiche per descriverli;
- come compito per casa: si forniscono i dati agli studenti che dovranno analizzare e trovare patterns da soli.

Esperimenti di test: cosa sono?

Esperimenti nei quali gli studenti usano una spiegazione o una relazione per effettuare previsioni circa il risultato di un esperimento.

Gli studenti eseguono l'esperimento e registrano il risultato. Basandosi sull'accordo (o meno) della previsione con i risultati sperimentali, e tenendo conto delle assunzioni teoriche, dei modelli usati e delle incertezze sperimentali, essi devono effettuare giudizi circa la spiegazione o le relazioni che stanno testando.

Essi dunque imparano che se la loro previsione è d'accordo con l'esperimento, la spiegazione o la relazione pensata non può essere rifiutata, mentre se non c'è accordo essi devono rigettare la spiegazione o riconsiderare le loro assunzioni.

Esperimenti di test: perché usarli?

Gli studenti:

- imparano il ragionamento *ipotetico-deduttivo* (logica del “se”, “e”, ”ma” “allora”...)
- imparano a basare la loro conoscenza sull’evidenza e non sull’autorità
- imparano la differenza tra assunzione, previsione, spiegazione
- imparano che la discordanza tra previsioni e esperimento può essere dovuto a svariati fattori: assunzioni incomplete, spiegazioni errate, o tecniche sperimentali inadeguate
- imparano a scegliere quando rigettare una spiegazione per un fenomeno

Esperimenti di test: come e dove usarli?

- a lezione: il docente descrive l'apparato sperimentale e gli studenti effettuano previsioni dell'esperimento a seguito di una spiegazione precedentemente elaborata. Il docente (o un terzo) esegue l'esperimento e gli studenti decidono l'accordo o meno delle previsioni con i risultati dell'esperimento
- in laboratorio: gli studenti eseguono in prima persona l'esperimento dopo aver effettuato delle previsioni, e giudicano in seguito l'accordo o meno con i risultati dell'esperimento. L'esperimento può anche essere ideato dagli studenti in prima persona, a seconda del materiale a disposizione.

Esperimenti di applicazione: cosa sono?

Esperimenti che includono il risolvere un problema pratico o determinare una quantità sconosciuta mediante un esperimento.
Agli studenti può venire chiesto di usare più metodi sperimentali per determinare una stessa quantità e confrontare i risultati.

Esperimenti di applicazione: perché usarli?

Gli studenti:

- imparano ad affrontare problemi realistici
- imparano ad affrontare un problema da più punti di vista, usando più idee e confrontandole
- imparano a scegliere quali assunzioni effettuare per risolvere un problema e cosa tralasciare
- imparano ad applicare la fisica nella vita di tutti i giorni usando strumentazioni semplici
- imparano a confrontare risultati di diversi esperimenti

Esperimenti di applicazione: come e dove usarli?

- in laboratorio: agli studenti è richiesto di calcolare una quantità fisica effettuando un esperimento con degli strumenti a loro disposizione
- come problema-video: gli studenti possono raccogliere dati guardando un video di un esperimento e risolvere il problema richiesto (si può fare anche in classe o come compito per casa)

Rubrics for assessment

The Rutgers Physics and Astronomy Education (PAER) group has developed rubrics for assessment of scientific abilities. The rubrics contain descriptors for individual scientific sub-abilities. One can use the descriptors to assign either a numerical score or a descriptive score for a portion of student writing related to a certain sub-ability. The relationship between the scores is shown in the table below. We prefer to give students rubric description with a descriptive score as numerical scores were found to have a negative effect on student learning. A score of 0 describes a write-up in which the sub-ability is ‘Missing’, 1 stands for a write-up where the sub-ability is ‘Not adequate’, 2 describes a write-up with the sub-ability that ‘Needs some improvement’ and 3 describes a write-up in which is ‘Adequate’.

Ability to represent information in multiple ways

RUBRIC A: Ability to represent information in multiple ways					
	Scientific Ability	Missing	Inadequate	Needs improvement	Adequate
A1	**Is able to extract the information from representation correctly**	No visible attempt is made to extract information from the problem text.	Information that is extracted contains errors such as labeling quantities incorrectly, mixing up initial and final states, choosing a wrong system, etc. Physical quantities have no subscripts (when those are needed).	Some of the information is extracted correctly, but not all of the information. For example physical quantities are represented with numbers there are no units. Or directions are missing. Subscripts for physical quantities are either missing or inconsistent.	All necessary information has been extracted correctly, and written in a comprehensible way. Objects, systems, physical quantities, initial and final states, etc. are identified correctly and units are correct. Physical quantities have consistent subscripts.
A2	**Is able to construct new representations from previous representations**	No attempt is made to construct a different representation.	Representations are attempted, but use incorrect information or the representation does not agree with the information used.	Representations are created without mistakes, but there is information missing, i.e. labels, variables.	Representations are constructed with all given (or understood) information and contain no major flaws.
A3	**Is able to evaluate the consistency of different representations and modify them when necessary**	No representation is made to evaluate the consistency.	At least one representation is made but there are major discrepancies between the constructed representation and the given one. There is no attempt to explain consistency.	Representations created agree with each other but may have slight discrepancies with the given representation. Or there is no explanation of the consistency.	All representations, both created and given, are in agreement with each other and the explanations of the consistency are provided.
A4	**Is able to use representations to solve problems**	No attempt is made to solve the problem.	The problem is solved correctly but no representations other than math were used.	The problem is solved correctly but there are only two representations: math and words explaining the solution.	The problem is solved correctly with at least three different representations (sketch, physics representation and math or sketch, words and math, or some other combination)
A5	**Force Diagram**	No representation is constructed.	FD is constructed but contains major errors such as incorrect mislabeled or not labeled force vectors, length of vectors, wrong direction, extra incorrect vectors are added, or vectors are missing.	FD contains no errors in vectors but lacks a key feature such as labels of forces with two subscripts or vectors are not drawn from single point, or axes are missing.	The diagram contains no errors and each force is labeled so that it is clearly understood what each force represents.
A6	**Motion Diagram**	No representation is constructed.	Diagram does not show proper motion: either lengths of arrows (both velocity and velocity change) are incorrect or missing and or spacing of dots are incorrect.	Diagram has correct spacing of the dots but us missing velocity arrows or velocity change arrows.	The diagram contains no errors and it clearly describes the motion of the object. Dots, velocity arrows and velocity change arrows are correct.

A7	**Sketch**	No representation is constructed.	Sketch is drawn but it is incomplete with no physical quantities labeled, or important information is missing, or it contains wrong information, or coordinate axes are missing.	Sketch has no incorrect information but has either no or very few labels of given quantities. Subscripts are missing or inconsistent. Majority of key items are drawn.	Sketch contains all key items with correct labeling of all physical quantities have consistent subscripts; axes are drawn and labeled correctly.
A8	**Energy bar chart**	No representation is constructed.	Bar chart is either missing energy values, bars drawn do not show the conservation of energy or are drawn in the wrong places. Bars could also be labeled incorrectly. The system is not identified.	Bar chart has the energy bars drawn correctly, but some labels are missing or the system is not identified. The bar chart matches the process described with some other representation.	Bar chart is properly labeled and has energy bars of appropriate magnitudes. The system is clearly identified.
A9	**Mathematical**	No representation is constructed.	Mathematical representation lacks the algebraic part (the student plugged the numbers right away) has the wrong concepts being applied, signs are incorrect, or progression is unclear. The first part should be applied when it is appropriate.	No error is found in the reasoning, however they may not have fully completed steps to solve problem or one needs effort to comprehend the progression. No evaluation of the math in the problem is present.	Mathematical representation contains no errors and it is easy to see progression of the first step to the last step in solving the equation. The solver evaluated the mathematical representation.
A10	**Ray diagram**	No representation is constructed.	The rays that are drawn in the representation do not follow the correct paths. Object or image may be located at wrong position.	Diagram is missing key features but contains no errors. One example could be the object is drawn with the correct lens/mirror but rays are not drawn to show image. Or the rays are too far from the main axis to have a small-angle approximation. Or the diagram is drawn without a ruler.	Diagram has object and image located in the correct spot with the proper labels. Rays are correctly drawn with arrows and contain at least two rays. The ruler was used to draw the images.
A11	**Graph**	No graph is present.	A graph is present but the axes are not labeled. There is no scale on the axes. The data points are connected.	The graph is present and axes are labeled but the axes do not correspond to the independent and dependent variable or the scale is not accurate. The data points are not connected but there is no trendline.	The graph has correctly labeled axes, independent variable is along the horizontal axis and the scale is accurate. The trendline is correct.

Ability to design and conduct an observational experiment

RUBRIC B: Ability to design & conduct an observational experiment					
	Scientific Ability	Missing	Inadequate	Needs improvement	Adequate
B1	**Is able to identify the phenomenon to be investigated**	No phenomenon is mentioned.	The description of the phenomenon to be investigated is confusing, or it is not the phenomena of interest.	The description of the phenomenon is vague or incomplete.	The phenomenon to be investigated is clearly stated.
B2	**Is able to design a reliable experiment that investigates the phenomenon**	The experiment does not investigate the phenomenon.	The experiment may not yield any interesting patterns.	Some important aspects of the phenomenon will not be observable.	The experiment might yield interesting patterns relevant to the investigation of the phenomenon.
B3	**Is able to decide what physical quantities are to be measured and identify independent and dependent variables**	The physical quantities are irrelevant.	Only some of physical quantities are relevant.	The physical quantities are relevant. However, independent and dependent variables are not identified.	The physical quantities are relevant and independent and dependent variables are identified.
B4	**Is able to describe how to use available equipment to make measurements**	At least one of the chosen measurements cannot be made with the available equipment.	All chosen measurements can be made, but no details are given about how it is done.	All chosen measurements can be made, but the details of how it is done are vague or incomplete.	All chosen measurements can be made and all details of how it is done are clearly provided.
B5	**Is able to describe what is observed without trying to explain, both in words and by means of a picture of the experimental setup.**	No description is mentioned.	A description is incomplete. No labeled sketch is present. Or, observations are adjusted to fit expectations.	A description is complete, but mixed up with explanations or pattern. The sketch is present but is difficult to understand.	Clearly describes what happens in the experiments both verbally and with a sketch. Provides other representations when necessary (tables and graphs).
B6	**Is able to identify the shortcomings in an experimental and suggest improvements**	No attempt is made to identify any shortcomings of the experimental.	The shortcomings are described vaguely and no suggestions for improvements are made.	Not all aspects of the design are considered in terms of shortcomings or improvements.	All major shortcomings of the experiment are identified and reasonable suggestions for improvement are made.
B7	**Is able to identify a pattern in the data**	No attempt is made to search for a pattern	The pattern described is irrelevant or inconsistent with the data	The pattern has minor errors or omissions. Terms proportional are used without clarity- is the proportionality linear, quadratic, etc.	The patterns represents the relevant trend in the data. When possible, the trend is described in words.
B8	**Is able to represent a pattern mathematically (if applicable)**	No attempt is made to represent a pattern mathematically	The mathematical expression does not represent the trend.	No analysis of how well the expression agrees with the data is included, or some features of the pattern are missing.	The expression represents the trend completely and an analysis of how well it agrees with the data is included.
B9	**Is able to devise an explanation for an observed pattern**	No attempt is made to explain the observed pattern.	An explanation is vague, not testable, or contradicts the pattern.	An explanation contradicts previous knowledge or the reasoning is flawed.	A reasonable explanation is made. It is testable and it explains the observed pattern.

1. an ability to represent knowledge in multiple ways;
2. an ability to design experiments to investigate new phenomena, test hypotheses and solve experimental problems;
3. an ability to collect and analyze experimental data;
4. an ability to devise and test relationships and explanations;
5. an ability to evaluate reasoning and experimental design;
6. an ability to communicate.

- Ability to represent information in multiple ways
- Ability to design and conduct an observational experiment
- Ability to design & conduct an experiment to test an idea/hypothesis/explanation or mathematical relation
- Ability to design & conduct an application experiment
- Ability to communicate scientific ideas
- Ability to collect and analyze experimental data
- Ability to evaluate models, equations, solutions, and claims