

# Éducation à l'Esprit Critique

## TEACHING CRITICAL THINKING

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### Project summary

Critical thinking is at the heart of the latest educational policies. Yet if educational projects multiply, there still exist only very few scientific studies assessing the methods proposed by different stakeholders in education and training. These methods themselves in the norm do not build upon the existing scientific knowledge either. The present project aims at filling this gap by ① designing and testing the first evidence-based critical thinking training and, thanks to the complementarity of researchers and teachers of different disciplines ② converging towards a more precise definition of critical thinking and providing a psychometric scale of critical thinking for French-speaking participants ③ testing the educational resources using this new scale in two stages (a qualitative pilot study, a quantitative large-scale study) ④ spreading these resources to institutions and teachers, as well as to the media and the general public.

## Summary table of persons involved in the project:

Partner	Name	First name	Current position	Involvement	Role
CHART-EPHE Laboratoire Cognitions Humaine et Artificielle – EPHE	GAUVRIT	Nicolas	Associate Professor	50%	Scientific coordinator
CRP-CPO (EA 7273) Centre de Recherche en Psychologie : Cognition, Psychisme et Organisations, Université d'Amiens	HAINSELIN	Mathieu	Associate Professor	20%	Member, development team
IJN (UMR 8129) Institut Jean Nicod, École normale supérieure (ENS), École des hautes études en sciences sociales & CNRS	CASATI	Roberto	Research director	20%	Leader of the theoretical analysis
	PASQUINELLI	Elena	Project Manager	40%	Leader of the development team
Fondation LAMAP	ALLÉGRAUD	Katia	Project Manager	20%	Member, development team
SIRET: 53953864500026	FARINA	Mathieu	Project Manager	40%	Member, development team
	ZIMMERMANN	Gabrielle	Project Manager	20%	Member, development team
LIED-P7 UMR Laboratoire Interdisciplinaire des Energies de Demain – Paris 7 & CNRS	BRONNER	Gérald	Professor	20%	Leader of the impact analysis team
LP3C-R2 Laboratoire de psychologie: Cognition, Comportement, Communication – Rennes 2	DELOUVÉE	Sylvain	Associate Professor	40%	Leader of the psychometrics team
	NOËL	Yvonnick	Associate Professor	20%	Member, psychometrics team
INNOVAXIOM	HONNORAT	Laurence	CEO	20%	Leader of the diffusion team

## 1. Proposal's context, positioning and objective(s)

The political and social interest in critical thinking has increased in the last decade, notably fuelled by two factors.

First, citizens rely more and more on social networks or websites to get information. At the same time, hoaxes, fake news and mere lies spread at an unprecedented rate on the Internet, as was widely discussed by the press during the last US election campaign. Education specialists as well as the French Ministry of Education called for the development of Media and Information Literacy (MIL) to foster students' and citizens' ability to understand the complexity of the real world. The UNESCO also calls for such educational development.

Second, after the deadly terrorist attacks in France in 2015-2016, the roots of radicalization were investigated. It turned out that the endorsement of unsubstantiated conspiracy theories—and more generally a lack of critical thinking—were amongst the factors explaining these acts of violence.

In addition to these elements, a transversal skill such as critical thinking appears indispensable in order to be able to adapt in a changing world in which, as it is often repeated, many citizens might end up getting a job that didn't even exist when they were students (Halpern, 2002).

### 1.1. Objectives and scientific hypotheses

Critical thinking has long been mentioned in the regular curriculum in France. Science and philosophy teachers sometimes feel that they already include critical thinking in their classes, because they implicitly “show” their pupils how they should reason and because they know how important the issue is. The current approach relies thus on the good will and the intuitions of teachers, but there are good reasons to believe that the educational approach to critical thinking skills adopted in French school might be suboptimal.

First, one of the most robust finding in critical thinking education studies is that explicit teaching strategies are more efficient than implicit training (see Pithers & Soden, 2000; or Tiruneh, Verburch & Elen, 2014, for a meta-analysis). Second, teachers lack suitable supports and lesson plans for teaching critical thinking skills, at different stages of the child and adolescent development. Third, the current approach is not rooted in a scientific approach to the teaching of critical thinking skills, and in particular it does not deploy means for evaluating the impact of teaching critical thinking in school.

Is it even possible to teach critical thinking? Experts' opinions about this issue vary slightly, but the consensus is that a suitable training does improve critical thinking, although probably not as much as one would hope (for mildly different views on this topic, see, e.g., Willingham, 2007, and Halpern, 2002), with a medium effect size ( $g \approx .3$ ). This situation invites to a better understanding of how to teach and how to evaluate critical thinking skills in a school setting. Taking all this into account, the present project's objective is to design a critical thinking curriculum for pupils aged 8+. This curriculum will be scientifically supported in two ways.

First, it will be rooted on the existing scientific literature on critical thinking training. Note that the French Ministry of Education recently made a call for proposals for in-service teachers to gather and propose innovative training methods. The submitted projects were in the norm not grounded on the existing literature, nor were they coordinated among themselves. As a consequence, the Ministry obtained a set of rather disparate ideas, some of which are probably useless. Of the several hundreds submission, about eighty were selected on what appears to be an intuitive basis, without reference to scientific results. This, we dare claim, is hazardous. A rigorous scientific analysis assessing the proposals against the background of what is known about teaching critical thinking is needed.

Second, any new instance of training should be empirically supported. In the past, most attempts to foster critical thinking relied entirely on teachers' intuitions, not only in the conception phase, but also in the assessment of the outcomes. We plan to remediate this by providing a sound way to evaluate the impact of our forthcoming training curriculum. This is perfectly in line with the strand of evidence-based education, which states that education – just like medicine – should be informed by empirical evidence rather than built mostly or solely on the intuitions of practitioners.

Several studies following this line have been published in the last few decades (e.g., Allen et al., 1999), but we couldn't find any assessment of what is proposed in France. Boisvert (2000, 2002) however provided an isolated set of studies in a French-speaking community in Canada (see also, e.g., Audet et al., 1993; Daniel, Gagnon & Auriac-Slusarczyk, 2016).

Our objective is to design a critical thinking training curriculum for 8-14 year-old pupils that

- is coherent and progressive;
- is grounded on a sound definition of critical thinking;
- is rooted in scientific evidence;
- will be assessed by rigorous psychometric tools.

To achieve this final objective, we will

- synthesize the literature on the definition of critical thinking and dimensions as well as the definition proposed by the Ministry of Education (see above figure) to build a consensual definition of critical thinking relevant to educational issues and coherent with the scientific existing literature;
- design a multi-disciplinary and multi-grade critical thinking training based on the scientific consensus on this topic;
- create a critical thinking scale adapted to the French community based on existing tests (most of them are in English, for adults, or focusing on one aspect of critical thinking) and on the proposed definition;
- assess the impact of the proposed training using the psychometric tools created.

Our target is to define critical thinking skills and disposition in a way coherent with both educational needs as expressed by the French Ministry of Education and the scientific community's view; our hypothesis is that a coherent set of training interventions based on scientific evidence will be conducive to developing critical thinking.

## **1.2. Originality and relevance in relation to the state of the art**

*The definition of critical thinking is not set down yet, but there is sufficient consensus for us to consider giving a coherent, workable definition taking into account the scientific literature as well as the view of the Ministry. There is an urgent need for clarification of how critical thinking should be measured. Moreover, we could not find any validated scale of critical thinking suitable for French-speaking children and teenagers. We will thus design such as scale. Last, in a time were the French Ministry of National Education calls for a real and evidence-based critical thinking training in the classrooms, no such training exists. Thanks to the complementarity of researchers and teachers in our project, we will design and test the first evidence-based critical thinking training for 8+ year olds.*

### **1.2.1. The definition of critical thinking**

The roots of critical thinking literature can be traced back to three disciplines: philosophy, psychology, and to a lesser extent, education (Lewis & Smith, 1993; Sternberg, 1986; Lai, 2002). The philosophical approach focuses on theoretical aspects of the ideal thinker, defining rules for a sound argumentation (Thayer-Bacon, 2000) and describing what would be the “perfections of thought” (Paul, 1992), i.e. the normative constraints on what is a good argument or a valid pattern of inference.

The psychological approach is more concerned with how people actually reason than with how they should. They define critical thinking in terms of behaviour and mental processes. As an example, Willingham (2007) defines critical thinking as “seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts, solving problems, and so forth”.

Finally, educators have also been active in the discussions about critical thinking, bringing important practical contributions by their familiarity with the classrooms, and bringing interesting concepts (e.g., Bloom's taxonomy; Athanassiou, McNett & Harvey, 2003) even if some have been criticized as too vague (Paul, 1985).

Although the approaches and definitions of critical thinking brought but those strands differ from each other, they also agree on important points:

First, they all agree that critical thinking comprises a set of abilities such as analysing arguments, claims or evidence (Ennis, 1985), making inductive or deductive inferences (Facione, 1990; Tindal & Nolet, 1995), judging or evaluating (Lipman, 1988; Case, 2005) and making decisions and solving problems (Willingham, 2007). Second, they agree that critical thinking is not only a matter of skills, but that one also has to consider the dispositional dimension; i.e. a tendency to use its critical thinking skills when relevant encompasses, e.g., a willingness to entertain others' viewpoints (Bailin et al., 1999), and a desire to be well-informed (Ennis, 1985). Last, the importance of background knowledge is recognized (Lai, 2011).

### 1.2.2. Teaching & assessing critical thinking

On the possibility of teaching critical thinking in an efficient manner, there is some consensus about a few general features: in order to be efficient, a training program must be explicit as to its objectives and methods and be rooted in different scholar disciplines to prompt transfer (Willingham, 2007; Gauvrit & Pasquinelli, 2017). These general features however do not guarantee any efficiency: as for any educational intervention, the practical knowledge of people teaching in the classroom is indispensable to make educational innovation effective. Ideally, any program aiming at developing critical thinking should include researchers and teachers working together.

Anyone wishing to validate a method to promote critical thinking in the classroom in France will face a difficulty when the question of measurement arises. There are several critical thinking scales available internationally, but few are translated in French (but see Auriac-Slusarczyk, Adami & Daniel, 2011). Nelly Darbois, a CORTECS member, published an online review of existing tests of critical thinking . She found 5 tests existing in French version (not always properly validated), including one (Cornell critical thinking test) suitable for children:

- *The California Critical Thinking Disposition Inventory* (CCTDI; Facione & Facione, 1990) focuses on the dispositional aspect of critical thinking;
- *The Watson Glaser Critical Thinking Appraisal* (WGCTA ; Watson & Glaser, 1980) is designed for adults participants;
- *The Cornell Critical Thinking Test X and Z* (Ennis, Millman & Tomko, 1985) are designed for children and teenagers and were translated by Boisvert (2002), but we could not find any validation of the French version;
- *The Ennis-Weir Critical Thinking Essay Test* (Ennis & Weir, 1985) is not relevant for children (participants have to write an essay responding to a letter) and only measures fallacy detection. Too narrow in scope, the French version of this test has never been validated to the best of our knowledge;
- *The General Analytical Aptitude Test* (GAAT) – Critical Thinking. No scientific publication could be found about this test designed for adults.

### 1.2.3. Our positioning

Considering all of the above-mentioned elements, a preliminary fresh synthesis of the definition(s) of critical thinking, informed with empirical elements about the factorial allure of critical thinking, is in order. In this vein, an approach mixing philosophy and psychology in the study of reasoning is certainly appropriate (Smith & Casati, 1994; Casati & Varzi, 1997; Pasquinelli 2014). Such approach is deemed to enlighten on-going research — especially those performed by members of the present consortium — in reasoning on abstract material (Dieguez, Wagner-Egger, Gauvrit, 2015; Pasquinelli, 2009), or in relation to emotional influence on decision (Bagneux, Font & Bollon, 2013; Bollon & Bagneux, 2013), in a social environment (Ernst-Vintila, Delouée & Roland-Lévy 2011) in the Internet era (Bronner, 2011).

Paradoxically, the numerous critical thinking training projects sent by teachers in response to the French Ministry of Education 2016 call are not yet subject to any conceptual or empirical scrutiny. In a sense, it is high time to apply critical thinking to critical thinking training. Some members of the consortium (Gérald

Bronner, Elena Pasquinelli for the Fondation La main à la pâte, Nicolas Gauvrit, and Sylvain Delouvé) have pleaded with the Ministry of Education Cabinet for setting up a system of rigorous evaluations.

The French Direction de l'évaluation, de la perspective et de la performance (DEPP) - the statistics analysis department devoted to evaluating and analysing progress in the domain of education and training, related to the Ministry of education - is now formally involved and several collaborations have been established with members of the consortium (Nicolas Gauvrit, Fondation La main à la pâte). The DEPP will implement the future critical thinking scale online, help gather data on large-scale samples, and provide assistance in the sampling and gathering of data.

Notwithstanding the importance of a scientific approach to critical thinking training, we cannot expect building a training program without the active implication of teachers who have a front-line expertise. This is why this project includes a member of Innovaxiom who regularly trains adolescents and adults in creativity and decision making, as well as Fondation La Main à La Pâte (supported by the French Academy of science, the École normale of Paris and Ecole normale Lyon), with a longstanding expertise in developing pedagogical resources for primary and secondary school teachers and in teachers' professional development aimed at the enhancement of science education. The Fondation La main à la pâte can count on a large network of teachers and researchers in various domains of science, including researchers in education and cognitive science. This collaboration between researchers and teachers will help design a training program relevant to the children we target.

This project does not build upon a previously funded project, nor do we have any other funding available.

### **1.3. Risk management and methodology**

The various studies (pilot study for the critical thinking scale, validation of the critical thinking scale, pilot studies of training program, impact analysis of the training program) included in the project are mostly based on quantitative observations and on the experimental method. The validation of scales of critical thinking will be done according to the standard psychometric methodology (e.g., Item Response Models). The pilot study of the training program will use the qualitative analysis of voice recordings and filmed sessions. The impact study of the intervention, which forms the core of the project, will be carried out using a post-test pre-test with a control group. These studies require the recruitment of large samples, which will be warranted by the DEPP.

Concerning the impact analysis, the Fondation La Main à la Pâte will grant access to a large sample of classes, via the network of schools that have an established relationship with the Fondation (Pilot Centers Network, Experimental Middle Schools Network), and via the teachers who regularly access the La main à la pâte web site (300,000 visits per month, 40,000 subscriptions).

The main risk associated to this project would be to find no effect of the critical thinking training program. This is however unlikely, since the program will be based on principles that have been validated internationally. However, if we were to find out that the final training has no positive effect, the tools developed during the project to measure critical thinking will be available to analyse the impact of other — and for some, already running — critical thinking training used in the classrooms.

## **2. Project organization and means implemented**

### **2.1. Scientific coordinator**

Nicolas Gauvrit is the scientific coordinator of this project. He has a multiple background in mathematics (ENS Lyon), psychology (University Paris-Saint-Denis) and cognitive sciences (cogmaster, EHES-ENS-X) in which he holds a PhD and HDR. He has taught and performed research in the field of experimental psychology of reasoning, applied mathematics, and educational studies. This multiple background will help bridge the different disciplines represented within the consortium.

His research focuses on probabilistic reasoning as a means to explain irrational beliefs, the Bayesian approach to randomness perception, the application of algorithmic complexity to the psychology of belief and educational psychology in relation with mathematics and reasoning. Since 2014, he has published on this subject, e.g., in *Cognition*, *Psychological Science*, *PLOS Computational Biology*, *Visual Cognition*, or *Behavior Research Methods*.



Nicolas Gauvrit has been devoted to the diffusion of critical thinking to the general public for more than ten years. He published 12 books and chapters on that subject matter such as *Statistique méfiez-vous !* (Ellipses, 2007) about fallacies in statistics, *Causes toujours* (Book-e-Book, 2013) co-authored by the philosopher Isabelle Drouet about the notion of causality or *The Myth of an Afterlife* (Rowman & Littlefield, 2015), a critical approach to claims of evidence for an afterlife. He also published more than 80 diffusion papers, some in prominent journals such as *Skeptics*, *Skeptical Inquirer*, *Pour la Science*, *Cerveau et Psycho*, *Le Monde*, promoting evidence-based education and critical thinking.

He has been invited by the French Ministry of Education to join the pilot committee of the “critical thinking education” project in September 2016. On the Ministry’s request, he gathered a team of 4 researchers in 2017 (including Sylvain Delouvé and Katia Terriot, involved in the present project), to start thinking about new means to assess critical thinking in the classroom. Through the *espritcritique.info* website created in August 2016, he collaborates with the CANOPÉ Network, co-producing educational short videos (researchers’ interviews) targeting in-service and prospective teachers. Seven videos have been shot as of March 2017, with interviews of Gérald Bronner and Elena Pasquinelli. The website *espritcritique.info* was thought of as a platform to bridge science, institutions and society on the question of critical thinking and its education.

For more than a year now, he has occasionally contributed to Fondation La Main à la Pâte projects linked with developing a scientific and more critical reasoning in children, together with 4 of the members of the present project. He also contributed to the think tank COMPAS (Institut Jean Nicod, ENS) by giving seminars on reasoning, pseudo-sciences, and the perception of randomness. Two members of the consortium, Elena Pasquinelli and Roberto Casati, also contributed to this think tank. He launched a series of training sessions toward pre-service teachers in 2017.

Nicolas Gauvrit will participate in the management of the project and bridge the different teams together. He will also take active participation in all work packages.

## 2.2. Consortium

The consortium is constituted by of 11 members from 7 scientific research and dissemination institutions, as well as 4 external advisors.

### 2.2.1. Partners

**CHArt-EPHE** — Human and Artificial Cognition (EA 4004). This multidisciplinary laboratory is attached to the École Pratique des Hautes Études and benefits from a tradition of interdisciplinary collaboration. N. Gauvrit (project coordinator) is pursuing research in human reasoning and education at the frontier of mathematics and experimental psychology.

**CRP-CPO** — Center for Research in Psychology: Cognition, Psyche et Organisations (EA 7273). This research unit located at the University of Picardie Jules Verne includes all psychology approaches. M. Hainselin develops researches on cognitive psychology, neuropsychology, education, metacognition and critical thinking.

**IJN** — Institut Jean Nicod (UMR 8129) is a research institution in cognitive sciences dependent on both ENS and EHESS. Roberto Casati will represent the institute and coordinate the task of defining critical thinking and review existing literature. Casati has developed an approach to philosophy as a form of conceptual negotiation, which is crucial for finding suitable ground for empirical studies of typically hard-to-define concepts (such as parts, events, objects, and more to the point, presence in virtual reality settings, augmented cognition, or innovation in education). Critical thinking is one of the concepts most in need of a proper definition, so as to facilitate multidisciplinary cross feeding and a fully empirical approach. Casati and his team will deploy their expertise in conceptual characterization so as to provide a definition of critical thinking that will interface different settings - schools, daily life decision-making, and academic research. IJN researchers work on several philosophy and cognitive science topics related to critical thinking, such as metacognition, social cognition, reasoning and biases, perceptual illusions, the facilitation of translational research in education (e.g. the Education, brain and cognition CogMaster course

and the Innovation, Education and society seminar at EHESS, both coordinated by Casati and Pasquinelli.)

**INNOVAXIOM** — This company has been working in the field of professional training (e.g. in creativity and critical thinking for decision making) for 10 years, as well as in the field of scientific dissemination. It regularly collaborates with prominent research institutes in France such as the CNRS, the CEA and the CNES. Laurence Honnorat will lead WP 5 (dissemination), but will also be involved in the creation of educational material (WP 3).

**LAMAP** — The mission of the Fondation La Main à la Pâte is to help teachers transmit and understand the scientific approach, to favor teachers' professional development in the domain of science teaching, and to develop pedagogical resources and tools that help teachers teaching science as a form of inquiry. It is widely represented in this project, especially in WP 3, with 4 people involved (K. Allégraud, M. Farina, E. Pasquinelli, G. Zimmermann). During the last three years, LAMAP has put teaching critical and scientific thinking at the center of its reflection and objectives. Science is in fact a natural domain for critical thinking. On the one side, science is grounded on methods and tools aimed at rigorously identifying facts and building solid theories and explanations for observed phenomena. These methods and tools can be taught, implicitly and explicitly, to students of all ages, in an appropriate manner in relationship with their development. Even if it helps, teaching science is not enough to foster critical thinking (Willingham 2007, Marin & Halper, 2011), and dedicated methods should be envisaged in close connection with science education, and namely with the education to scientific thinking, the nature of science, and scientific attitude. It is one of the main objectives of LAMAP to foster this kind of thinking through dedicated pedagogical resources, teachers' training and community management. Thanks to a network of several hundreds teachers, LAMAP will also make it possible to carry out studies on a large scale for the evaluation of interventions.

**LIED-P7** — Interdisciplinary Laboratory for Future Energies (UMR 8236), University Paris Diderot, CNRS. This multidisciplinary laboratory will be represented by G. Bronnera a sociologist known for his studies of the diffusion of rumours and his involvement in the development of intervention aimed at developing critical thinking in youth at risk of radicalization.

**LP3C-R2** (ex. CRPCC) — Laboratory of Psychology: Cognition, Behavior, Communication (EA 1285). S. Delouée pursues research in social psychology on judgment errors within this laboratory of the University Rennes 2. Yvonnick Noël is an expert in psychometrics, co-developer of the TACIT portal for the assessment and remediation of implicit comprehension among children.

### 2.2.2. External advisors

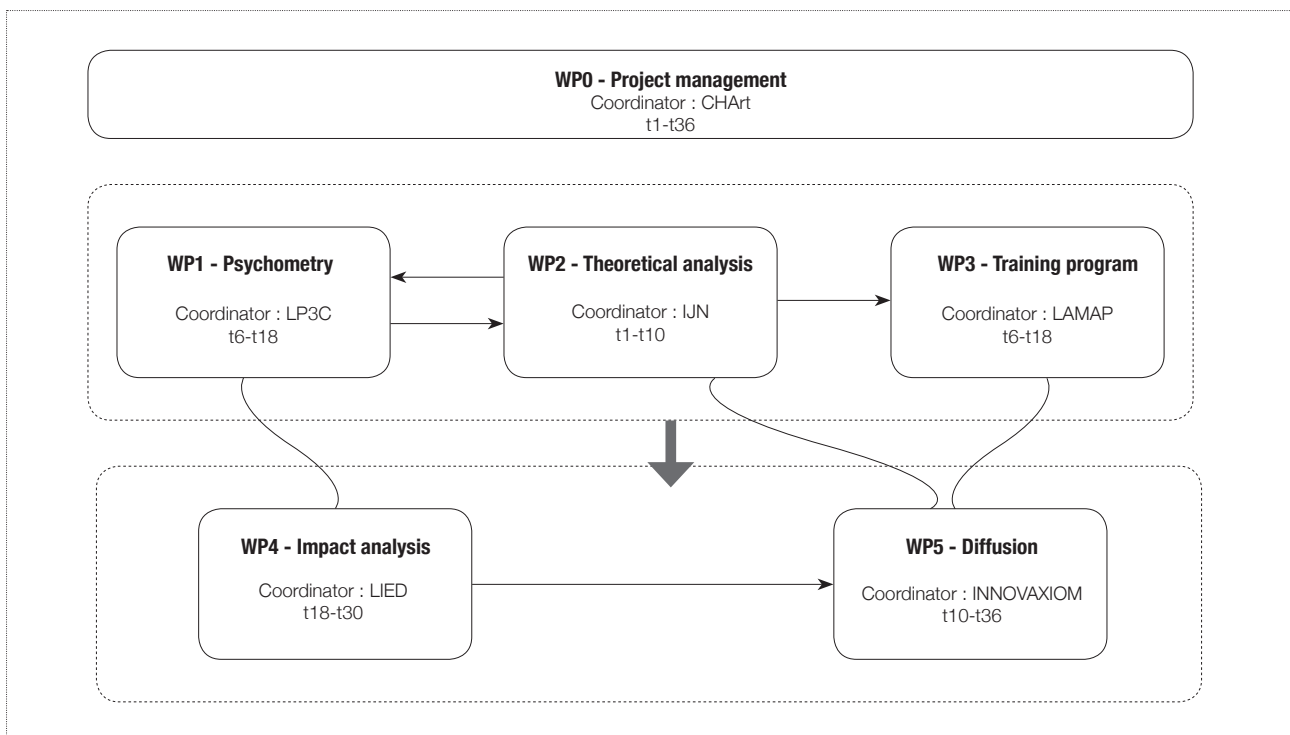
The following people have agreed to be part of an expert group: Franck Ramus is senior researcher (DR) at the CNRS (ENS). Katia Terriot is an educational psychologists from Institut National d'Étude du Travail et d'Orientation Professionnelle (INETOP). They will act as scientific advisors. Christophe Michel is a teacher, host of the YouTube channel "Hygiène Mentale", and already participates in critical thinking education experiments. Florian Gouthière is a mediator and scientific journalist at France 5. Both will act as mediation and dissemination advisors.

### 2.2.3. Rationale of the consortium

The extended consortium (members plus experts) was created bearing in mind that our project was by nature requiring a variety of views. First, there is a need for several disciplines.

- Philosophy (Roberto Casati, Elena Pasquinelli) in the reflexion toward a definition of critical thinking. Also, philosophy is one of the disciplines most involved in the critical thinking education discussion.
- Several fields within psychology: Social psychology and psychometrics (Sylvain Delouée, Yvonnick Noël), cognitive psychology (Franck Ramus, Mathieu Hainselin) and educational psychology (Nicolas Gauvrit, Katia Terriot).
- Sociology (Gérald Bronner) to grant a larger view on the effect of the Internet of our beliefs and manners of reasoning.





Second, we gathered both theorists and practitioners with an expertise in disseminating and teaching critical thinking. Their view is indispensable to design a curriculum that will in the end be applicable in real classrooms. This is why the extended consortium includes Laurence Honorat, a trainer with an expertise in science dissemination, Florian Gouthière, a TV journalist expert in science dissemination and critical thinking, as well as Christophe Michel, host of a renowned YouTube Channel on critical thinking. It also includes four members of the Fondation La main à la pâte with an extensive expertise in the development of educational resources, teachers' training and the management of communities of teachers (Gabrielle Zimmermann, Katia Allégraud, Mathieu Farina and Elena Pasquinelli).

The members of the consortium have a history of collaboration. Elena Pasquinelli is an associate member of the Institut Jean Nicod where she worked with Roberto Casati. She organized seminars on educational topics, in which Franck Ramus and Nicolas Gauvrit contributed. Nicolas Gauvrit, Sylvain Delouvé and Gérald Bronner have been working together on radicalization and participated in the seminar on beliefs organized by Gérald Bronner. Christophe Michel and Nicolas Gauvrit are regularly meeting during events about critical thinking, e.g. organized by the observatoire zététique, an association promoting the scientific method and rationality. Gabrielle Zimmermann, Katia Allégraud, Mathieu Farina, Nicolas Gauvrit and Elena Pasquinelli are already working together in the field of education to scientific reasoning and critical thinking. Laurence Honorat and Nicolas Gauvrit give trainings in critical thinking and decision making together at the École Centrale-Supelec.

### 2.3. Means of achieving the objectives

The objective of this project is to scientifically establish a critical thinking education program in the framework that is currently taking shape, proposing a first tested and validated canvas. More precisely, the project consists of 5 connected Working Packages or WP (plus a WP0). WP1 is the development of an operational definition of critical thinking based on an inventory of Scientific and philosophical publications on the subject, as well as a synthesis of current educational practices. WP2 concerns the construction and validation of a psychometric scale for measuring critical thinking in accordance with this definition. WP3 is the implementation of teaching resources aimed at developing the critical spirit from 3rd grade to 9th grade. The implementation includes the follow up of teachers having adopted the teaching resource. WP4 encompasses a pilot study and the impact study of these teaching resources via the measurement tool developed. WP5 concerns the dissemination of the results of the project (scales, pedagogical resources, impact analysis) to institutions, education actors and the general public

as well as the implementation of training for pre-service and in-service teachers and trainers, thanks to the support of the La Main à la Pâte Foundation.

The means to achieve our objectives are listed below, on a task-wise basis.

### 2.3.1. Work packages breakdown

Figure displays the task (WP) breakdown and their relations. Here is a list of specification of the different WP except WPO (management).

#### WP0. Project management. Leader: Nicolas Gauvrit (CHArt-EPHE)

As project coordinator, CHArt-EPHE will guarantee the good achievement of management and coordination actions. This includes:

- providing the technical, financial and administrative coordination for the project in accordance with the objectives set for the whole project and with all guidelines provided by the ANR agency;
- ensuring efficient communication internally (between partners) and externally (with ANR agency, Advisory board, and target groups of the project).

#### WP1. Theoretical analysis. Leader: Roberto Casati (IJN)



**Objective:** reviewing existing literature on critical thinking with a focus on the definition problem and the measurement issue.

**Means to achieve this objective:** 2 one-day meetings with the extended consortium

**Indicator of success:** submission of a generic paper to a scholarly journal

Partners' contribution: All members of the consortium will participate, as well as the research engineer

**Work program:**

- from t1 to t4 (4 first months), we will create a shared Zotero bibliography and a shared synthesis document on a private page on the website espritcritique.info.
- from t4 to t6, we will continue and organize 2 meetings with the extended consortium to complete a consensus document about (1) a working definition of critical thinking (2) a review of existing assessment tools
- from t6 to t10, we will write and submit a review paper on critical thinking.

**Deliverables:** technical report or review paper

**Methods, risks, etc.:** review of literature, meta-analysis.

#### WP2. Psychometry. Leader: Sylvain Delouée (LP3C-R2)



**Objective:** creating and validating a French scale of critical thinking suitable for children from grade 3 to 9.

**Means to achieve this objective:** a small sample for preliminary qualitative study ( $n \approx 40$ ), a medium diverse sample for further analysis ( $n \approx 200$ ), a large stratified sample for final calibration and validation ( $n \approx 1400$ , i.e. around 200 by grade level). The DEPP and LAMAP will help gather these samples.

**Indicator of success:** publication of the proposed test of critical thinking in a scientific journal

**Partners' contribution:** Nicolas Gauvrit, Yvonnick Noël, Mathieu Hainselin and the research engineer will act under the supervision of Sylvain Delouée on this part of the project for the theoretical part.

Mathieu Farina, Katia Allégraud, Gabrielle Zimmermann will ensure the test is suitable for targeted participants. All consortium members will act as advisors.

**Work program:**

- from t6 to t10: based on the first part of the theoretical review (WP1), we will create a first version of a critical thinking test
- from t10 to t11: first study with small samples of children to ensure the test is adequate for targeted children, one or two rounds to get version 1 of the test
- from t11 to t13: second study to evaluate version 1 and create version 2 of the test
- from t14 to t18: large calibration study and publication of the test

**Deliverables:** psychometric validation report

**Methods, risks, etc.:** Item Response Models, classical psychometric methods. In case the creation of the scale takes more time than expected, we will start the impact analysis using existing (although less reliable test, such as the Cornell) as pre-test.

**WP3. Training program. Leader: Elena Pasquinelli (LAMAP)**



**Objective:** designing and implementing in pilot classes a complete training program for critical thinking, grades 3-9.

**Means:** meeting of the consortium (t10). The LAMAP foundation manages a huge network of teachers willing to develop scientific and critical thinking in children. This network will be useful in testing the first versions of the training in the classrooms. The research engineer and trainees will also participate in this investigation. For WP3, the network of teachers will receive the training program. The LAMAP team will follow the teachers during the implementation of the program in the classrooms.

**Indicator of success:** publication of the training program on the LAMAP website or by an editor.

**Partners' contribution:** Elena Pasquinelli, Mathieu Farina, Gabrielle Zimmermann and Katia Allégraud will work on this part of the project. Christophe Michel, Roberto Casati, Laurence Honnorat and Gérald Bronner will act as advisors. Laurence Honnorat and trainees will observe classrooms and capture vidéos, get teachers feedback and analysing the first versions on the program.

**Work program:**

- from t6 to t12: creation of the first version of the program
- from t12 to t14: classroom testing to adjust the program and write version 1.0
- from t14 to t16: classroom testing of version 1.0
- from t16 to t18: final proof-reading and web-publication of version 2.0

**Deliverables:** the complete program implemented in the classrooms, video recordings.

**Methods, risks, etc.:** didactic engineering, qualitative study and observations in the classroom (video recording and analysis of interactions, a priori analysis, analysis of pupils' reaction).

**WP4. Impact analysis. Leader: Gérald Bronner (LIED)**



**Objective:** assessing the effect of the program designed in WP3.

**Means:** Trainees and the research engineer will help collect and analyse data.

**Indicator of success:** submission of a scholarly empirical paper.

**Partners' contribution:** the analysis will be performed by the research engineer and two trainees

under supervision of Gérald Bronner and Yvonnick Noël. Christophe Michel, who already participated in a similar qualitative study, will act as advisor.

**Work program:**

- from t18 to t21: as soon as the program is published on the LAMAP website, a call for participation will be launched so that in-service teachers willing to participate in the test can volunteer (the LAMAP network includes several thousands of teachers). The selected teachers will be randomly assigned to the test or control group, and will have their pupils take the (online) test in the classroom themselves — some classes will be selected to be visited by trainees who will come and administrate the test.
- from t22 to t28: some randomly chosen classes will be visited by trainees for video recording and qualitative analysis
- from t28 to t30 the teachers who have accepted to participate in the experiment will have their pupils pass the critical thinking scale a second time (posttest).

**Deliverables:** statistical analysis and observational data report

**Methods, risks, etc.:** quantitative multivariate methods or ANCOVA using our assessment tool, pretest-posttest design. A complementary qualitative analysis (a few class sessions observations) will also be performed. In case the data do not support the efficiency of our program, we will use the observational data to provide a fine-grained analysis of the reasons why the program failed and suggest directions for future research and program design.

**WP5. Diffusion. Leader: Laurence Honnorat (INNOVAXIOM)**



**Objective:** disseminate the results of the project to the general public, the science community and the educational community

**Means:** a website will be deployed, a press conference as well as a restitution conference

**Indicator of success:** submission of two books (one scientific, one for the general public), radio broadcasts, the number of connections to videos

**Partners' contribution:** All members of the consortium will take part in this WP under the supervision of Laurence Honnorat. Florian Gouthière will help target the journalist and media, Christophe Michel will help target the teachers.

**Work program:**

- from t10 to t36: community management to get a pole of interested teachers, citizens and education managers
- from t30 to t36: submission of papers in general public journals, contact with education administration to launch training session in critical thinking toward teachers, journalists, etc.
- t36: restitution conference in Paris.

**Deliverables:** a press release, video links.

*2.3.2. Justification of resources sought*

In order to reach the objectives, the resources we will need (total 307 k€), sorted by member and expressed in k€ are listed here (without 8% environment costs):

**CHART-EPHE** (Nicolas Gauvrit, WP0, management) – Research engineer (120); overhead costs (7; travel expenses and conference fees for experts and members of the consortium); services (17; community management and restitution conference). **TOTAL: 144k€**

**CRP-CPO** (Mathieu Hainselin) – Service provider (14; sampling, video capture...). Overhead costs (14; travel expenses and conferences fees, meetings with experts). **TOTAL: 28k€**

**IJN** (Roberto Casati, WP1, review) – Overhead costs (27; conferences, books, meetings with experts and travel expenses). **TOTAL: 27k€**

**INNOVAXIOM** (Laurence Honnorat, WP5) – Services (10; press conferences, video capture, media relation...). Overhead costs (5; travel expenses and conferences fees). **TOTAL: 15k€**

**LAMAP** (PI: Elena Pasquinelli, WP3, training program) – Material (3) ; non-permanent with funded requested (29); service (3). **TOTAL: 35k€**

**LIED** (Gérald Bronner, WP5, impact) – Service (10; translation, proofreading and publication fees); overhead costs (10; conferences, books, meetings with experts and travel expenses). **TOTAL: 20k€**

**LP3C** (PI Sylvain Delouvé, WP4, psychometrics) – Material (5; computer); services (18, critical thinking scales, website creation and maintenance); overhead costs (15; conferences, books, meetings with experts and travel expenses). **TOTAL: 38k€**

### 3. Impact and benefits of the project

#### 3.1. Scientific, educational and social impact

The results of the project will have scientific, educational and social impact.

##### 3.1.1. Scientific aspect

Despite the long-standing and continued international interest in the assessment of critical thinking skills and dispositions, there still is no assessment tool available in French for the primary school through high-school students, to the best of our knowledge. Most tests have only been validated in English or other non-French languages (El Hassan & Madhum, 2007; Stupple et al., 2017, Ennis, Millman & Tomko, 1985), and were designed for college students or adult participants (Butler, 2012; Wagner & Harvey, 2006; Facione, 1991). One exception concerning the age of participants — targeting primary school — has been released recently (Gelerstein et al., 2016). To the best of our knowledge however, no validated psychometric test of critical thinking skills and disposition exists in French for children of age 8-14 years. One important although not final objective of the present project is to provide a theoretically sound psychometric scale to assess critical thinking. Plus, we will include an important aspect of critical thinking in the 21st century that is missing in most existing tests: abilities to gather and gauge information from the Internet.

##### 3.1.2. Educational aspect

The French ministry of Education has recently pushed an ambitious program aiming at developing critical thinking in students. This objective is far from recent, but a novel move was made to change existing (and possibly inefficient) methods. Reasons for the apparent failure of previous attempts to teach critical thinking encompass

- A lack of explicit information about how to do so directed toward future teachers
- A lack of formalization of methods used by teachers who each were invited to build their own method
- The fact that educational methods used in class were built without reference to the existing scientific corpus — for instance, most of them are implicit, whereas explicit methods are known to be more efficient
- The absence of empirical validation of methods or comparison between methods.

In line with the growing strand of evidence-based education, our aim is to build and assess an educational tool to enhance critical thinking skills and disposition. This is new in three respects. First, this will be the first attempt to ground such a class on the scientific existing evidence, in France at least. Second, this class will go from primary to high school in a homogenous and reasoned manner. Last, this will be the first time in France that such a program will be scientifically tested — but see McMillan (1987) or Tiruneh, Verburgh and Elen (2014) for a meta-analysis of international studies.



### *3.1.3. Social aspect*

The recent boom of interest in critical thinking education was prompted by social and political concerns. After the deadly attacks in Charlie Hebdo and Le Bataclan, the issue of radicalization was raised. It turned out that one factor explaining why ordinary people could embrace hazardous ideology, sometimes leading to radicalization, the justification of terrorism and to mere violence, is the power of the Internet and the shallowness of critical thinking of many while surfing online (Bronner, 2015). In parallel to de-radicalization policies, Information and Media Education was put forward, as part of the more general purpose of critical thinking. Thus, teaching critical thinking is not only a matter for schools but also, more generally, a social global issue. Developing critical thinking is a means to reduce radicalization.

Possibly less mediatized, but certainly more widespread than radicalization, irrational beliefs and pseudo-sciences are also spreading both online and “away from keyboard”. Although this might seem anecdotal, pseudo-scientific beliefs may have important social negative outcomes. For instance, the anti-vaccine movement is becoming so popular that it now poses a global health risk to the population (Pacotte, Delouvé & Rateau, 2013; Jacobson, Targonski & Poland, 2007). In the same vein, concern was raised by climate change denial in the political class (Dunlap, 2013; Lewandowsky et al., 2015). We can certainly not expect critical thinking education to annihilate endorsement of such unfounded worrisome ideas in the population. However, we do believe that it could have an impact that will matter.

### **3.2. Relevance to the ANR 2018 work programme challenge**

This project directly address the fourth axis of challenge number 8 of the ANR 2018 call by proposing new tools to develop integration and adaptation to the community. More precisely, the 4th axis emphasizes (1) education, which is the main field of the present project, (2) cognitive capacities, which is (with the dispositional aspect of critical thinking) a main target of the present project and (3) lifelong formation, which is granted by our effort toward teachers’ in-service training. This project is also clearly relevant to challenge 11, 4th axis.

Cognitive capacities. Our project aims at developing critical thinking skills and disposition in children. This includes the ability to depart knowledge from beliefs, information from myths. And this is a crucial prerequisite to autonomous lifelong learning. In this respect, the project is particularly relevant to this issue.

Educational innovation. Our project is innovative in two ways. First, the reflection on the education to critical thinking is still to be done in France. Indeed, although critical thinking is pointed at as an issue of primary interest, the Ministry of Education just launched, a few months ago, a first call to gather projects from in-service teachers. Many of these projects are interesting, but all are restricted to certain grades and fields, contrary to the present one. Second, our project will hopefully stimulate a movement toward evidence-based education. Evidence-based decisions is nowadays seen as obvious when it comes to medicine, but for some reason it is still not the case in education. Paradoxically, even those who profess to teach critical thinking often fail to apply critical thinking to their own methods, and test it rigorously. In that respect too, our project is innovative.

### **3.3. Dissemination and exploitation strategy**

Our project will be useful to the community, not a particular corporation. Therefore, we do not intend to commercially exploit any of its outcomes. On the other hand, given the nature of this project, the dissemination strategy is crucial; and since the project’s objectives include scientific, educational and social targets, dissemination was thought within this threefold framework.

#### *3.3.1. Scientific communication*

All the scholar members of the consortium will take part in the dissemination of the scientific results of this project, under the supervision of Laurence Honnorat who has an expertise in the field.

Scientific dissemination canals include conferences, scientific journals and books. Concerning conferences, we will target both international and national conferences. Given the national importance

of the project, targeting French-speaking communities makes sense. Conferences on education will be favoured. We plan three international conferences and three national conferences. The last national conference will be the restitution conference, possibly taking place either at the Institut Henri Poincaré (IHP) or the École Normale Supérieure in Paris to maximize its symbolic impact.

Concerning scientific papers, we will submit at least

- One review paper at the end of stage 1 about the theoretical and operational definitions of critical thinking, in a philosophy of psychology journal such as *Informal Logic*
- One or more technical manuscript(s) about the validation of the French scale of critical thinking, for instance to *Psychological Assessment* or *Educational and Psychological Measurement*
- Several (e.g. according on the grades under scrutiny) papers in educational or applied psychology journals such as *Applied Cognitive Psychology* or *Thinking Skills and Creativity*.
- Last, we will publish two collective books:

The first one, in French, will review existing literature about education and critical thinking, and will also include accounts from educators. This book is already in progress and will contain chapters from about 20 authors, including Mathieu Hainselin, Elena Pasquinelli, Gérald Bronner, Sophie Mazet, Sebastian Dieguez, Pascal Wagner-Egger. We expect to have this book published in 2019.

The second one, in English, will review more thoroughly and in a more academic manner what we know about critical thinking education and what our project will add to the existing literature. This book will be planned later, near the end of the present project schedule. We will appeal to prominent authors such as Diane Halpern and Daniel Willingham. Possible publishers include Springer, World Scientific and Rowman & Littlefield.

### 3.3.2. Educational dissemination

The educational dissemination is crucial and includes two stages. First, before the educational material is tested, educators should be familiarized with the notion of critical thinking. This sensitization stage has already begun. Once our educational toolkit is validated, the second stage, aiming at presenting these particular tools will start. The means used in our strategy to disseminate knowledge about critical thinking to educators include:

- Collaboration with CANOPÉ to produce videos targeting teachers. Seven videos (interviews with Elena Pasquinelli and Gérald Bronner) are already realized and will soon be available on the CANOPÉ website . More videos with interviews of other scientists such as Franck Ramus (acting as scientific expert in the present project) are planned. INNOVAXIOM will help build more videos in this line.
- Professional development for teachers. Information about critical thinking and how to teach it should be part of teachers' regular background. LAMAP is a recognized actor in the professional development of in-service teachers and teachers' trainers. The Fondation has established a national network of Maisons pour la science (Houses for Science). The project of the Houses of science was launched in 2012 at the initiative of the Académie des Sciences, with the support of the Investissements d'Avenir fund. The aim of the Houses for Science is to help teachers bring innovation to their science teaching practices. Each House caters to its own region, offering professional development courses to teachers from kindergarten to the final year of middle school who teach science and technology to their classes. The network is made up of 9 Houses for Science (from September 2015) and is coordinated by the Fondation La main à la pâte, which is its national center. Each Maison pour la science is located and partners with a University. The network of the Maisons pour la science will constitute an additional resource for the dissemination of the teaching resource and for the professional training of teachers to its use and aims. Other initiatives will be developed by the members of the consortium, e.g., in September 2018, critical thinking class for prospective in-post teachers will start in the "Nord de France" area, organized by the ESPE Lille-Nord-de-France. Conferences for teachers and prospective teachers are also already planned.
- Professional development for teacher educators. In complement to professional development actions aimed at teachers and prospective teachers, we will propose sessions for teachers' educators. In parallel, the consortium of this project will take contact with the ESEN and the IFE . Several members

of the consortium have already worked with these institutions by the past.

- Promoting critical thinking through the La Main à la Pâte (LAMAP) website and network. Elena Pasquinelli, member of the consortium, is in charge of the national schools network at LAMAP comprising thousands of schools. Preliminary resources about critical thinking are already available on the website and will be complemented with new articles and pieces of information as the project goes on.

Promoting longitudinal impact analysis. The present project will not be the endpoint of critically thinking about critical thinking. Follow-up studies investigating future methods should be promoted. In this respect, we will get in touch with two institutions working in the area of evaluating education, CNESCO and DEPP . A formal meeting with the direction team of the DEPP to present our calendar was held the 21st of March 2017. We are waiting for their feedback. Our proposal was to implement a longitudinal study of critical thinking skills and dispositions in students using the 2019 panel, a sample of tens of thousands of pupils followed by the DEPP.

### *3.3.3. General public dissemination*

In the last few years, a general interest in critical thinking gave birth to many initiatives in the public. Social networks groups were created and attracted thousands of users (e.g., Zététique, with more than 8,000 members as of February 2018). A variety of YouTube channels about critical thinking (e.g., Hygiène Mentale, with more than 120,000 followers as of february 2018) were launched. Books became bestsellers (e.g., Sophie Mazet's Manuel d'autodéfense intellectuelle, Robert Laffont, 2015). As one would expect, these initiatives were of unequal quality.

The general public dissemination will promote an informed scientific approach to critical thinking, pushing and collaborating with the best existing channels and creating new scientifically sound material. Because this is not within the field of expertise of all researchers, our partner INNOVAXIOM will be in charge of capturing videos, organize the community management, press conferences, final conference and the project website. ■

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