# Learning Progression

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# *Introduction*

In last years ***Learning Progressions (LPs***) have been increasingly used by researchers in science education to describe *how students develop their understanding of a given concept across school levels*.

(Duncan & Hmelo-Silver., 2009; Smith, Wiser, Anderson, & Krajcik, 2006; Stevens, Delgado & Krajcik, 2010; Wilson & Bertenthal, 2006).

# *Introduction*

Despite other countries, in Italy Science Education Research is not explicitly involved in educational reforms

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the reference to research results in general and to the use of learning progression in curricula design are less explicit.

# *Introduction*

In the Italian National Indications framework, the curricula of scientific disciplines (Science, Physics and Mathematics) are not organized around "big ideas", and no learning path for students' knowledge is explicitly cited.

Anyway when looking at the National Indications it is possible to recognize that these implicitly assumes a progression from qualitative explanations towards more quantitative models of the natural phenomena towards a more complex one.

# Introduction

LPs can:

- be useful means to improve teaching practices at different school levels;

- play a key role in order to reform and build coherent curricula and to develop instructional educational materials.

# *Definition of LP*

*"descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as children learn about and investigate a topic over a broad span of time"* (NRC, 2007).

# *Definition of LP*

LPs are based on a developmental view of learning:

How students **learn** a given **science content**

*upper anchor:* scientifically correct idea.

.....

....

*Level 2*

*Level 1*

*Lower anchor:* intuitive ideas

progress through subsequent levels of more sophisticated understanding

(Driver, 1994; Posner et al., 1982)

# *LPs application*

Kobrin et al. (2015) described an approach to understand the structure, content, usability, and validity of learning progressions.

In particular they identify five area of science education interested by learning progressions approach:

- Standards Development
- Curriculum Development
- Large-Scale Summative Assessment
- Formative Assessment and Instruction
- Teacher Development

# *Big Ideas*

LPs are usually built around "***big ideas***" in science, i. e. "core" concepts.

(Corcoran, Mosher & Rogat, 2009)

Le Big Ideas sono sono concetti «fondamentali» che aiutano gli studenti a:

- connettere diversi fenomeni, leggi empiriche e modelli esplicativi
- riflettere sulle conoscenza e le pratiche degli scienziati
- sviluppare attitudini ed idee basate sui modelli dei fenomeni dei sistemi naturali
- essere consapevoli del valore culturale della Scienza

# *Big Ideas*

Discussione a coppie (con mentimeter): quali sono secondo voi esempi di big ideas? Elencatene quante più ve ne vengono in mente

https://www.mentimeter.com/s/3904ffe819d2ab35b97c47f8164f71e6/7d159ca56906

# *Esempi di Big Ideas*

- Proprietà della materia
- Energia
- Onde
- Moto e forza
- Moti della Terra

- Azione a distanza
- Composizione della Terra e suo clima
- Informazione genetica e sua trasmissione
- Evoluzione e diversità degli organismi, esseri viventi
- Meccanica quantistica e materia

# *Developing and validating LP*

Previously research results, students’ answers to questionnaire or interviews, well known misconceptions are used to hypothesise a first version of the LP (HLP)

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Design a measurement instrument (usually a questionnaire or an interview)

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Test the alignment between LP and actual students’ achievements

↓

If the alignment is satisfying

No → Revise HLP → (back to: Design a measurement instrument)

Yes ↓

Validate/reviserd version of LP (RLP)

# *Developing and validating LP*

To test the alignment between students' achievements and LP two methods are used:

- ***Qualitative approach*** data from interviews and open tasks

(e,g Krajicik et al., 2010; Shea & Duncan, 2013).

- ***Quantitative approach*** scoring students' answers to a multiple-choice questionnaire

(e,g, Hadelfedt et al., 2016; Neumann, Viering, Boone & Fischer, 2013)

# *LP and big ideas*

Researchers have developed many LPs around b*ig ideas* from different scientific area:

- **Energy** (Neumann, Viering, Boone & Fischer, 2013)
- **Matter** (Stevens, Delgado & Krajcik, 2010; Hadenfeldt, et al. 2016)
- **Force and motion** (Alonzo & Steedle, 2009)
- **Water** (Gunckel, Covitt, Salinas, & Anderson, 2012)
- **Modern genetics** (Todd & Romine, 2016)
- **Stellar Structure and evolution** (Colantonio et al. 2018)

# *LPs and astronomical topics*

Recently, there has been an increasing interest of science education research community towards students' difficulties in understanding astronomical topics and there have been some attempts to extend LPs approach to astronomical core concepts:

(Plummer, 2014; Plummer 2009; Sneider, Bar & Cavanagh, 2011)

- **Solar System formation** (Plummer et al. 2015)
- **Celestial motion** (Plummer & Maynard, 2014; Plummer & Krajcik 2010)

No LP has yet been validated across all school levels from, middle school up to post graduate.

# *Example: Seasons*

TABLE II. – *Revised learning progression.*

| Phenomenon | Progression level | Progress indicator: The students know that |
|---|---|---|
| Season | 1 | Seasons are due to Earth's axis inclination w.r.t. the orbit's plane |
| | 2 | Level 1 + the inclination of solar rays changes during the year |
| | 3 | Level 2 + constant direction in space of Earth's axis |
| | Upper anchor | Level 3 + revolution of Earth around the Sun and constant tilt of Earth's axis w.r.t. the orbit's plane |

(Galano, 2015)

# Example: Stellar Structure and Evolution

TABLE II. Initial LP about SSE (LP1).

| Level | Hydrostatic equilibrium | Composition and aggregation state | Functioning and evolution |
|---|---|---|---|
| Upper Anchor | Equilibrium of a star is justified by balancing gravitational force with radiative pressure forces or other physical quantities related to nuclear reactions on a star's element of volume | Stars are considered as celestial objects made mainly of H and He and described by specific physical quantities (mass, temperature, radius). Spherical shape is recognized and justified. Internal structure and state of aggregation are recognized and justified | The role of gravity as a central force in stars' formation is correctly recognized. Stars' functioning is justified in terms of nuclear reactions and heat transfer mechanisms. Life and death stages of a star are related to the star's initial mass |
| Level 2 | Star equilibrium is justified by an incomplete or incorrect balancing of forces, or other quantities (e.g. energy) are incorrectly involved | Stars are considered as celestial objects made mainly of H and He and described by specific physical quantities (mass, temperature, radius). Spherical shape is recognized but not justified. Internal structure and state of aggregation are not recognized or correctly indicated. | Gravity is recognized as attractive force but its role in star's birth is unclear. Stars' functioning is justified in terms of nuclear reactions. The role of mass in subsequent stages of the star's life, including death, is unclear |
| Level 1 | Star equilibrium is recognized but no justification in terms of forces is given | Stars are considered as celestial objects made of gases, in particular H and He. Spherical shape is not recognized or incorrectly justified. Internal structure and state of aggregation are not recognized or correctly indicated. | Star's formation is attributed to a generic attraction. The role of nuclear reactions in the functioning of a star is recognized but their role in the stages of the star's life is unclear or incorrect. Final stages of star's life are incorrectly described |
| Lower Anchor | A star is considered as a system not in equilibrium [33] | Stars are considered as solid celestial objects made of dust, gases or pieces of planets, or seen as the result of collisions of other celestial bodies [15]. H and He can be recognized as components, but not the main ones. Shape is not recognized as regular [18] | Gravity is not recognized in the formation process [33]. Nuclear reactions are recognized as important for stars' functioning without explanation or they are confused with "burning" chemical reactions [15]. Final stages of star's life are incorrectly described [33] |

# *Example: Stellar Structure and Evolution*

**Dimensions**

Initial LP about SSE (LP1)

| Hydrostatic equilibrium | Composition and aggregation state | Functioning and evolution |
|---|---|---|
| Equilibrium of a star is justified by balancing gravitational force with | Stars are considered as celestial objects made mainly of H and He and described by specific physical | The role of gravity as a central force i stars' formation is correctly recognized. Stars' functioning is |

# *Example: Stellar Structure and Evolution*

## Hydrostatic Equilibrium

*Hypothesize LP*

| | |
|---|---|
| Upper Anchor | Equilibrium of a star is justified by balancing gravitational force with radiative pressure forces or other physical quantities related to nuclear reactions on a star's element of volume |
| Level 2 | Star equilibrium is justified by an incomplete or incorrect balancing of forces, or other quantities (e.g. energy) are incorrectly involved |
| Level 1 | Star equilibrium is recognized but no justification in terms of forces is given |
| Lower Anchor | A star is considered as a system not in equilibrium [33] |

# Example: Stellar Structure and Evolution

## Hydrostatic Equilibrium

*Final LP*

Upper Anchor — Equilibrium of a star is justified by balancing gravitational force with radiative pressure forces … o … n a … olume

Level 4 — Role of thermodynamics in stars' equilibrium is correctly recognized, but mechanism that relates balancing pressure forces to nuclear reactions is partially understood or unclear

Level 3 — Unbalancing of gravitational force is correctly recognized but no further mechanism to explain stars' equilibrium is provided

Level 2 — … ing of … quantities … e … lved

Level 1 — Star equilibrium is recognized but no … rms of

Lower Anchor — A star is considered as a system not in equilibrium [33]

# Conclusion

Why Learning Progressions? They..

- improve teaching practices at different school levels
- reform and build coherent curricula
- develop instructional educational materials
- help teachers how students develop their understanding of a given concept

# Grazie per l'attenzione

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