COMMENT INNOVER EN PÉDAGOGIE SCIENTIFIQUE EN IDENTIFIANT LES CONCEPTIONS PRÉALABLES (INCOMPLÈTES OU ERRONÉES) DES ÉTUDIANTS AFIN D'ÉLABORER DES INTERVENTIONS INSPIRÉES DE CHACUNE DES FAMILLES DE MODÈLES DU CHANGEMENT CONCEPTUEL?

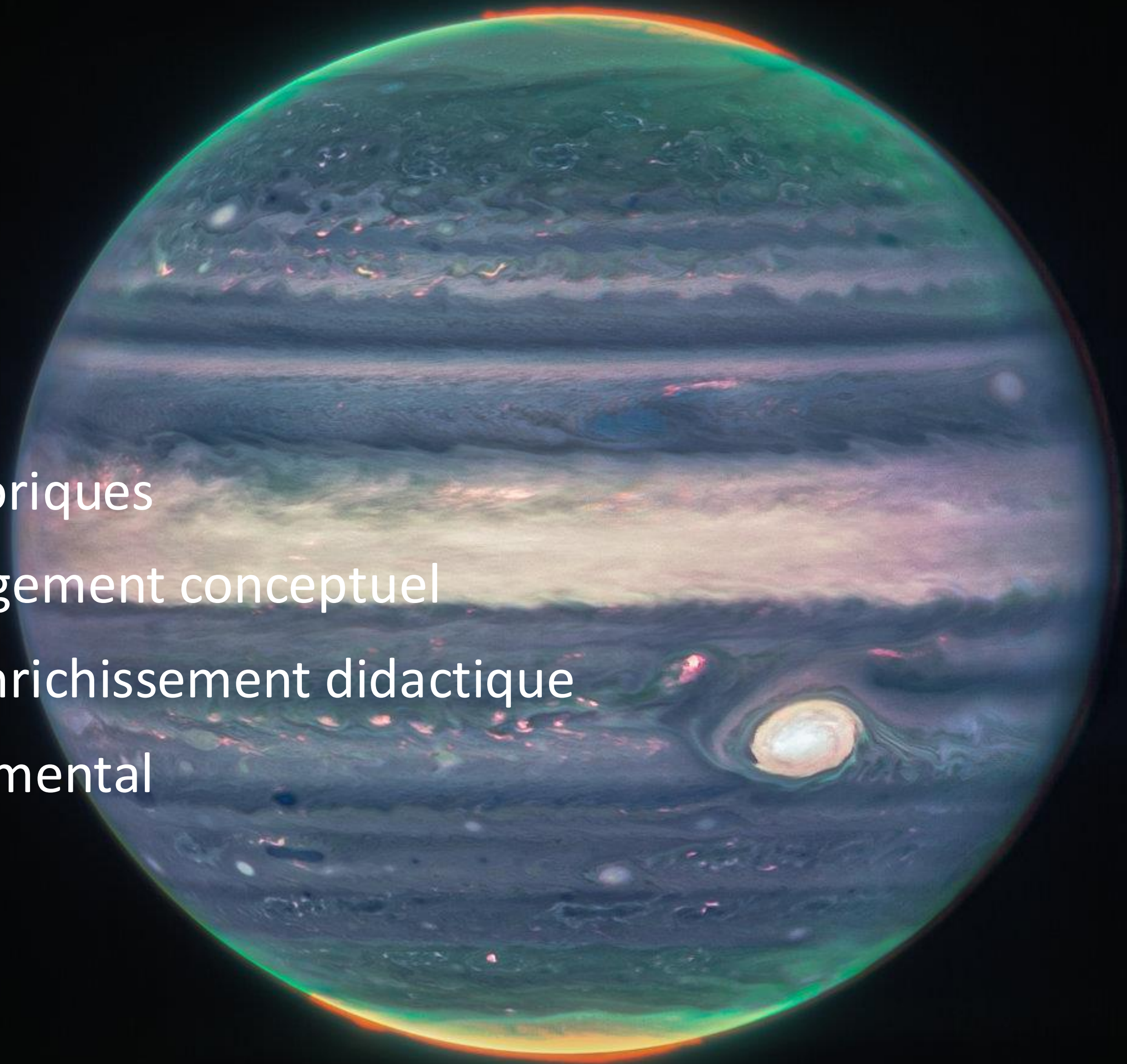
MARTIN RIOPEL

DÉCEMBRE 2024

RÉSUMÉ

Cette conférence explore les moyens d'innover en pédagogie scientifique en considérant les conceptions préalables des étudiants, souvent incomplètes ou erronées, comme point de départ pour l'apprentissage. L'objectif est ensuite de concevoir des interventions pédagogiques basées sur les principaux modèles du changement conceptuel permettant de comprendre comment les étudiants modifient ou enrichissent leurs représentations initiales pour construire des savoirs plus précis et opérationnels. En combinant des approches théoriques et pratiques, la présentation propose des outils pour identifier ces conceptions et les utiliser pour adapter les enseignements. Des exemples d'interventions s'appuient sur des stratégies diversifiées issues des principales familles de modèles du changement conceptuel, et susceptibles de favoriser des apprentissages profonds et durables. Enfin, des protocoles expérimentaux sont proposés pour rendre compte de l'évolution de ces conceptions et de la persistance des apprentissages correspondants.

PLAN



- Introduction
- Précurseurs historiques
- Théorie du changement conceptuel
- Propositions d’enrichissement didactique
- Protocole expérimental
- Conclusion

INTRODUCTION

À PROPOS DE LA REMARQUE DE PATRICE POTVIN

QUESTION GÉNÉRALE?

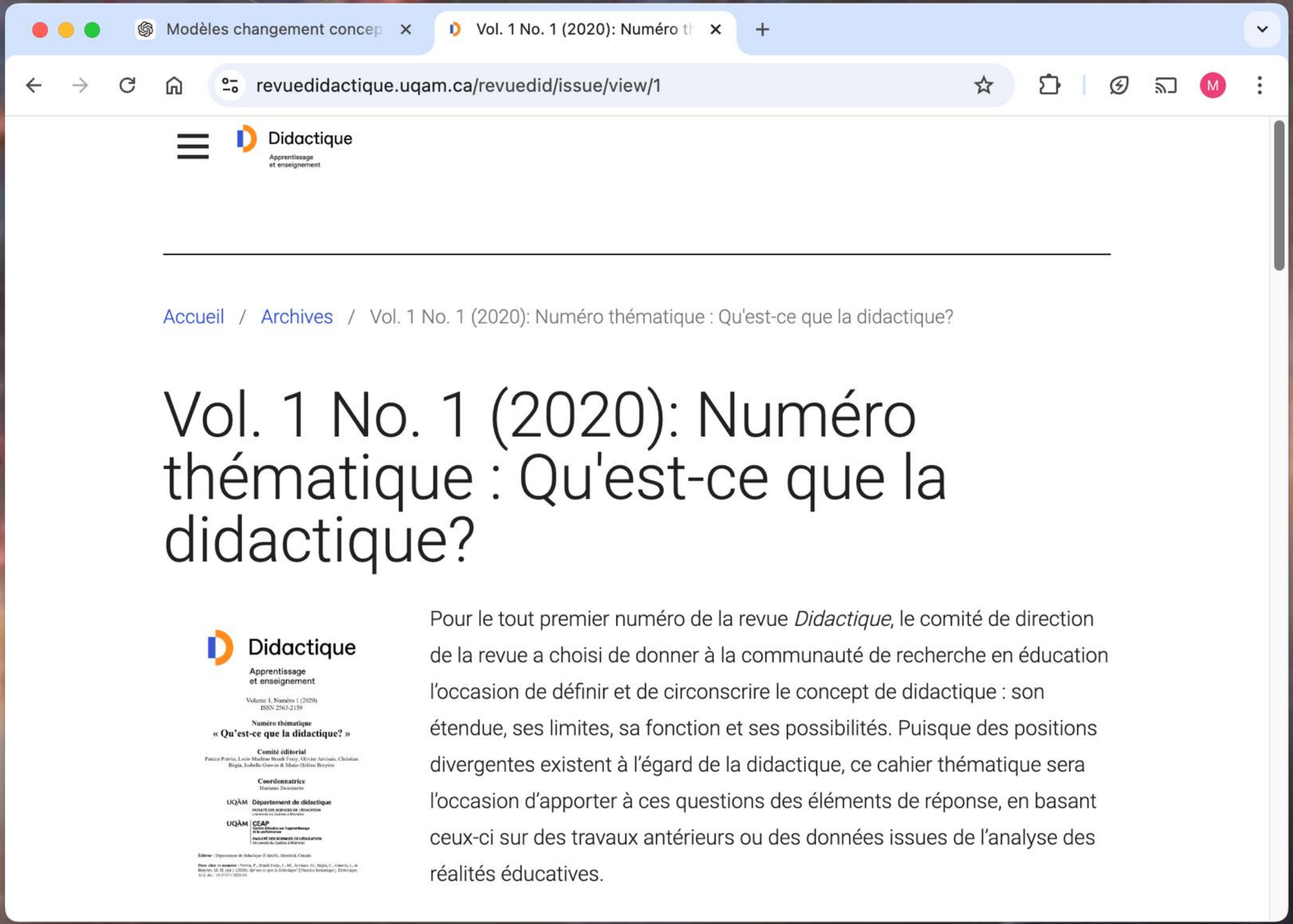
Comment enrichir la dimension didactique
d’un projet de recherche en éducation scientifique?

1 Insatisfaction → Pourquoi?

2. Intelligibilité → Aucune connaissance préalable

3. Plausibilité → Est-ce que vous pourriez le faire?

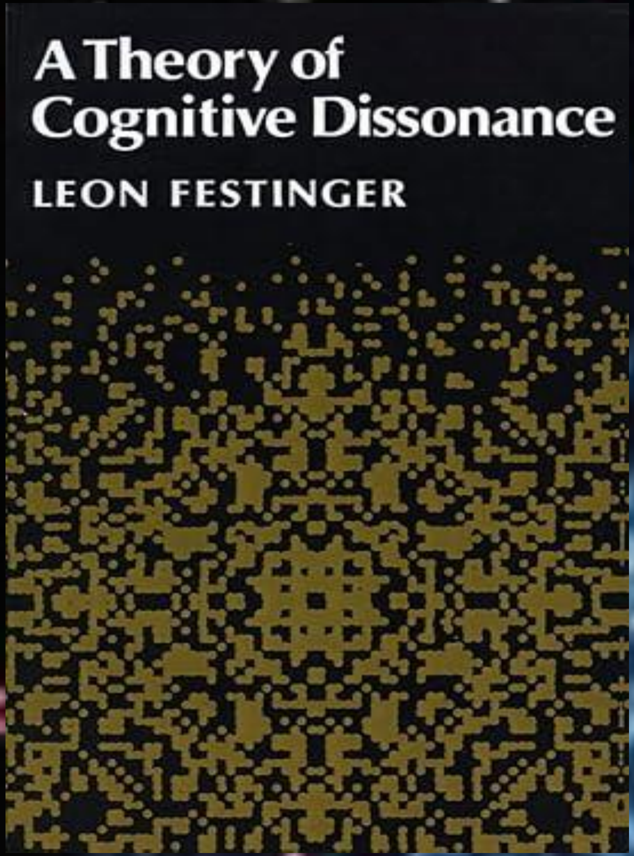
4. Fécondité → Base pour exploration + contribution

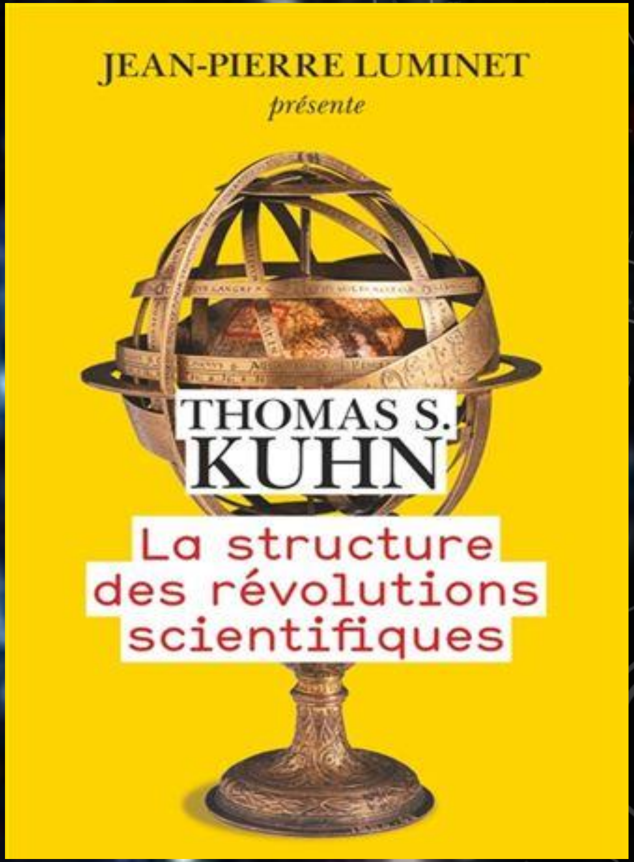


https://revuedidactique.uqam.ca/revuedid/issue/view/1

PRÉCURSEURS HISTORIQUES


Piaget, Jean
La Construction du réel chez l'enfant
Delachaux & Niestlé


A Theory of Cognitive Dissonance
LEON FESTINGER


JEAN-PIERRE LUMINET
présente
THOMAS S. KUHN
La structure des révolutions scientifiques

PIAGET (1937) – LA NAISSANCE DE L'INTELLIGENCE CHEZ L'ENFANT

1. Les mécanismes d'assimilation et d'accommodation

- **Assimilation** : Intégration de nouvelles informations dans des schémas existants.
- **Accommodation** : Modification ou création de nouveaux schémas en réponse à des informations qui ne peuvent être intégrées dans les schémas existants.

Ces concepts sont similaires aux idées centrales de la théorie du changement conceptuel, où l'apprentissage implique une restructuration des concepts pour intégrer des connaissances conflictuelles ou nouvelles.

2. Le rôle du conflit cognitif

Piaget a mis l'accent sur le rôle du **déséquilibre** ou du **conflit cognitif** dans le développement. Lorsque les schémas d'un individu ne peuvent expliquer une nouvelle expérience, cela crée un déséquilibre qui motive une réorganisation des schémas.

Cette idée se retrouve dans la théorie du changement conceptuel, où les apprenants révisent leurs conceptions initiales face à des preuves incompatibles ou contradictoires.

FESTINGER (1957) – A THEORY OF COGNITIVE DISSONANCE

- **Conflit cognitif** : Les deux théories reconnaissent qu'un déséquilibre cognitif (dissonance ou conflit) est une condition essentielle pour le changement. Dans la théorie du changement conceptuel, ce conflit provient d'une contradiction entre une conception initiale et des observations ou informations nouvelles.

- **Résolution par réorganisation** : Festinger explique que la dissonance est réduite en modifiant soit les croyances, soit la perception de la réalité. De la même manière, la théorie du changement conceptuel montre que l'apprentissage implique souvent une restructuration des connaissances existantes pour les rendre compatibles avec de nouvelles données.

KUHN (1962) – LA STRUCTURE DES RÉVOLUTIONS SCIENTIFIQUES

Comment se produit le progrès scientifique ?

- Contrairement à l'idée classique de progrès linéaire et cumulatif (chaque découverte s'ajoutant aux précédentes), Kuhn questionne si le progrès scientifique est en réalité marqué par des ruptures profondes, appelées révolutions scientifiques, où un paradigme est remplacé par un autre.

Le progrès scientifique mène-t-il à une vérité absolue ?

- Kuhn remet en question l'idée que la science se rapproche progressivement d'une vérité ultime sur le monde. Il se demande si la science est plutôt un processus de reconstruction constante des modèles de compréhension.

Green, E. D. (2016). What are the most-cited publications in the social sciences (according to google scholar)? *Impact of social sciences blog*.

Book	Author	Date*	Discipline	Citations
The Structure of Scientific Revolutions	Thomas Kuhn	1962	Philosophy	81,311
Diffusion of Innovations	Everett Rogers	1962	Sociology	72,780
Pedagogy of the Oppressed	Paulo Freire	1968/1970	Education	72,359
Competitive Strategy	Michael E Porter	1980	Economics	65,406
Imagined Communities	Benedict Anderson	1983	Political Science	64,167
Mind in Society	LS Vygotsky	1978	Psychology	63,809
Discipline and Punish	Michel Foucault	1976/1977	Philosophy	60,700
A Theory of Justice	John Rawls	1971	Political Science	58,594
Social Foundations of Thought and Action	Albert Bandura	1986	Psychology	55, 324
The Interpretation of Cultures	Clifford Geertz	1973	Anthropology	48,984
The History of Sexuality (3 Volumes)	Michel Foucault	1978-1986	Philosophy	47,955
Situated Learning: Legitimate Peripheral Participation	Jean Lave and Etienne Wenger	1991	Education	47,627
The Fifth Discipline	Peter M Senge	1992	Management	43,876
Institutions, Institutional Change and Economic Performance	Douglass North	1990	Economics	43,411
Culture's Consequences	Geert Hofstede	1980	Management	42,144
The Presentation of the Self in Everyday Life	Erving Goffman	1959	Sociology	40,573
Das Kapital	Karl Marx	1867-1894	Economics	40,237
Distinction: A Social Critique of the Judgement of Taste	Pierre Bourdieu	1984	Sociology	39,729
The Social Construction of Reality	Peter Berger and Thomas Luckmann	1966	Sociology	38,845
Metaphors We Live By	George Lakoff and Mark Johnson	1980	Linguistics	38,723

THÉORIE DU CHANGEMENT CONCEPTUEL

SCIENCE NORMALE – CRISE – RÉVOLUTION SCIENTIFIQUE

CONCEPTION PRÉALABLES – CONFLIT COGNITIF – CHANGEMENT CONCEPTUEL

LE PREMIER MODÈLE DE CHANGEMENT CONCEPTUEL

- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science education*, *66*(2), 211-227.

Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change*

GEORGE J. POSNER, KENNETH A. STRIKE, PETER W. HEWSON, and WILLIAM A. GERTZOG
Department of Education, Cornell University, Ithaca, New York 14853

It has become a commonplace belief that learning is the result of the interaction between what the student is taught and his current ideas or concepts.[1] This is by no means a new view of learning. Its roots can be traced back to early Gestalt psychologists. However, Piaget's (1929, 1930) early studies of children's explanations of natural phenomena and his more recent studies of causality (Piaget, 1974) have perhaps had the greatest impact on the study of the interpretive frameworks students bring to learning situations.

This research has led to the widespread study of students' scientific misconceptions.[2] From these studies and, particularly, from recent work by researchers such as Viennot (1979) and Driver (1973), we have developed a more detailed understanding of some of these misconceptions and, more importantly, why they are so "highly robust" and typically outlive teaching which contradicts them (Viennot, 1979, p. 205).

But identifying misconceptions or, more broadly speaking, "alternative frameworks"

Le modèle de changement conceptuel de Posner (1982) repose sur l'idée que l'apprentissage, en particulier dans les sciences, nécessite parfois un **changement radical** des concepts plutôt qu'une simple accumulation d'informations. Ce processus est inspiré des idées de Thomas Kuhn sur les révolutions scientifiques.

QUATRE CONDITIONS NÉCESSAIRES

INSATISFACTION	L'apprenant doit percevoir que ses idées actuelles sont inadéquates ou inconsistantes face à de nouvelles données ou situations.
INTELLIGIBILITÉ	Le nouvel ensemble d'idées ou de conceptions proposé doit être intelligible et accessible pour l'apprenant.
PLAUSIBILITÉ	Le nouveau concept doit apparaître plausible, cohérent, et capable de résoudre les problèmes que l'ancien concept ne pouvait pas expliquer.
FÉCONDITÉ	Le concept doit offrir des opportunités d'exploration et d'application, montrant son utilité dans des contextes variés.

PROPOSITIONS D'ENRICHISSEMENT DIDACTIQUE

Identifier des conceptions préalables → Comparer des interventions conflictuelles → Expliquer des changements conceptuels

IDENTIFIER DES CONCEPTIONS PRÉALABLES

INCOMPLÈTES OU ERRONÉES ET PARFOIS RÉSISTANTES

LE PREMIER INVENTAIRE DE CONCEPTIONS (QUESTIONNAIRE À CHOIX MULTIPLES)

- Abou Halloun, I., & Hestenes, D. (1985). Common sense concepts about motion. *American journal of physics*, *53*(11), 1056-1065.
- Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The physics teacher*, *30*(3), 141-158.

Common sense concepts about motion

Ibrahim Abou Halloun* and David Hestenes
Department of Physics, Arizona State University, Tempe, Arizona 85287
**Now at The Lebanese University*

(Received 1 August 1984; accepted for publication 28 January 1985)

Common sense beliefs of college students about motion and its causes are surveyed and analyzed. A taxonomy of common sense concepts which conflict with Newtonian theory is developed as a guide to instruction.

I. INTRODUCTION

In the preceding article[1], we established a need for physics instruction which takes the initial *common sense* (CS) beliefs of students into account. Other investigators[2-9] have identified specific CS beliefs that conflict with Newtonian theory and so interfere with physics instruction. But a more systematic and complete taxonomy of CS beliefs is needed for efficient instructional design. The purpose of this article is to survey and categorize CS concepts of motion which should be taken into account in mechanics instruction. We are aiming for a comprehensive picture of CS concepts which includes the insights of previous investigators as well as some observations of our own.

In this article we will not attack the difficult problem of designing instruction to accommodate CS preconceptions. But let us note that CS concepts cannot be avoided in physics instruction, for common sense is a codification of experience providing meaning to our natural language. Discourse on physics would be impossible without it. Indeed, physics and science in general can be regarded as an extension and modification of common sense. Conventional physics instruction frequently appeals tacitly to common sense knowledge, but students have trouble when that knowledge is faulty. It is difficult for students to determine

Published in: *The Physics Teacher*, Vol. **30**, March 1992, 141-158

Force Concept Inventory

David Hestenes, Malcolm Wells, and Gregg Swackhamer

Every student begins physics with a well-established system of commonsense beliefs about how the physical world works derived from years of personal experience. Over the last decade, physics education research has established that these beliefs play a dominant role in introductory physics. Instruction that does not take them into account is almost totally ineffective, at least for the majority of students.

Specifically, it has been established that[1] (1) commonsense beliefs about motion and force are incompatible with Newtonian concepts in most respects, (2) conventional physics instruction produces little change in these beliefs, and (3) this result is independent of the instructor and the mode of instruction. The implications could not be more serious. Since the students have evidently not learned the most basic Newtonian concepts, they must have failed to comprehend most of the material in the course. They have been forced to cope with the subject by rote memorization of isolated fragments and by carrying out meaningless tasks. No wonder so many are repelled! The few who are successful have become so by their own devices, the course and the teacher having supplied only the opportunity and perhaps inspiration.

Table I. Newtonian Concepts in the Inventory.

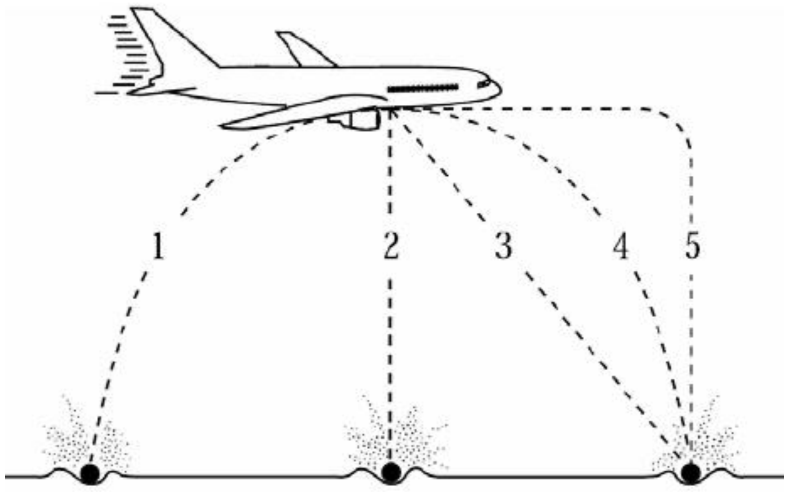
	Inventory Item
0. Kinematics	
Velocity discriminated from position	20E
Acceleration discriminated from velocity	21D
Constant acceleration entails	
parabolic orbit	23D, 24E
changing speed	25B
Vector addition of velocities	(7E)
I. First Law	
with no force	4B, (6B), 10B
velocity direction constant	26B
speed constant	8A, 27 A

Table II. A Taxonomy of Misconceptions Probed by the Inventory. Presence of the misconceptions is suggested by selection of the corresponding Inventory Item.

	Inventory Item
0. Kinematics	
Kl. position-velocity undiscriminated	208,C,D
K2. velocity-acceleration undiscriminated	20A; 21B,C
K3. nonvectorial velocity composition	7C
1. Impetus	
I1. impetus supplied by "hit"	9B,C; 22B,C,E; 29D
I2. loss/recovery of original impetus	4D; 6C,E; 24A; 26A,D,E
I3. impetus dissipation	5A,8,C; 8C; 16C,D; 23E; 27C,E; 29B
I4. gradual/delayed impetus build-up	6D; 8B,D; 24D; 29E
I5. circular impetus	4A,D; 10A
2. Active Force	
AFl. only active agents exert forces	11B; 12B; 13D; 14D; 15A,B; l8D; 22A
AF2. motion implies active force	29A
AF3. no motion implies no force	12E
AF4. velocity proportional to applied force	25A; 28A
AF5. acceleration implies increasing force	17B
AF6. force causes acceleration to terminal velocity	17A; 25D
AF7. active force wears out	25C,E
3. Action/Reaction Pairs	
AR1. greater mass implies greater force	2A,D; 11D; 13B; 14B
AR2. most active agent produces greatest force	13C; 11D; 14C
4. Concatenation of Influences	
CI1.largest force determines motion	l8A,E; 19A
CI2. force compromise determines motion	4C, 10D; 16A; 19C,D; 23C; 24C
CI3. last force to act determines motion	6A; 7B; 24B; 26C
5. Other Influences on Motion	
CF. Centrifugal force	4C,D,E; l0C,D,E
Ob. Obstacles exert no force	2C; 9A,B; 12A; 13E; 14E
Resistance	
R1. mass makes things stop	29A,8; 23A,B?
R2. motion when force overcomes resistance	28B,D
R3. resistance opposes force/impetus	28E
Gravity	
G1. air pressure-assisted gravity	9A; 12C; 17E; 18E
G2. gravity intrinsic to mass	5E; 9E; 17D
G3. heavier objects fall faster	1A; 3B,D
G4. gravity increases as objects fall	5B; 17B

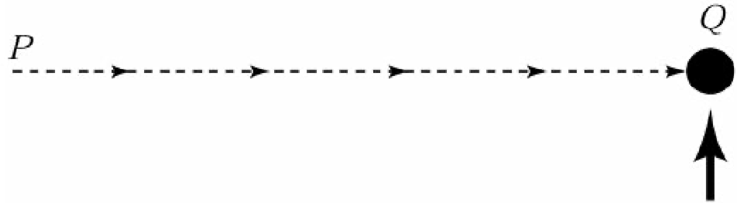
14. Une boule de quilles tombe accidentellement de la soute à bagages d'un avion volant horizontalement. D'après une personne au sol regardant l'avion, laquelle des trajectoires 1-5 représente le mieux la trajectoire de la boule de quilles après qu'elle ait quitté l'avion?

- ◯ 1.
- ◯ 2.
- ◯ 3.
- ◯ 4.
- ◯ 5.



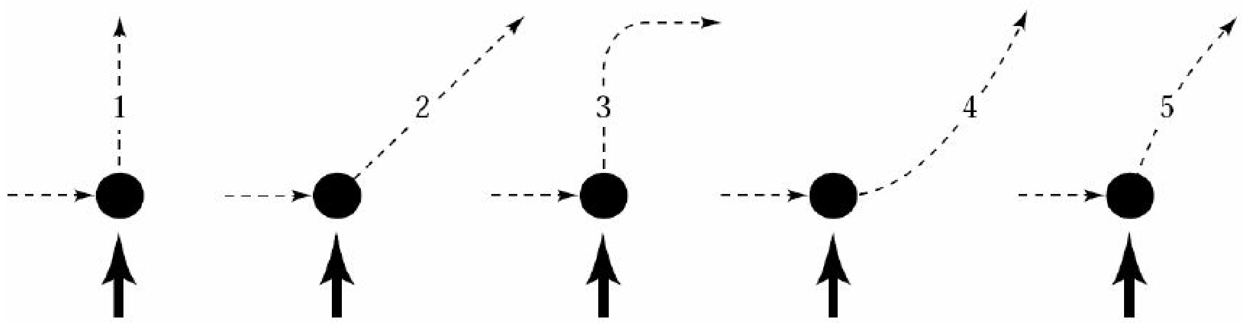
Utilisez l’énoncé et la figure ci-dessous pour répondre aux quatre prochaines questions (8-11).

La figure illustre une rondelle de hockey vue du dessus qui glisse à vitesse constante v_o, en ligne droite du point P au point Q, sur une surface horizontale sans friction. Les forces exercées par l’air sont négligeables. Quand la rondelle atteint le point Q, elle reçoit un rapide coup horizontal orienté dans la direction de la flèche en gras. Si la rondelle avait été au repos au point P, le coup lui aurait donné une vitesse horizontale v_k dans la direction du coup.



8. Laquelle des 5 trajectoires ci-dessous la rondelle suivra-t-elle après avoir reçu le coup?

- ◯ 1.
- ◯ 2.
- ◯ 3.
- ◯ 4.
- ◯ 5.



UN EXEMPLE PLUS RÉCENT (QUESTIONS OUVERTES ET ENTREVUES)

- Parker, M., Hedgeland, H., Braithwaite, N. S. J., & Jordan, S. E. (2024). GRCI: An investigation into the feasibility of a General Relativity Concept Inventory. *European Journal of Science and Mathematics Education*, *12*(4), 489-501.

European Journal of Science and Mathematics Education, 2024, **12**(4), 489-501
ISSN: 2301-251X (Online)

OPEN ACCESS

Research Article

GRCI: An investigation into the feasibility of a General Relativity Concept Inventory

Mark A. J. Parker [1*]
0000-0002-1984-9624

Holly Hedgeland [2]
0000-0003-3703-7942

Nicholas St. J. Braithwaite [3]
0000-0002-1586-3736

Sally E. Jordan [1]
0000-0003-0770-1443

[1] School of Physical Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UNITED KINGDOM
[2] Clare Hall, University of Cambridge, Herschel Road, Cambridge, CB3 9AL, UNITED KINGDOM
[3] Faculty of Science, Technology, Engineering & Mathematics, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UNITED KINGDOM
[*] Corresponding author: mark.parker@open.ac.uk

Citation: Parker, M. A. J., Hedgeland, H., Braithwaite, N. St. J., & Jordan, S. E. (2024). GRCI: An investigation into the feasibility of a General Relativity Concept Inventory. *European Journal of Science and Mathematics Education, 12*(4), 489-501.


ESERA 2025 Conference
THE 16TH CONFERENCE OF THE EUROPEAN SCIENCE EDUCATION RESEARCH ASSOCIATION
25-29 AUGUST 2025, COPENHAGEN, DENMARK
JOIN THE NEW ESERA PRELUDE 21-24 AUGUST 2025
254 Days
12 Hours
46 Minutes
22 Seconds

D'AUTRES FORMATS ET MÉTHODES

- Questions d'association
- Questions à deux niveaux (two-tier)
- Questions à trois niveaux (three-tier)
- Temps de réponses
- Imagerie cérébrale

PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH **16,** 020107 (2020)

Development and validation of the moon phases concept inventory for middle school

Pierre Chastenay*

Département de didactique, Université du Québec à Montréal,
CP 8888, succursale Centre-ville, Montréal, Québec H3C 3P8, Canada

Martin Riopel

Département de didactique, Université du Québec à Montréal,
CP 8888, succursale Centre-ville, Montréal, Québec H3C 3P8, Canada

(Received 24 February 2020; accepted 4 June 2020; published 29 July 2020)

We present the development and validation of a new assessment tool, the Moon Phases Concept Inventory for Middle School (MPCI-MS), a concept inventory about the phases of the moon targeting students aged 10 to 14 years old. Items in the questionnaire are based on a careful examination of the concept domain of phases of the moon, ideas and concepts necessary to understand the mechanism of lunar phases, as chosen by a panel of seven professional astronomers. Questions and multiple-choice answers were tested for readability with 5th grade students, tested for reading level, and submitted to a second panel of professional astronomers to check for face and construct validity of the items. The MPCI-MS was tested with $N = 296$ students from grade 5 in elementary school to secondary 2 ($M_{age} = 10.2$ to 14.1). One item about global perspective on lunar phases had to be removed because of poor psychometric properties. The revised MPCI-MS has a post-test Cronbach alpha score of 0.786 and good overall psychometric properties: the mean difficulty index for the MPCI-MS pretest is 0.47, and 0.61 for the post-test; mean point-biserial correlation (post-test) is 0.376. Test-retest without instruction at one-week interval showed high test-retest reliability [$M_{pre} = 13.696$, $M_{post} = 14.523$; $t(45) = 1.315$, $p = 0.192$]. We conclude that the MPCI-MS is a reliable and valid instrument that can discriminate between novices and experts, and can be used to assess 10 to 14 year-old students' learning gains on the topic of lunar phases. The final version of MPCI-MS is a 19-item instrument, including two new questions about eclipses, that takes between 15 and 25 min for students to complete.

DOI: 10.1103/PhysRevPhysEducRes.16.020107

1. **Les images de gauche montrent différentes phases de la Lune. Les noms de ces mêmes phases sont à droite, dans le désordre. À l’aide d’un trait, relie chaque image au nom de la phase correspondante.**

- ☐ Premier quartier
- ☐ Lune gibbeuse décroissante
- ☐ Nouvelle lune
- ☐ Lune décroissante ou dernier croissant

Journal of Education in Science, Environment and Health
Volume 1, Issue 2, 2015 ISSN: 2149-214X

Exploring Secondary Students' Conceptions about Fire Using a Two-Tier, True/False, Easy-to-Use Diagnostic Test

Patrice Potvin*, Yannick Skelling-Desmeules, Ousmane Sy
Université du Québec à Montréal

Abstract

This article describes the design of a misconception diagnostic test about fire-related phenomena. It proposes a new test format in which a certainty-measuring tier has been integrated into each of the true/false response choices. This format is argued to be easier for teachers to use than the increasingly popular three-tier format. First, we review the available literature about misconception diagnostic tests and then literature about fire-related misconceptions. We then describe the design process of the test, which was preceded by an interview phase. We then describe its administration to 221 secondary school students. We finally present, in an explorative and accessible manner, the results that were obtained. These results support the existence of previously recorded misconceptions, but also bring certain nuances to some of their previous interpretations. They also support the hypothesis according to which some misconceptions are presumed to be more widespread than they truly are. Conclusive remarks are formulated about the benefits of the use of our—and other—misconception diagnostic tests.

Keywords: Misconceptions, Diagnostic test, Fire, Certainty.

Introduction

The Use of Misconception Diagnostic Tests

Table 3. Distribution percentage of potential "misconceptual" answers for each statement

Question number	Statement	Correct response	Inaccurate but certain	Inaccurate and uncertain	Does not know	Accurate but uncertain	Accurate and certain	Missing (N)
12	The Sun is a true fire.	F	60	20	5	8	6	4
3	Diamonds can burn.	T	50	22	16	7	4	4
20	Flames go up because they search for oxygen, which is in the air and not in the soil.	F	48	33	8	5	6	5
45	Fire is a gas.	F	45	35	9	3	9	6
11	Lava is a true fire.	F	40	23	6	12	19	5
57	Lighting a match is absolutely necessary to start a wood fire.	F	39	15	1	3	41	6
13	Fireworks are a true fire.	T	38	25	10	18	10	5
77	The tip of the flame is hotter than the base.	T	38	22	20	11	9	7
74	A bigger fire is always hotter.	F	36	25	6	14	19	6
71	Water can extinguish a fire because it neutralizes the flames.	F	35	36	11	7	10	7
48	Friction (like rubbing two rocks together) is absolutely necessary to start a wood fire.	F	32	22	5	12	29	7
23	At its origin, light from fire came from energy that came from the Sun.	T	30	26	28	10	5	7
62	Smoke is a part of the cycle of fire.	F	28	32	21	9	9	8
39	Fire is made of matter.	F	26	34	18	10	12	6
60	Black smoke (instead of whiter smoke) indicates that the fire is more intense.	F	26	29	18	12	14	8
76	The ember is hotter than the flame.	F	26	22	30	14	8	7
72	Water can extinguish a fire because it transforms fire into smoke.	F	24	27	10	14	25	6
2	Metals can burn.	T	24	25	12	23	17	5
65	Smoke contains oxygen.	F	24	21	23	16	16	8

npj | Science of Learning

www.nature.com/npjscilearn

ARTICLE OPEN

An fMRI study of scientists with a Ph.D. in physics confronted with naive ideas in science

Geneviève Allaire-Duquette[1] ✉, Lorie-Marlène Brault Foisy[1], Patrice Potvin[1], Martin Riopel[1], Marilyne Larose[1] and Steve Masson[1] ✉

A central challenge in developing conceptual understanding in science is overcoming naive ideas that contradict the content of science curricula. Neuroimaging studies reveal that high school and university students activate frontal brain areas associated with inhibitory control to overcome naive ideas in science, probably because they persist despite scientific training. However, no neuroimaging study has yet explored how persistent naive ideas in science are. Here, we report brain activations of 25 scientists with a Ph.D. in physics assessing the scientific value of naive ideas in science. Results show that scientists are slower and have lower accuracy when judging the scientific value of naive ideas compared to matched control ideas. fMRI data reveals that a network of frontal brain regions is more activated when judging naive ideas. Results suggest that naive ideas are likely to persist, even after completing a Ph.D. Advanced experts may still rely on high order executive functions like inhibitory control to overcome naive ideas when the context requires it.

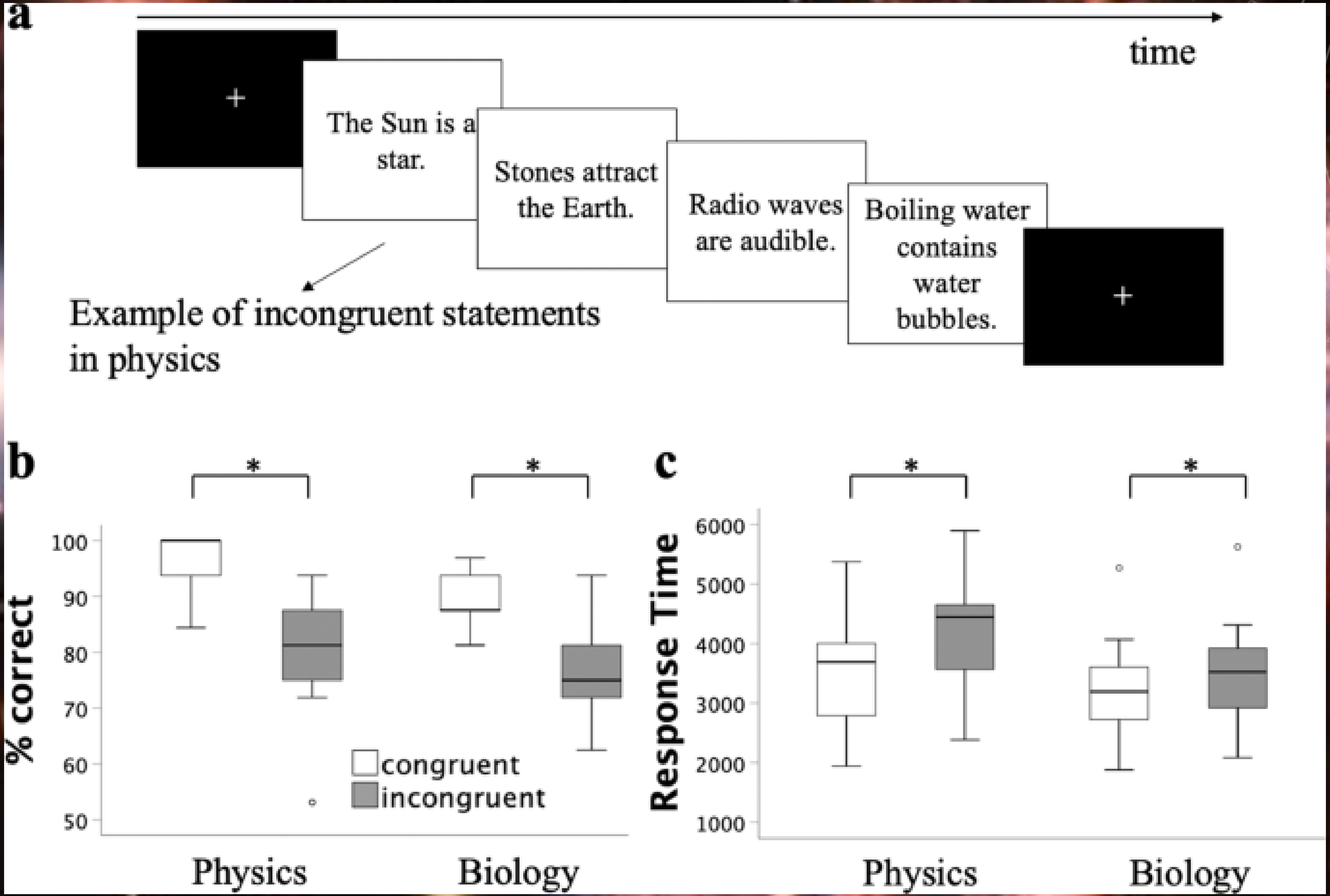
npj Science of Learning (2021)6:11 ; https://doi.org/10.1038/s41539-021-00091-x

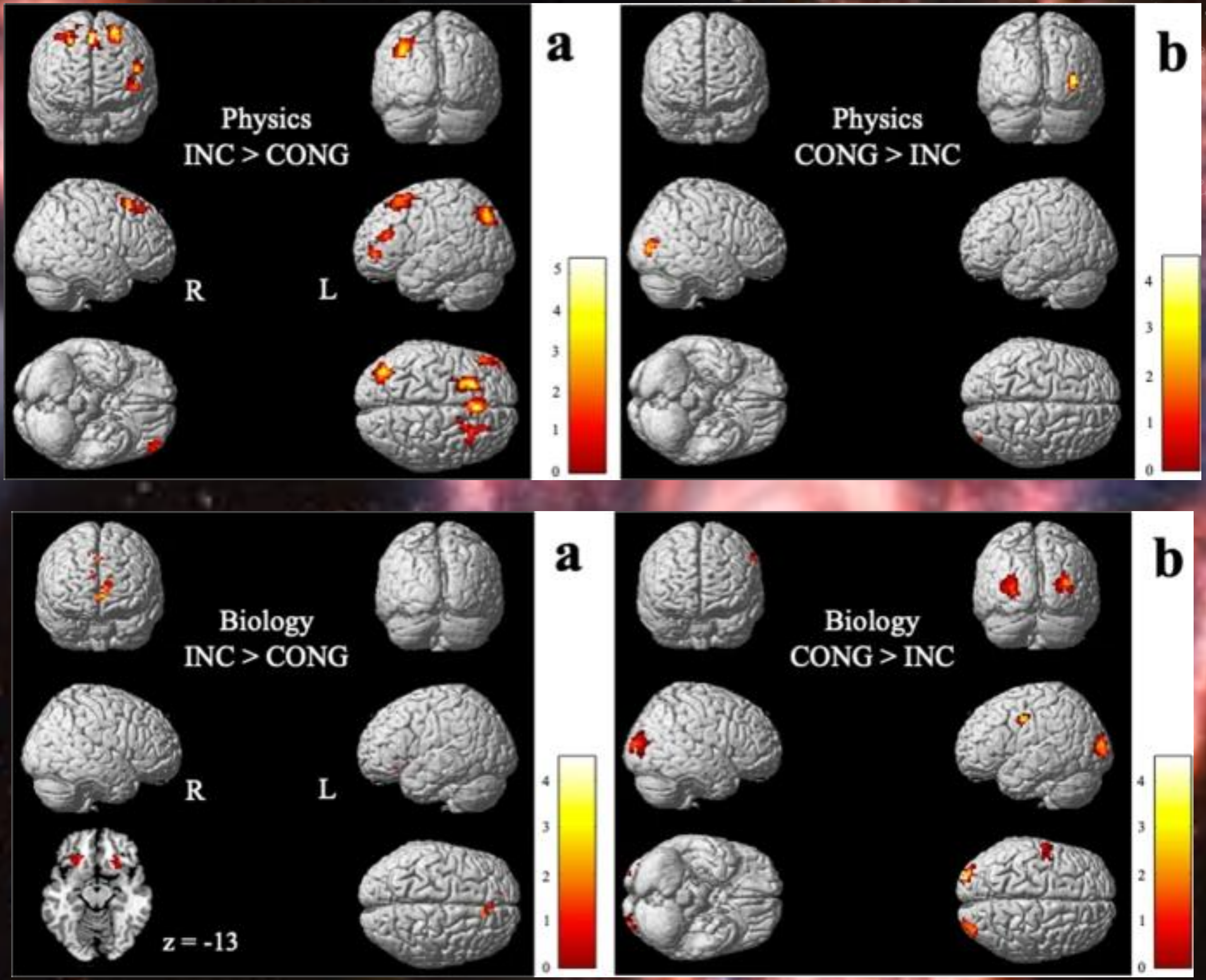
INTRODUCTION

Over the course of their lives, humans hold to many naive ideas or misconceptions about how nature works. Contrary to what one might have thought, these naive ideas are often far from being irrational or senseless and can even be useful in everyday living. However, some naive ideas have proved to be a "pain in the neck" for science educators, since they are often incompatible with the

interferences[27]. Hence, conceptual change is thought to be contingent upon the capacity to suppress or inhibit dominant naive ideas to allow the expression of less prevalent scientific ones[28].

Behavioral studies explored the processing of naive ideas in experts with statement-verification tasks. Results suggest that mature scientific knowledge doesn't involve radically overwriting


a
time
The Sun is a star.
Stones attract the Earth.
Radio waves are audible.
Boiling water contains water bubbles.
Example of incongruent statements in physics
b
% correct
100
90
80
70
60
50
congruent
incongruent
Physics
Biology
c
Response Time
6000
5000
4000
3000
2000
1000
Physics
Biology


a
Physics
INC > CONG
R
L
5
4
3
2
1
0
b
Physics
CONG > INC
4
3
2
1
0
a
Biology
INC > CONG
R
L
z = -13
4
3
2
1
0
b
Biology
CONG > INC
4
3
2
1
0

COMPARER DES INTERVENTIONS CONFLICTUELLES

IL EXISTE PLUSIEURS FAÇONS DE PRODUIRE UN CONFLIT COGNITIF

DES DÉCISIONS DIDACTIQUES POSSIBLES

Prendre quelques précautions
(Prévenir)

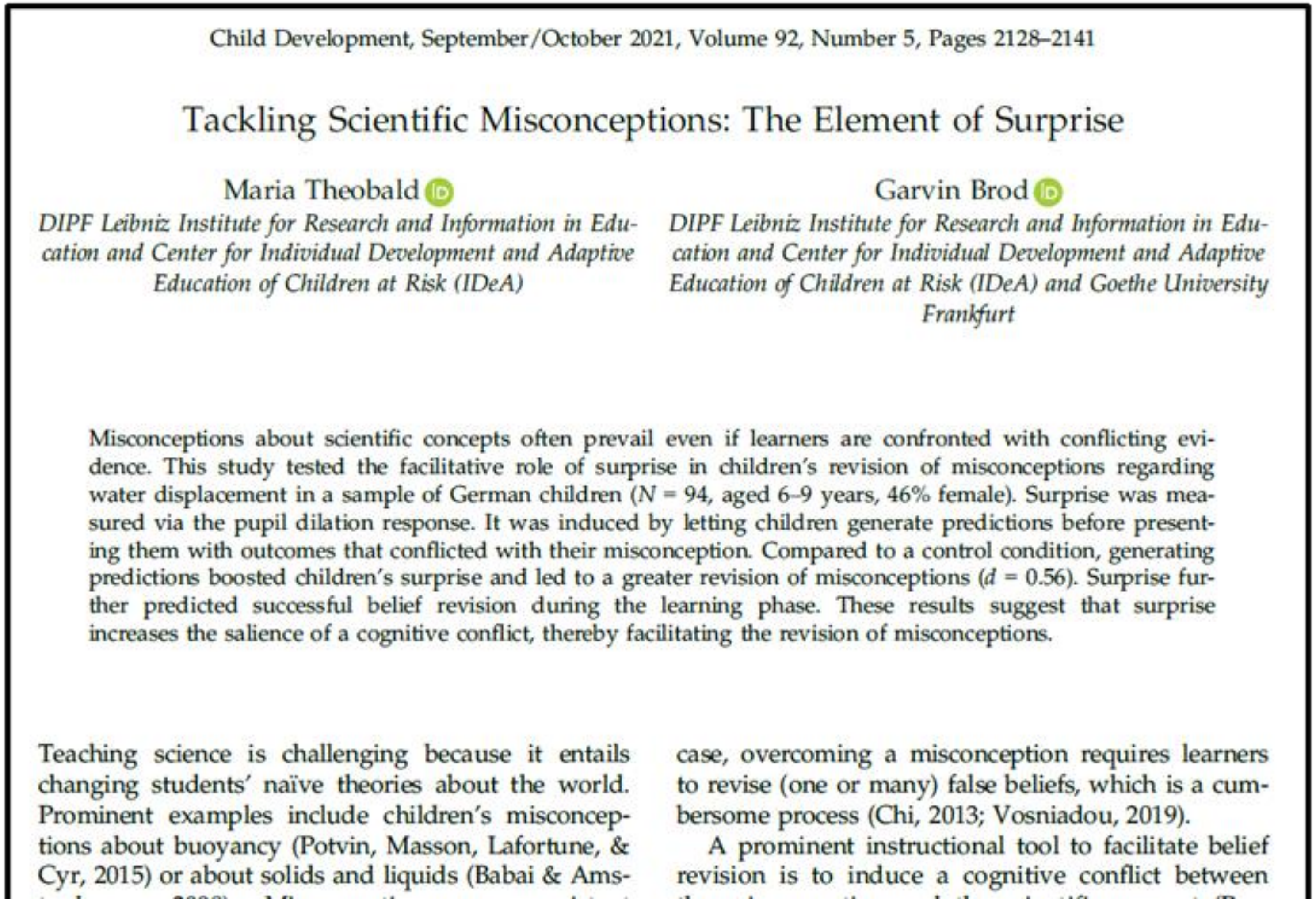
Fermer les yeux
(Ignorer)

Prendre les choses en main
(Passer à l'offensive « systématique »)

CONFLIT COGNITIF

État psychologique qui survient lorsqu'on prend conscience d'un problème de correspondance entre une conception préexistante et une information nouvelle, une réalité observée, ou une conception concurrente.

CONFLITS ET RÉSOLUTIONS (*MEANINGFUL* CONFLICT)


Child Development, September/October 2021, Volume 92, Number 5, Pages 2128–2141

Tackling Scientific Misconceptions: The Element of Surprise

Maria Theobald
DIPF Leibniz Institute for Research and Information in Education and Center for Individual Development and Adaptive Education of Children at Risk (IDeA)

Garvin Brod
DIPF Leibniz Institute for Research and Information in Education and Center for Individual Development and Adaptive Education of Children at Risk (IDeA) and Goethe University Frankfurt

Misconceptions about scientific concepts often prevail even if learners are confronted with conflicting evidence. This study tested the facilitative role of surprise in children's revision of misconceptions regarding water displacement in a sample of German children (N = 94, aged 6–9 years, 46% female). Surprise was measured via the pupil dilation response. It was induced by letting children generate predictions before presenting them with outcomes that conflicted with their misconception. Compared to a control condition, generating predictions boosted children's surprise and led to a greater revision of misconceptions (d = 0.56). Surprise further predicted successful belief revision during the learning phase. These results suggest that surprise increases the salience of a cognitive conflict, thereby facilitating the revision of misconceptions.

Teaching science is challenging because it entails changing students' naïve theories about the world. Prominent examples include children's misconceptions about buoyancy (Potvin, Masson, Lafortune, & Cyr, 2015) or about solids and liquids (Babai & Ams-

case, overcoming a misconception requires learners to revise (one or many) false beliefs, which is a cumbersome process (Chi, 2013; Vosniadou, 2019).

A prominent instructional tool to facilitate belief revision is to induce a cognitive conflict between

Conception testée

« Plus l'objet est lourd, plus il déplacera d'eau »

Participants

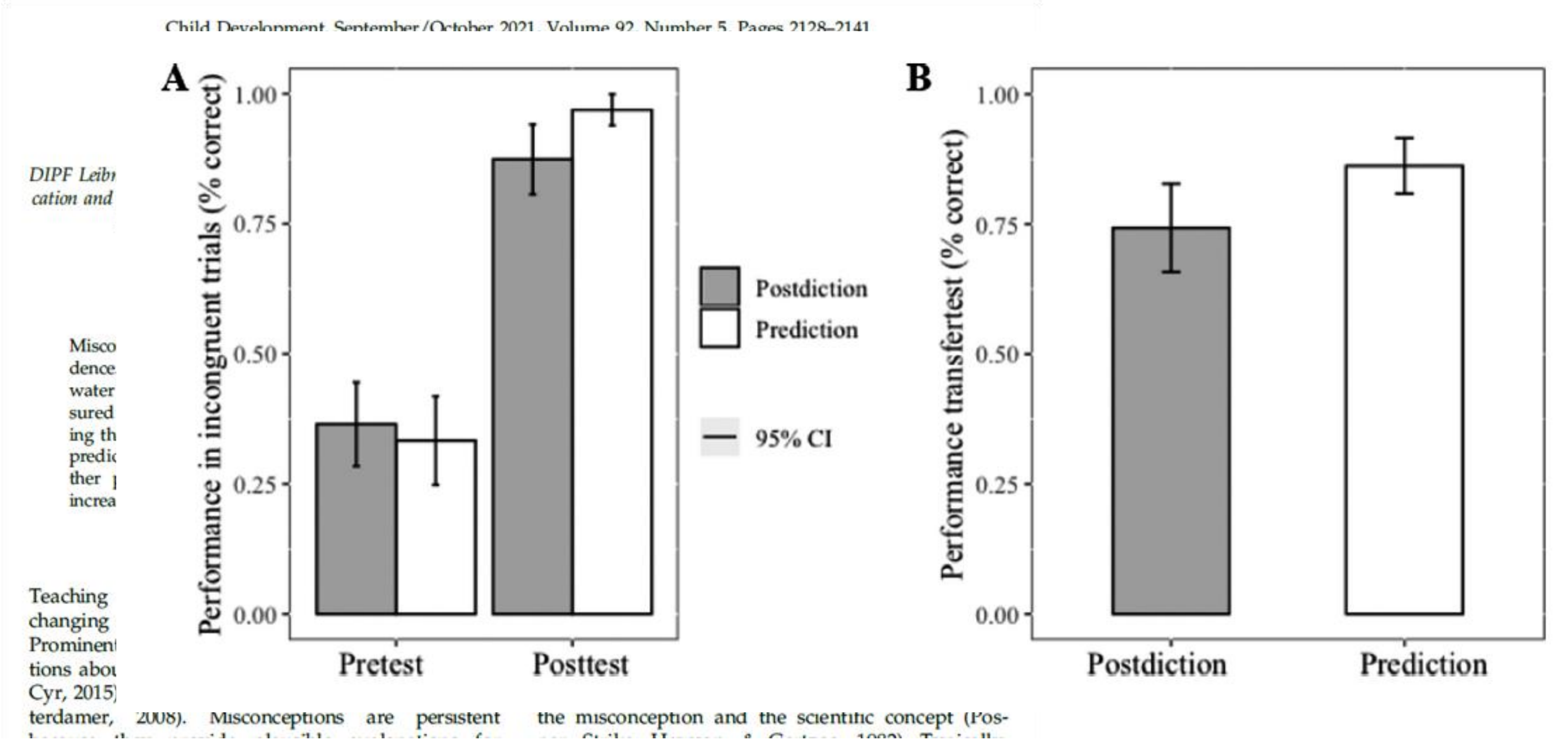
N=94, 6-9 ans

Deux conditions

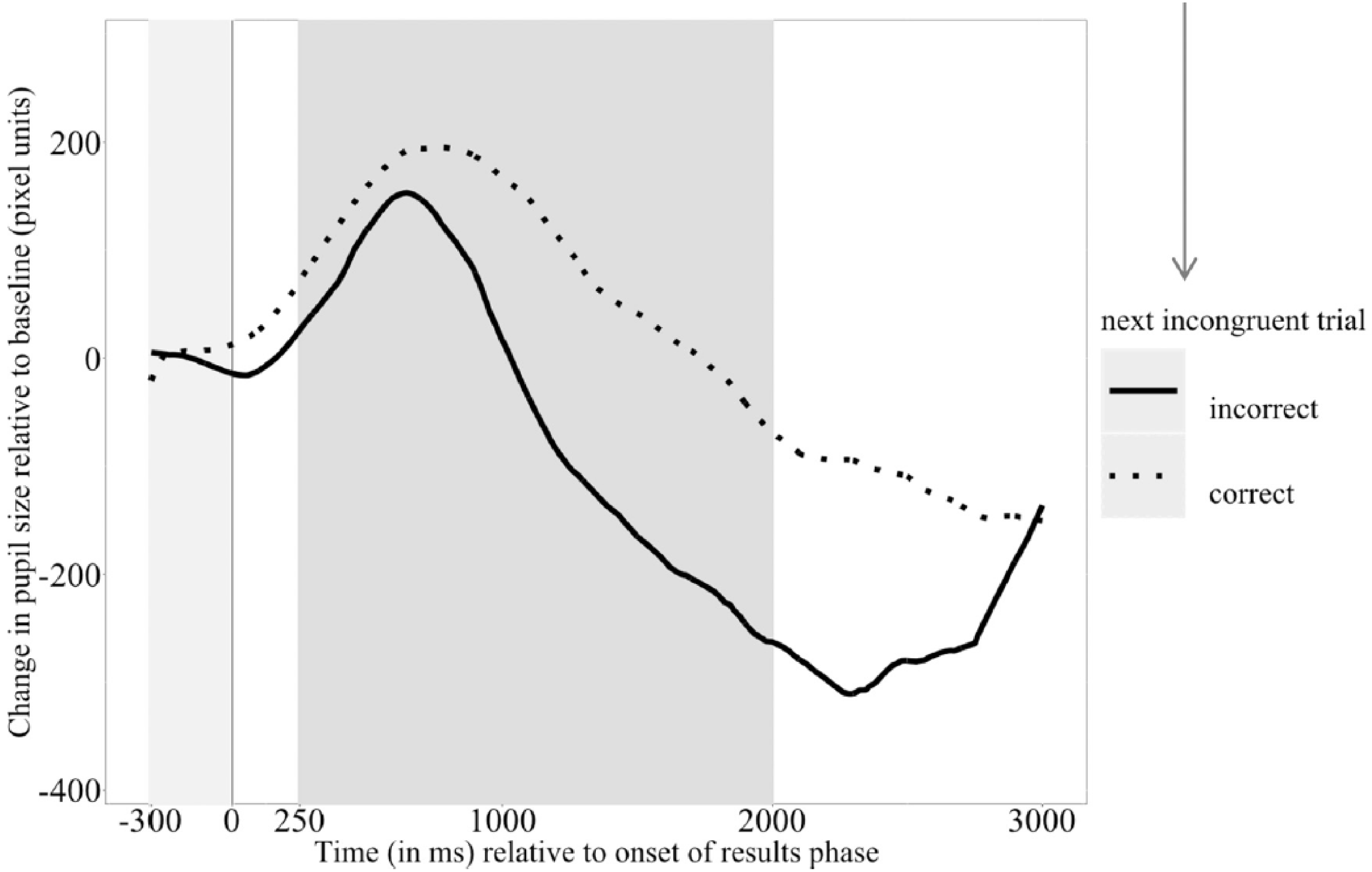
Prédiction : Les enfants faisaient une prédiction avant de voir le résultat.

Postdiction : Les enfants voyaient d'abord le résultat, puis exprimaient ce qu'ils auraient prédit.

CONFLITS ET RÉSOLUTIONS (*MEANINGFUL* CONFLICT)



CONFLITS ET RÉSOLUTIONS (*MEANINGFUL* CONFLICT)



UQÀM | Partenariat pour le développement et la réussite de la formation scientifique au secondaire

https://partenariatsciences.uqam.ca/apropos

frontiers | Frontiers in Education

TYPE Curriculum, Instruction, and Pedagogy
PUBLISHED 27 June 2024
DOI 10.3389/feduc.2024.1419714

Check for updates

OPEN ACCESS

EDITED BY
Evi Agostini,
University of Vienna, Austria

REVIEWED BY
Katja Kansteiner,
University of Education Weingarten, Germany
Ozden Sengul,
Boğaziçi University, Türkiye

*CORRESPONDENCE
Patrice Potvin
✉ potvin.patrice@uqam.ca

RECEIVED 18 April 2024
ACCEPTED 11 June 2024
PUBLISHED 27 June 2024

CITATION
Potvin P, Boissard B, Durocher É, Hasni A and Riopel M (2024) Empowering professional learning communities of secondary science teachers to uncover and address their students' misconceptions via research-oriented practices.
Front. Educ. 9:1419714.
doi: 10.3389/feduc.2024.1419714

Empowering professional learning communities of secondary science teachers to uncover and address their students' misconceptions via research-oriented practices

Patrice Potvin[1]*, Bénédicte Boissard[1], Éric Durocher[1], Abdelkrim Hasni[2] and Martin Riopel[1]

[1]Département de Didactique, Université du Québec à Montréal, Montréal, QC, Canada, [2]Faculté d'Éducation, Université de Sherbrooke, Sherbrooke, QC, Canada

The Partnership for the Development and Success of Science Education in Secondary Schools project seeks to improve science education by fostering a dynamic environment for professional development and teacher-led inquiry within professional learning communities (PLCs). Addressing the long-standing problem of outdated pedagogical approaches, the initiative encourages secondary science teachers to actively engage in action research to identify

AUTRES IDÉES…

- Textes de réfutation
- Récits historiques
- Expériences par la pensée
- Démonstrations effectuées par l'enseignant
- Expérimentations menées par les étudiants
- Explicitation en entrevue individuelle
- Discussions en groupes d'étudiants
- Débats pour toute une classe
- ???

RÉACTIONS AUX INFORMATIONS CONTRADICTOIRES

- Potvin, P. (2023). Response of science learners to contradicting information: A review of research. *Studies in Science Education*, *59*(1), 67-108.

STUDIES IN SCIENCE EDUCATION
https://doi.org/10.1080/03057267.2021.2004006

Routledge
Taylor & Francis Group

Check for updates

Response of science learners to contradicting information: a review of research

Patrice Potvin

Département de Didactique, Université du Québec à Montréal, Montréal, Canada

ABSTRACT

This article presents a critical and systematic review of the science education research literature that explores the response of learners to contradicting information (anomalous data). The review is framed in the cognitive conflict process model (CCPM) and provides an analysis of (1) the types and frequency of possible responses, (2) the conditions by which cognitive conflict is successfully triggered, and (3) the preliminary conditions that eventually favour conceptual changes. The results conclude, among other things, that anomaly-induced cognitive conflict is rather inefficient if triggered in isolation, without supportive processing activities, or without the initial availability of conceptual alternatives. A prospective synthesis is then provided, supporting Ohlsson's view of science education activities that concentrate on cognitive utility rather than emphasising on discrediting initial conceptions. A reflection about the integration of such considerations with contemporary issues is also provided.

ARTICLE HISTORY

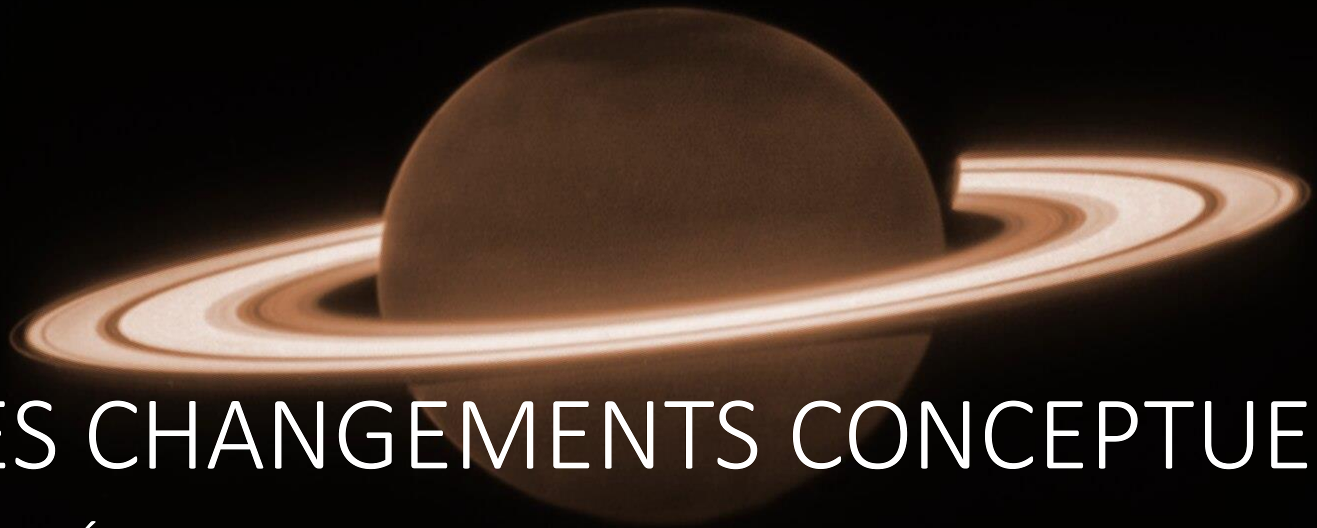
Received 5 May 2021
Accepted 22 October 2021

KEYWORDS

Review; science education; conceptual change; response; anomalous data; contradicting information

Theme	Chinn and Brewer (1998)	S. Kang et al. (2004)	Lin (2007)	Lee and Byun (2012)	Anggoro et al. (2019) (Averaged)
Means of exposing learners to discrepant info	Text	Computer-assisted instruction	Experiments	Demonstration	Demonstration
Theme	Geology/ palaeontology	Density	Basic physical properties	Force and motion	Force and motion
Ignorance	9	-	1	21	15
Rejection	34	19	56	0	-
Exclusion	2	6	3	9	-
Uncertainty about validity	17	8	4	7	-
Uncertainty about interpretation	-	-	14	9	-
Abeyance	9	-	7	11	6
Reinterpretation	23	4	4	0	18
Belief decrease	-	14	-	-	-
Peripheral change	2	10	2	36	52
Theory change	4	39	9	7	9

Minus sign ('-') means that this category was not considered.



EXPLIQUER DES CHANGEMENTS CONCEPTUELS

PLUSIEURS MODÈLES EN COMPÉTITION…

Studies in Science Education

Routledge
Taylor & Francis Group

ISSN: 0305-7267 (Print) 1940-8412 (Online) Journal homepage: https://www.tandfonline.com/loi/rsse20

Models of conceptual change in science learning: establishing an exhaustive inventory based on support given by articles published in major journals

Patrice Potvin, Lucian Nenciovici, Guillaume Malenfant-Robichaud, François Thibault, Ousmane Sy, Mohamed Amine Mahhou, Alex Bernard, Geneviève Allaire-Duquette, Jérémie Blanchette Sarrasin, Lorie-Marlène Brault Foisy, Nancy Brouillette, Audrey-Anne St-Aubin, Patrick Charland, Steve Masson, Martin Riopel, Chin-Chung Tsai, Michel Bélanger & Pierre Chastenay

To cite this article: Patrice Potvin, Lucian Nenciovici, Guillaume Malenfant-Robichaud, François Thibault, Ousmane Sy, Mohamed Amine Mahhou, Alex Bernard, Geneviève Allaire-Duquette, Jérémie Blanchette Sarrasin, Lorie-Marlène Brault Foisy, Nancy Brouillette, Audrey-Anne St-Aubin, Patrick Charland, Steve Masson, Martin Riopel, Chin-Chung Tsai, Michel Bélanger & Pierre Chastenay (2020): Models of conceptual change in science learning: establishing an exhaustive inventory based on support given by articles published in major journals, Studies in Science Education, DOI: 10.1080/03057267.2020.1744796

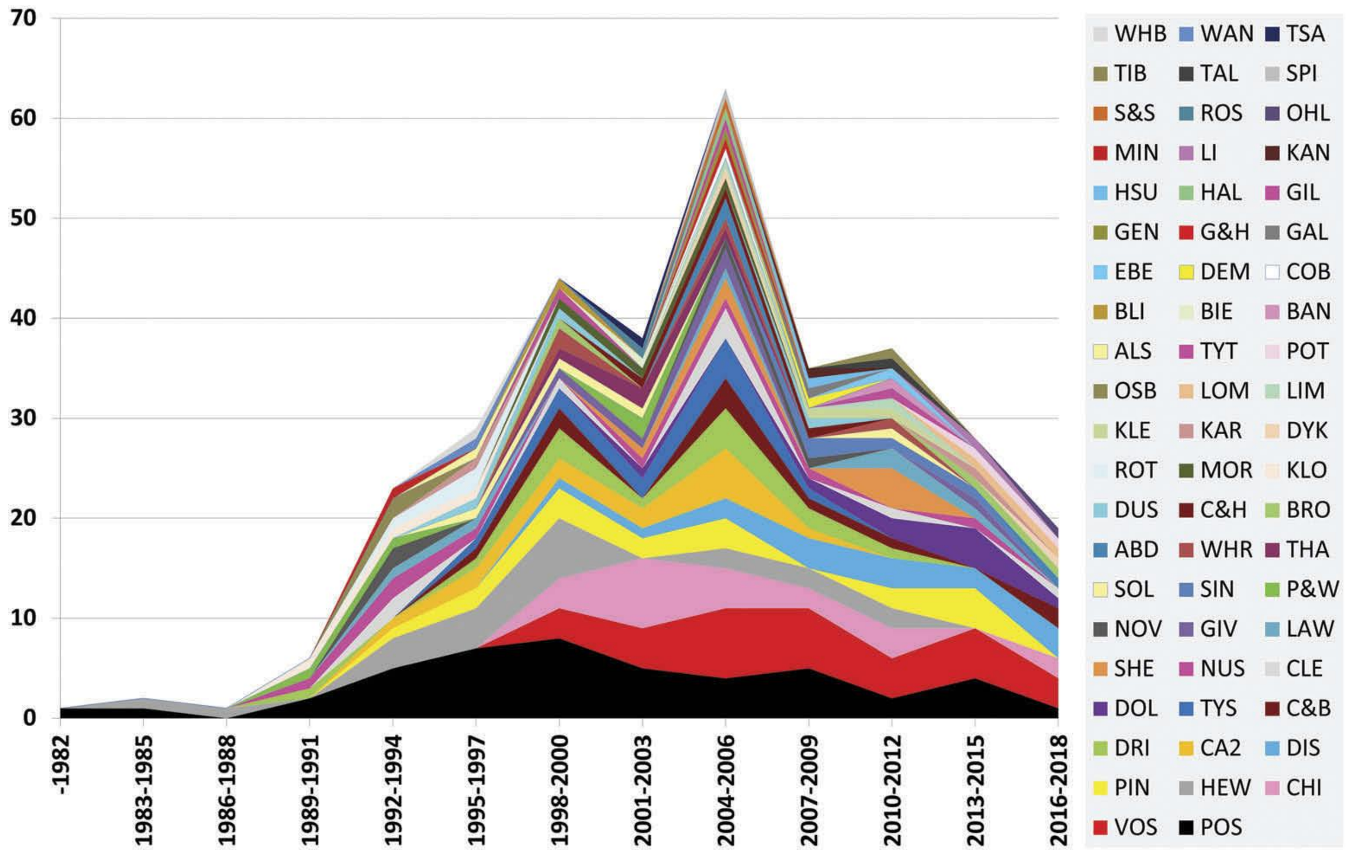


Figure 11. Distribution over time of articles providing empirical confirmation for each CC model.

Table 3. Ordered list of CC models.

Rank	Author(s) - Name of the model	Codes	Recommended reference for understanding the model	Short description of the mechanism by which CC occurs	Empirical support (N)	Favourable position statement (N)	Support by explicit mention (N)	Support by implicit mention (N)	Total recorded positive examples of support (N)
1	Posner et al. - General model of conceptual change	POS	(Posner et al., 1982)	CC consists of people's central, organizing concepts in the conceptual ecology changing from one set of concepts to another set, incompatible with the first. Four conditions are necessary: (1) dissatisfaction with the pre-existing concept; new concept perceived as (2) plausible, (3) intelligible and (4) fruitful.	45	65	136	15	261
2	Vosniadou - Mental model modification	VOS	(Vosniadou, 1994)	CC consists of the gradual modification of one's mental models of the physical world, achieved either through enrichment or revision. Enrichment involves adding new information to existing conceptual structures. Revision involves changes in individual beliefs or presuppositions or in the relational structure of a theory.	32	32	69	26	159
3	Chi et al. - Ontological category shift	CHI	(M. T. H. Chi, Slotta, & De Leeuw, 1994)	Entities in the world can be classified according to three ontological categories (matter, processes, mental states). CC is the reassignment of a concept's categorical membership across ontological categories, mostly from the category of matter to the category of processes.	21	21	58	14	114
4	Hewson - Conceptual capture and conceptual exchange	HEW	(P. W. Hewson, 1980)	A new conception can be "captured", i.e., incorporated into existing conceptions if intelligible/plausible/fruitful. If the new conception contradicts existing conceptions, its acceptance is blocked. For a person to accept it, the status of blocking conceptions has to lower before the status of the new conception rises, in a "conceptual exchange".	21	20	53	26	120
5	Pintrich et al. - Beyond cold conceptual change	PIN	(Pintrich, Marx, & Boyle, 1993)	The CC process is mediated via the dynamic interplay of three types of factors: motivational (e.g., personal interest), classroom contextual (e.g., task structures) and cognitive (e.g., activation of prior knowledge).	17	13	36	22	88
6	diSessa - P-prims reorganization	DIS	(diSessa, 1993)	CC consists of the reorganization of phenomenological primitives (p-prims) into a larger cognitive system. P-prims are small, fragmentary causal relationships forming the naive sense of mechanisms in intuitive physics.	15	13	44	21	93
7	Driver et al. - Students' epistemological reasoning characterization	DRI	(Driver, Leach, & Millar, 1996)	Nature of students' scientific knowledge is represented via 3 epistemological representations: (1) phenomenon-based reasoning; (2) relation-based reasoning; and (3) model-based reasoning, each linked with distinct ways of portraying scientific enquiry and the nature of scientific explanation. Scientific knowledge is socially constructed.	13	10	33	41	97
8	Carey - Strong restructuring of theories	CA2	(Carey, 1985)	CC occurs via strong (rather than weak) restructuring of children's theory-like conceptual structures through three processes: (1) replacement of the initial concept by a new one; (2) differentiation, in which the initial concept splits into two or more new concepts; and (3) coalescence, in which two or more initial concepts form a single concept.	13	9	41	11	74
9	Chinn & Brewer - Response to anomalous data	C&B	(Chinn & Brewer, 1993)	Seven forms of response to anomalous data are possible: (a) ignoring it; (b) rejecting it; (c) excluding it from current theory; (d) holding it in abeyance; (e) reinterpreting it; (f) making peripheral changes to current theory; and (g) changing current theory. CC corresponds to g (change in core beliefs) and partly to f (change in peripheral beliefs).	10	11	24	19	64
	Tyson et al. -			Conceptual change proceeds through 3 dimensions: (1) ontological, i.e., how the learner perceives the nature of the thing being studied; (2)					

				knowledge, well-honed strategic repertoire, abiding interest and investment.					
76	Prawat - Knowledge organization and reflective awareness	PRA	(Prawat, 1989)	Two factors foster CC: (1) organizational, i.e., concepts are represented as nodes within a system and are interconnected via associative links, thus teaching must connect elements of naive and scientific views; and (2) amount of reflective awareness, i.e., learners' ability to access relevant strategies in new learning situations.	-	-	1	1	2
77	Ali - Preconception activation strategies	ALI	(Ali, 1990)	Conceptual change can be produced in 5 steps: 1. search for their own preconceptions; 2. compare and contrast their own preconceptions with the new information; 3. formulate a new conception, based on the previous step; 4. apply the new conception; and 5. evaluate the new conception.	-	-	1	-	1
78	Anders & Commeyras - Feminist perspective	AND	(Anders & Commeyras, 1998)	Relationship between gender and science learning in mixed-gender contexts is crucial. The major role of inquiry on CC within this perspective involves deconstructing normative constructs such as reason, science and objectivity across genders. The social roles and power relations across genders must also be examined.	-	-	1	-	1
79	Carey - Quinian bootstrapping	CA1	(Carey, 2009)	Quinian bootstrapping occurs in 2 phases: (1) establishing new mental symbols initially interpreted in terms of concepts already available (placeholders); and (2) modelling a phenomenon in terms of the set of interrelated symbols in the placeholder structure, leading to explicit representation and the capacity to formulate a new concept.	-	-	1	-	1
80	Furberg & Arnseth - Sociocultural perspective	FUR	(Furberg & Arnseth, 2009)	CC consists of students' meaning making via collaborative learning activities. The 4 central aspects of meaning making are: (a) students' use of resources in problematizing; (b) multiple aspects of teacher intervention; (c) changes in interactional accomplishments; and (d) institutional aspect of meaning making.	-	-	1	-	1
81	Giordan & de Vecchi - Allosteric learning model	GIO	(Giordan & DeVecchi, 1987)	Conceptual change consists of the transformation of initial conceptions into more functional conceptions, via simultaneous deconstructions and reconstructions that are analogous to changes in the conformation of the allosteric protein. An optimal pedagogical learning environment is necessary for this transformation to occur.	-	-	1	-	1
82	Miyake - Conceptual change through collaboration	MIY	(Miyake, 2008)	Conceptual change occurs via collaboration: solutions to problems evolve in a divergent group of learners. Solutions are then sorted to integrate those that are most relevant and promising into a schema or some abstracted representation of the solution, which becomes a solid source for further changing the concepts into scientific ones.	-	-	1	-	1
83	Myers & Alvermann - Critical postmodernist perspective	MYE	(Myers & Alvermann, 1998)	This perspective embraces the desire to reveal the codes of power within students' relations and student-teacher relations, and the discourses of oppression in order to enable all participants to be emancipated, i.e., contest being made into the objects of texts and truths and negotiate new subjectivities (i.e., scientific conceptions) and relationships.	-	-	1	-	1
84	Schwitzgebel - Children's theories and drive to explain	SCH	(Schwitzgebel, 1999)	Upon the presentation of counter-evidence that conflicts with a learner's initial theory, the learner's explanation-seeking curiosity is aroused and he will be driven to construct a new theory that will quench his curiosity.	-	-	1	-	1
85	Tao & Gunstone - Context-independent and stable conceptual change	TAO	(Tao & Gunstone, 1999)	Conceptual change proceeds in 2 phases: a context-dependent and unstable phase, where students vacillate between alternative and scientific conceptions across contexts, and a context-independent and stable phase, where students perceive the commonalities and accept the generality of scientific conceptions across contexts.	-	-	1	-	1
86	Chinn & Samarapungavan - Resubsumption multiple routes	C&S	(Chinn & Samarapungavan, 2008)	CC can occur via Ohlsson's resubsumption or via multiple routes that are derivatives of it: (1) resubsumption + substantial modifications of conceptual system B before or after resubsumption; (2) revision of a single conceptual system instead of resubsumption; (3) invention of new conceptions; and (4) reconceptualizing a domain; etc.	-	-	-	1	1

FAMILLES DE MODÈLES

- Modèles de remplacement
- Modèle de changement
- Modèles sociocognitifs
- Modèles pluralistes

FAMILLES DE MODÈLES

Catégorie	Modèles	Justification
Modèles basés sur le conflit conceptuel	POS, C&B, NUS	Basés sur le conflit entre conceptions existantes et nouvelles informations.
Modèles basés sur la révision des théories	VOS, CHI, HEW, DIS, CA2	Changements structurels profonds des théories ou catégories mentales.
Modèles sociocognitifs et contextuels	DRI, TYS, DOL, SHE, GIV	Importance des facteurs sociaux, contextuels et motivationnels.
Modèles mixtes ou multidimensionnels	PIN, CLE, LAW, WHR	Combinaison de plusieurs dimensions : cognitive, contextuelle et motivationnelle.

MODÈLES BASÉS SUR LE CONFLIT CONCEPTUEL

Objectif pédagogique : Créer un **conflit cognitif** entre l'idée intuitive d'évolution intentionnelle et la réalité des mécanismes aléatoires et non intentionnels.

- **Étape 1 :** Présentez une idée fausse courante : **« Les organismes évoluent parce qu'ils en ont besoin »** (l'évolution comme une intention).
- **Étape 2 :** Montrez une **vidéo ou simulation** illustrant l'évolution des phalènes du bouleau durant la révolution industrielle, où seules les variations **aléatoires** de couleur et la **pression de sélection** (prédation) expliquent leur évolution.
- **Étape 3 :** Demandez aux étudiants d'expliquer pourquoi la phalène sombre est devenue dominante et confrontez leurs réponses à leurs idées initiales.

2. MODÈLES BASÉS SUR LA RÉVISION DES THÉORIES

Objectif pédagogique : Amener une **révision structurée et progressive** des explications initiales vers une compréhension théorique plus robuste.

- **Étape 1 :** Demandez aux étudiants de proposer des explications pour l'évolution de certains traits (par exemple, les longs cous des girafes).
- **Étape 2 :** Introduisez les **concepts clés** progressivement : variation, héritabilité, surproduction, et sélection.
- **Étape 3 :** Utilisez des études de cas (par exemple, les pinsons de Darwin ou l'évolution des bactéries résistantes aux antibiotiques) pour montrer comment ces concepts expliquent les observations.
- **Étape 4 :** Guidez les étudiants pour **restructurer leurs théories** initiales (par exemple, remplacer l'idée de besoin ou d'intention par des processus sélectionnés au fil du temps).

3. MODÈLES SOCIOCOGNITIFS ET CONTEXTUELS

Objectif pédagogique : Intégrer les concepts de l'évolution dans un **contexte social** et collaboratif tout en confrontant les conceptions erronées.

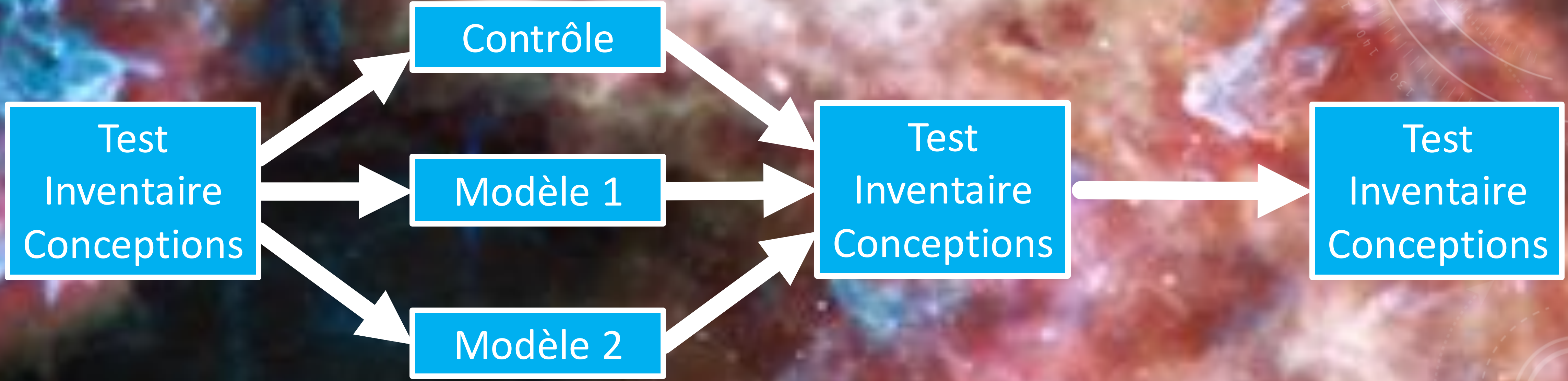
- **Étape 1 :** Organisez un débat en classe autour de la question : **« Pourquoi les espèces évoluent-elles ? »**. Divisez la classe en groupes avec des rôles différents :
- Groupe 1 : Défend l'évolution comme un processus intentionnel.
- Groupe 2 : Défend l'évolution basée sur la **sélection naturelle**.
- **Étape 2 :** Chaque groupe prépare des arguments en utilisant des **données scientifiques** (par exemple, fossiles, résistances bactériennes).
- **Étape 3 :** Animez un **débat structuré**, suivi d'une discussion collective où le professeur recentre les échanges sur les **faits scientifiques**.

4. MODÈLES MIXTES OU MULTIDIMENSIONNELS

Objectif pédagogique : Combiner des dimensions **cognitives** (simulation), **contextuelles** (interaction active) et **réflexives** (discussion) pour favoriser un changement conceptuel profond.

- **Étape 1 :** Utilisez un **logiciel de simulation** pour montrer comment une population d'organismes évolue face à des pressions sélectives (par exemple, variation de couleur dans un environnement changeant).
- **Étape 2 :** Les étudiants modifient les paramètres (taux de mutation, prédation, nourriture) pour **observer l'impact** sur la population.
- **Étape 3 :** Après la simulation, engagez une **discussion réflexive** : Pourquoi certaines variations survivent-elles ? Quel rôle joue le hasard dans l'évolution ? Comment cette simulation modifie-t-elle leur compréhension de l'évolution ?
- **Étape 4 :** Reliez ces observations aux concepts clés de la sélection naturelle (variation, pression de sélection, adaptation).

PROTOCOLE EXPÉRIMENTAL


Test Inventaire Conceptions
Contrôle
Modèle 1
Modèle 2
Test Inventaire Conceptions
Test Inventaire Conceptions

CONCLUSION

IL Y A ENCORE BEAUCOUP À FAIRE