Fully Individualized Curriculum with Decaying Knowledge Problem: a Novel Hard Problem

ALEXIS LEBIS, JEREMIE HUMEAU, ANTHONY FLEURY, GUILLAUME LOZENGUEZ, MATHIEU VERMEULEN

I-SITE ULNE FIPE 2018 - APACHES.WP.IMT.FR

ALEXIS.LEBIS@IMT-LILLE-DOUAI.FR

I-SITE UNIVERSITÉ LILLE NORD-EUROPE

IMT Lille Douai
École Mines-Télécom
IMT-Université de Lille

SORBONNE UNIVERSITÉ
CRÉATEURS DE FUTURS DEPUIS 1257

Université de Lille

KU LEUVEN

Université Catholique de Lille 1875

Université Grenoble Alpes

IUT Lumière Lyon 2
Le choix de l'alternance

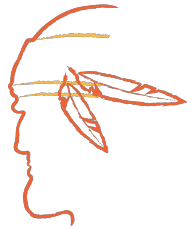
INTRODUCTION

CONTEXT

Adoption of a competency-based approach

Replacement of predefined curricula by modular curricula

→ Possibility for students to customize their curriculum to different degrees



EXT

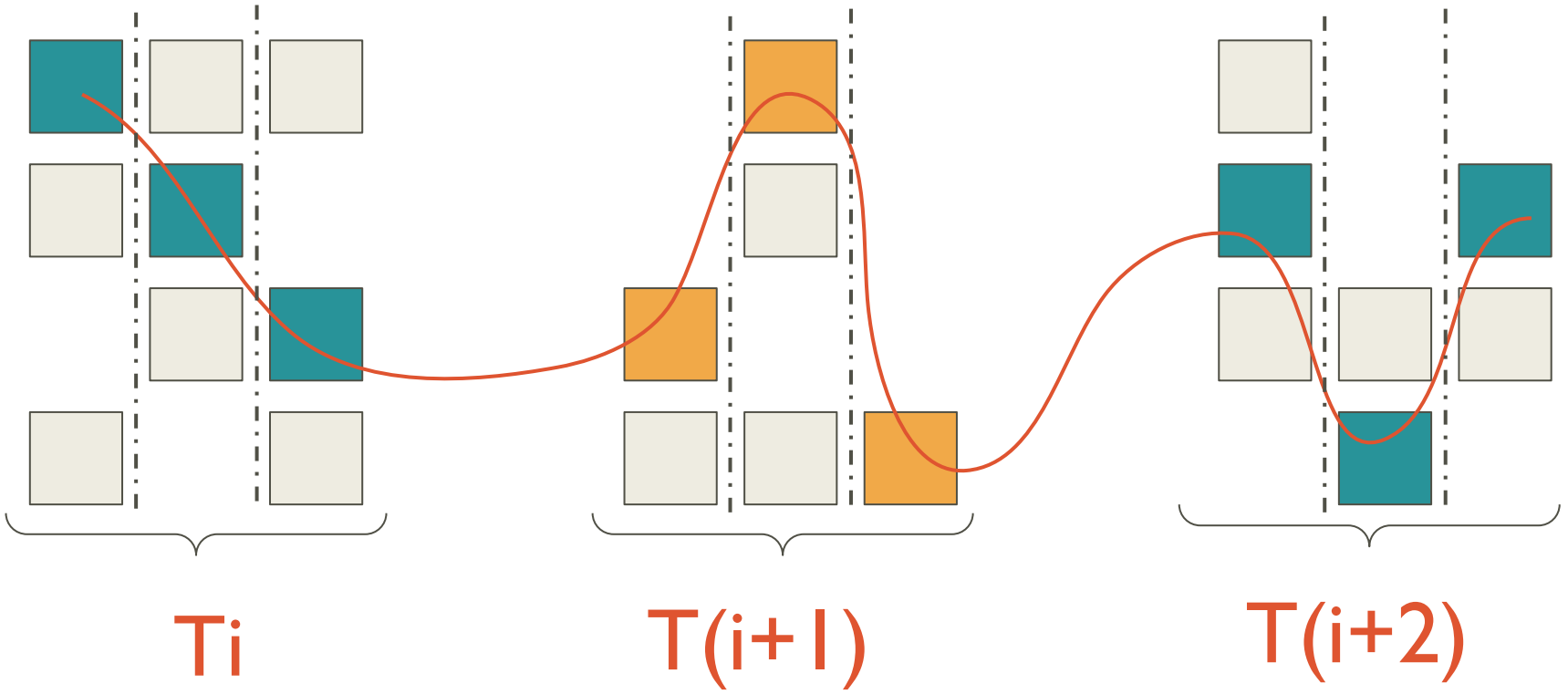
Adoption of a competency-base

Replacement ricula by modular curricula

What if: fully modular?

ility for students to customize their curriculum to different degrees

CONTEXT



Student's objective

ISSUES FOR STAKEHOLDERS

Institution

- How to attest that a certification is attainable
- How to ensure that a course is properly placed in the catalog
- ...

Teacher

- How to properly assist students with such heterogeneous backgrounds
- How to design pedagogical content, re-take exame
- ...

Student

- How to choose the best course for its personal or professional goal
- How to adapt your course in case of failure
- ...

STATE OF THE ART OVERVIEW

- ITS / E-learning platform:
  - Recommendation of pedagogical resources
  - Learning path, personalisation of experience

Principal focus

- **PERSONALISED** curriculum (and not individualised):
  - Stochastic and sequence model (Wong, C., 2018)
  - Data-driven approach (Bakenkhöler, M. et al., 2018)
  - Characterization of curriculum prerequisite (Molontay, R., et al., 2020)

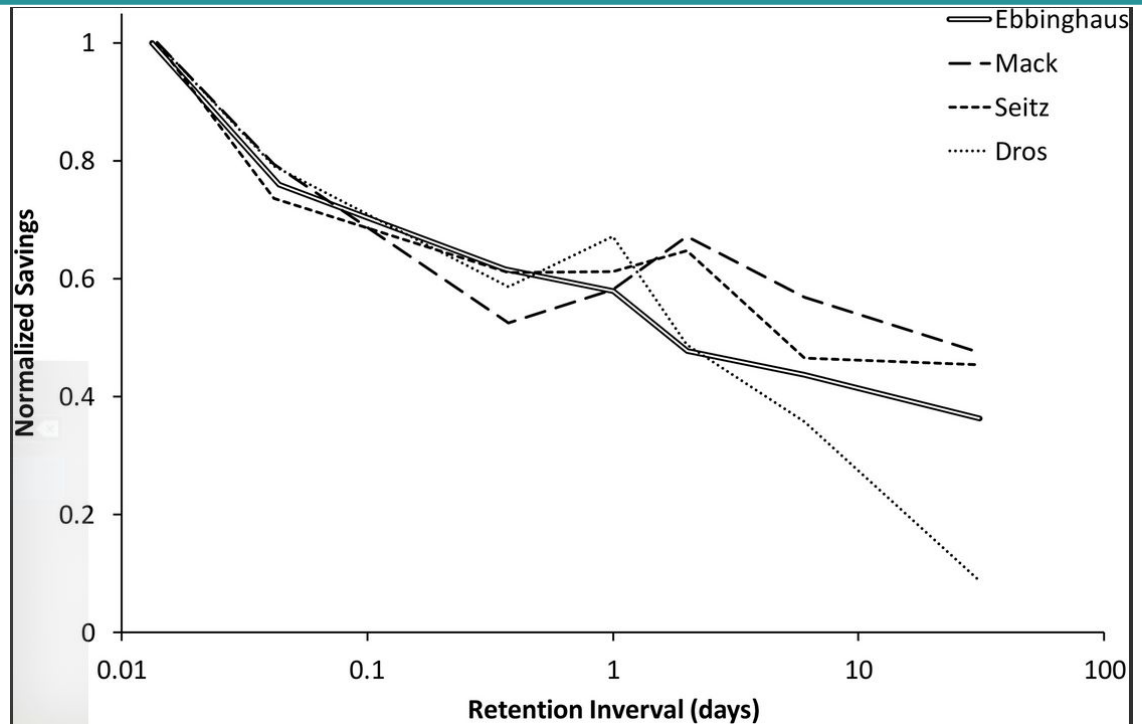
STATE OF THE ART OVERVIEW

La compétence et le profil de l'apprenant sont toujours représentés comme des monolithes agrégateurs

- **PERSONALISED** curriculum (and not individualised):
  - Stochastic and sequence model (Wong, C., 2018)
  - Data-driven approach (Bakenkhöler, M. et al., 2018)
  - Characterization of curriculum prerequisite (Molontay, R., et al., 2020)

OBSERVATION

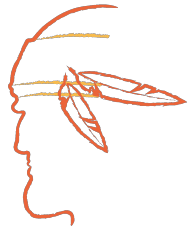
However, learned competencies are not fixed: they **evolve** over <u>time</u> (Ebinghaus ; Mack ; Dros ; Molinari…)



OUR INTUITION

Works on learning path, curriculum, prerequisites

Forgetting theory regarding competencies over time

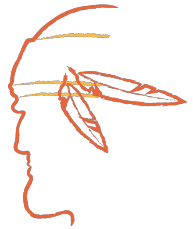


OVERVIEW OF THE PROBLEM

How to recommend, at a specific time t, a course according to some coherence criteria, which meets the training expectations of learners...

... knowing that the courses have strong prerequisites, that competence is difficult to evaluate...

... and that the competence of the learners evolve, being able to make courses not adapted in a too distant horizon?



OVERVIEW OF T LEM

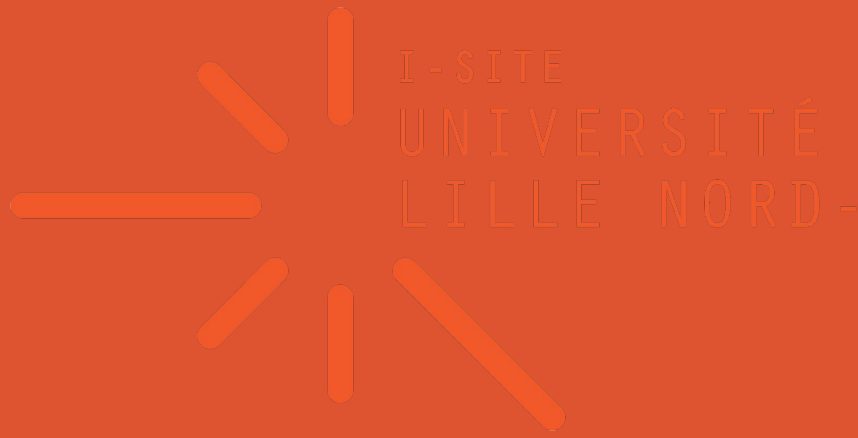
How to recommend, at a specific tim ding to some coherence criteria, which g expectations

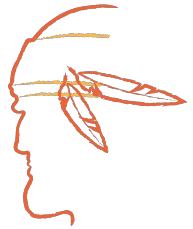
... knowing th ve strong prerequisites, that is difficult to evaluate...

competence of the learners evolve, being able to ake courses not adapted in a too distant horizon?

Well… that's a new problem! (very hard, like we'll see)

MODELING





PREMISE

We have not modeled the whole problem.

We excluded :

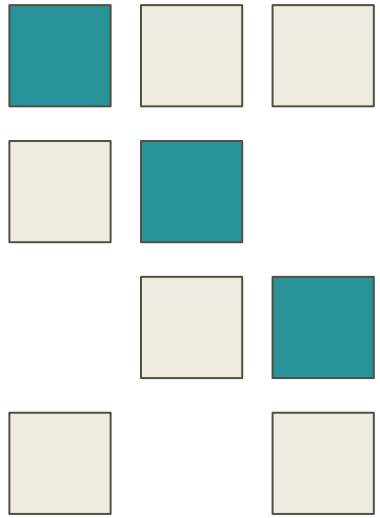
- The effectiveness of a teacher to train a specific competency
- The ability of a student to learn a specific competency
- Availability of teachers
- Availability of classrooms
- The mutability of skills outside the school context

} Modélisable par un poids dans notre proposition

} MàJ du profil etudiant en temps réel

PROBLEM DESCRIPTION

- A course *c, such that* :
  - Prerequisite (expressed as competencies and their magnitude *m*)
  - Competencies brought (how many of m_c)
  - Disponibility (*e.g.* 1st et 3rd semester)
  - ECTS credit



DESCRIPTION DU PROBLÈME

- A competence *k*, such that :
  - An id
  - A magnitude $m \in [0;1]$
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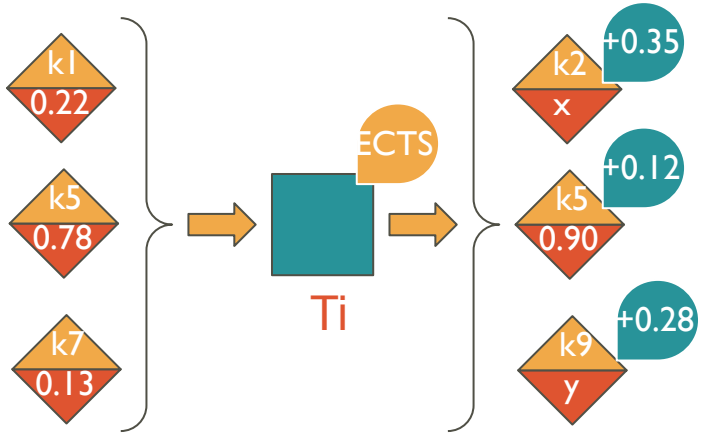

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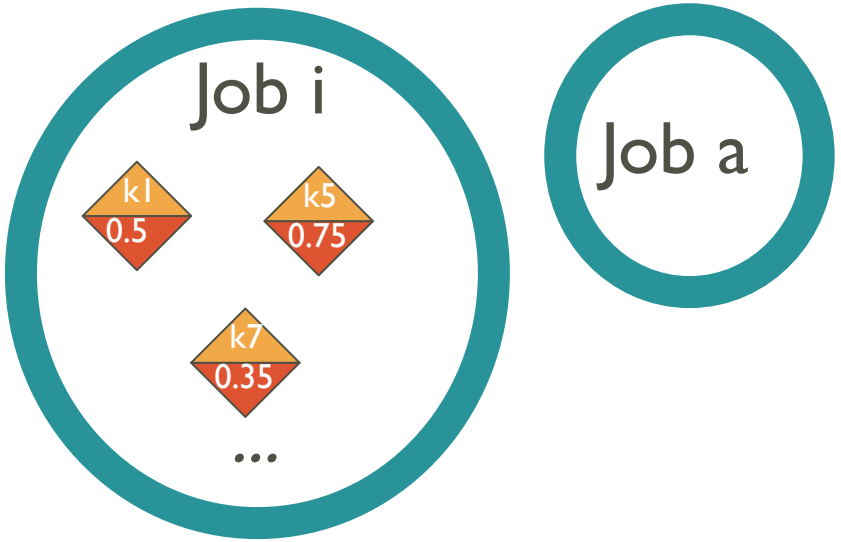
- A course catalogue *C*
- A job *J (professional objectif of students)*
  - Prerequisites (expressed as competencies and their *m*)



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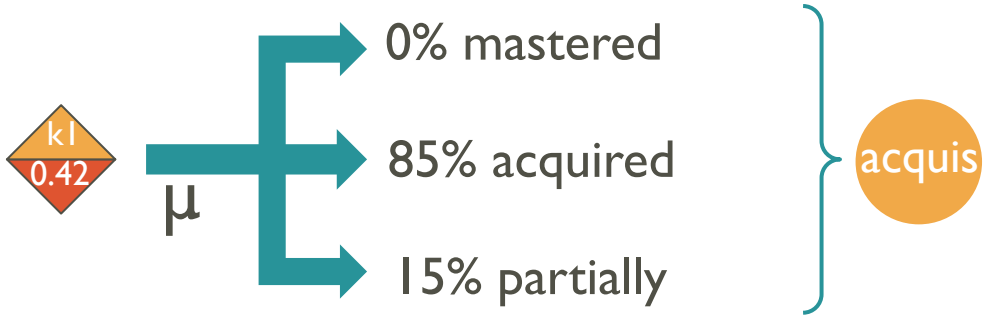
  - Prerequisites (expressed as competencies and their *m*)
- A graduation scale s
  - *e.g.* MAPI
- A fuzzification function μ
  - $\mu : m \mapsto s$



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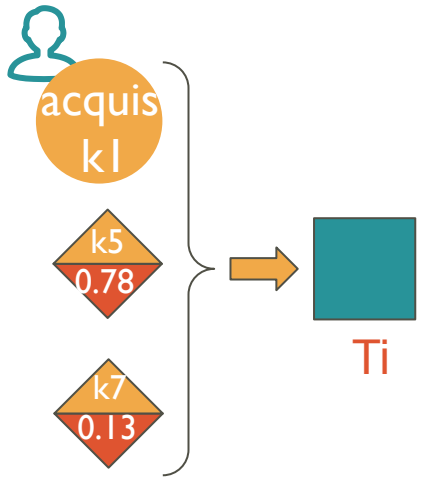

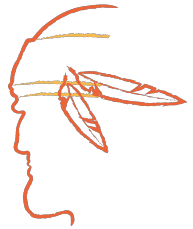

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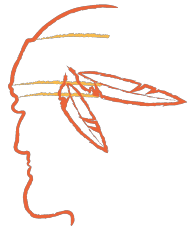
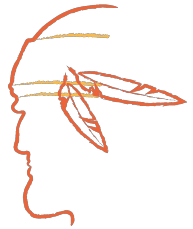
- A fuzzification function μ
  - $\mu : m \mapsto s$
- A decay function δ (for k)
  - $\delta : t \times m \mapsto m$
  - $\delta(t_1,m) < \delta(t_2,m) \leftrightarrow t_1 < t_2$
- A student profile *P*
  - At *t*, stored the learned competencies and m
- … and constraints
  - # c by semester, etc.



OVERVIEW OF OUR ALGO

1. According to the course catalog C, the student profile P, the job J desired by the student, and the problem constraints ;
2. Find a course assignment such that no prerequisites are violated ;
3. While skills not used for a certain period of time (e.g. semester) decay.

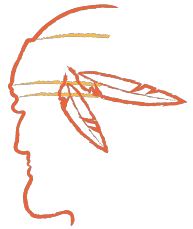


INTUITION OF PROBLEM SOLVING

Let's imagine a catalog of 5 courses (c1,..,c5) and four semesters (master). We take one course per semester (we suppose that the magnitude is always sufficient)

- c1 | teach : {0.5k1, 0.2k2} | need : {Ø} | avail : {t0, t1, t2}
- c2 | teach : {0.3k2} | need : {Ø} | avail : {t0}
- c3 | teach : {0.6k3, 0.4k5} | need : {0.3k1} | avail : {t0, t2, t3}
- c4 | teach : {0.1k2, 0.7k4} | need : {0.3k1, 0.2k2} | avail : {t1, t2, t3}
- c5 | teach : {0.5k3} | need : {Ø} | avail : {t1}

- Objectif | need : {0.5k2, 0.4k3, 0.2k5}

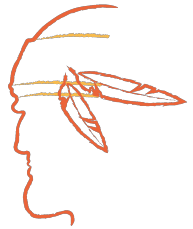


INTUITION OF PROBLEM SOLVING

Finding a manual solution to this problem (very very basic!) is already difficult...

… and we haven't even taken into account the erosion of skills yet!

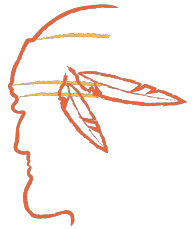
Brings up questions like: do you have to force a slot to prevent a skill from decaying?



COMPUTATION CONSIDERATION

Computationally, decay forces us to explore very deeply to ensure that prerequisite constraints are still met ← never good that!

EXPÉRIMENTATION I



BENCH : DISCUSSION ET GENERATION

To our knowledge, there is no catalog of courses properly described

Random generation of test sets (catalogs, jobs)

No certainty about the existence of solutions

RÉSULTATS

S : Number of semestre

C : Number of courses to take by semester

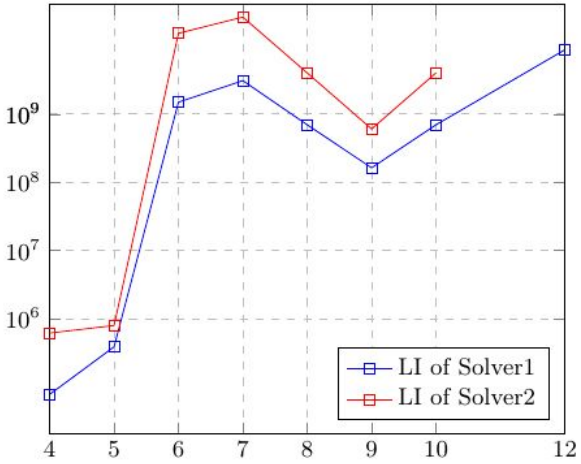
K : Total available competencies

N (X-axis) : Available courses for each semesters

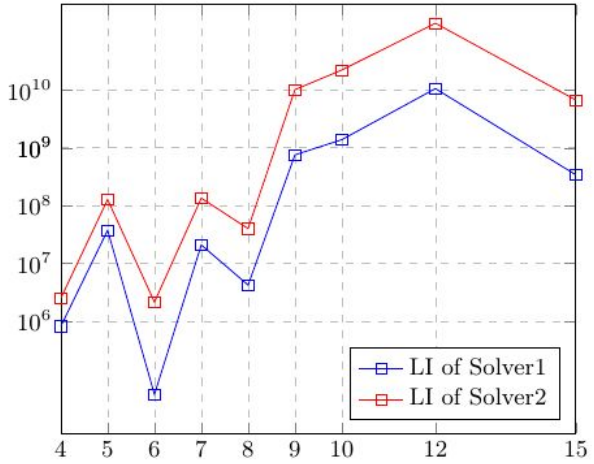
Y-axis : Logical inferences

τ : 12h of computing

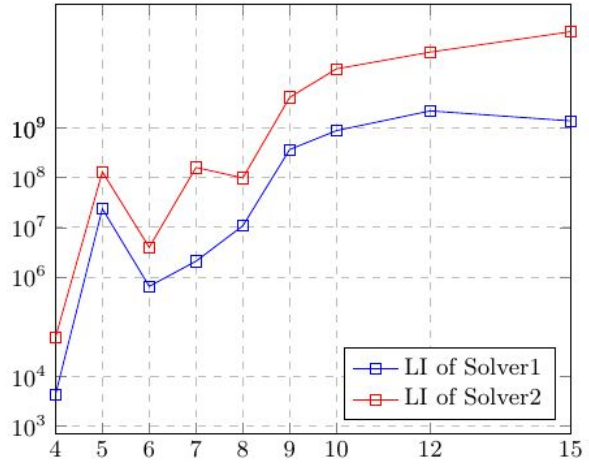
a) $S = 6, C = 2, K = 10$



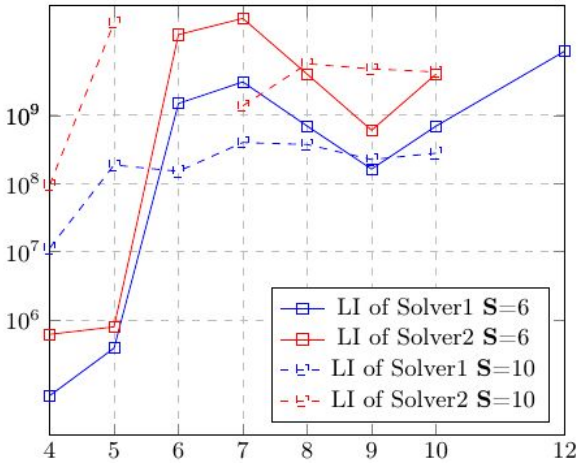
b) $S = 6, C = 2, K = 20$



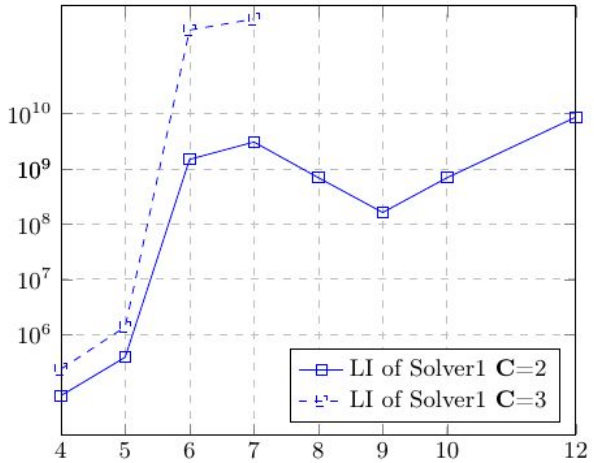
c) $S = 6, C = 2, K = 30$



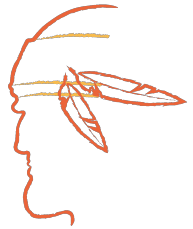
d) $C = 2, K = 10$ and $S = 6$ vs. $S = 10$



e) $S = 6, K = 10$ and $C = 2$ vs $C = 3$



COMPLEXITY STUDY



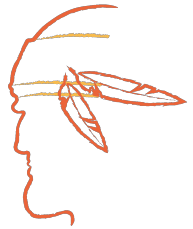
PARTIALLY ORDERED KNAPSCAK

We simplify the problem, then we transform the dependence of the courses into a graph G of type AND-OR, of size ||C||+1 nodes

We generate n non-conditional graphs G' from G

We show that G' can be assimilated to a POK, then we reintroduce the removed elements, and we show that they make the problem at least as difficult (multi-objective)

EXPÉRIMENTATION 2



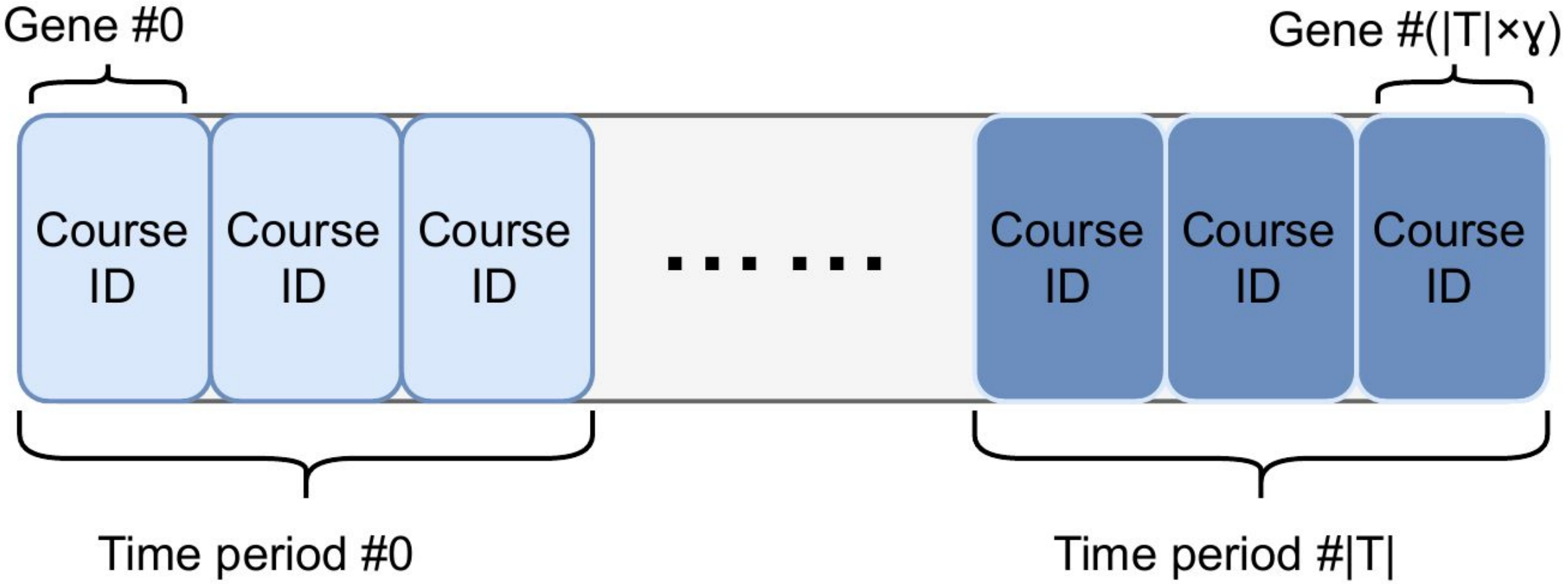
META-HEURISTIQUE

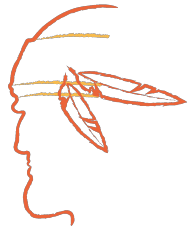
We use a genetic algorithm to solve the problem; allows to introduce nuance in the path and point of interest

Random generation of test sets, by interpolating the existing (400 courses over 5 years, 200 skills, 15 courses / semesters)

No certainty about the existence of solutions

META-HEURISTIQUE



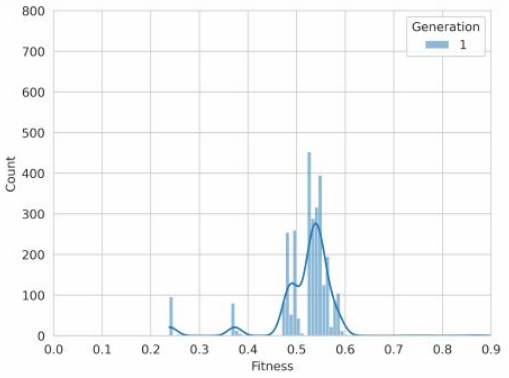


FITNESS

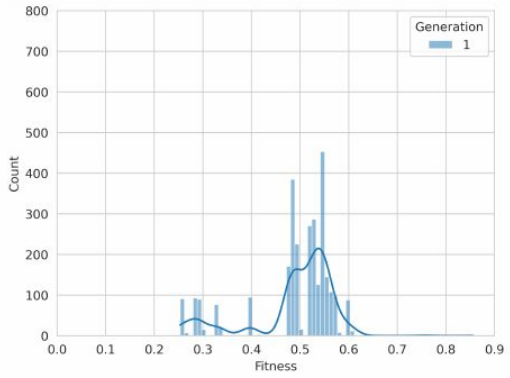
- The number of courses misplaced (== violating their availability)
- The distance between the number of ECTS expected per period and the one obtained
- The distance of the magnitudes for each course from the learner's profile
- The distance of the magnitudes for each skill expected by the job

1/4

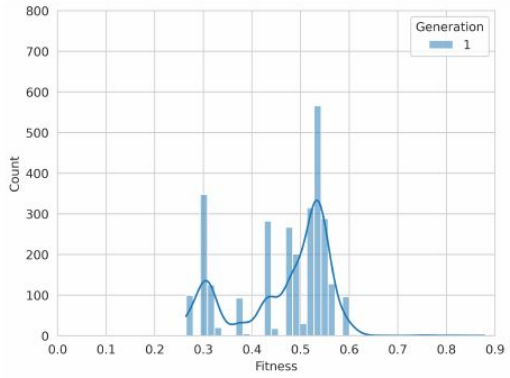
CONFIGURATIONS



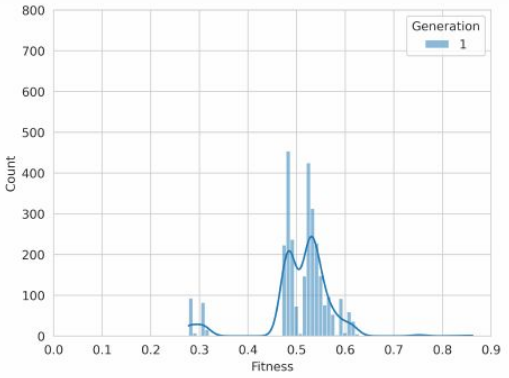
(a) $M = 0.25; X = 0.25$



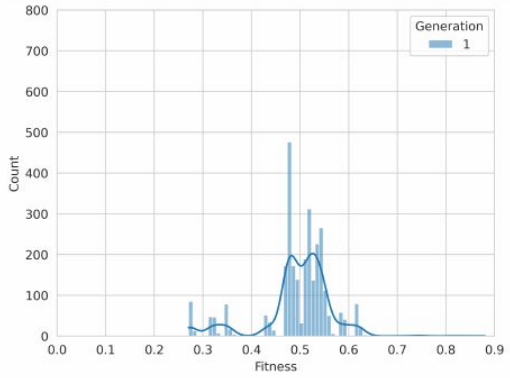
(b) $M = 0.25; X = 0.50$



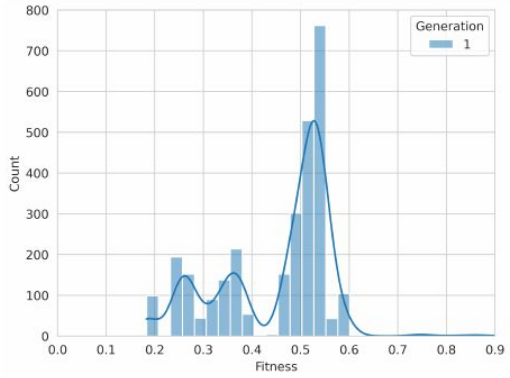
(c) $M = 0.25; X = 0.75$



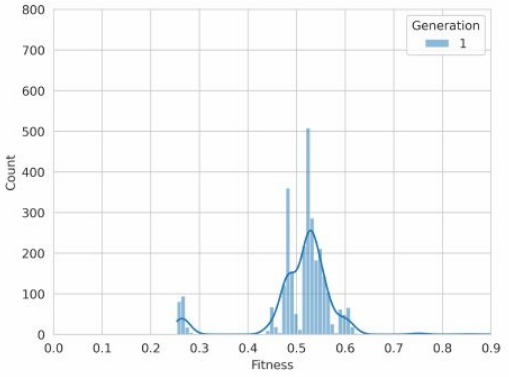
(d) $M = 0.50; X = 0.25$



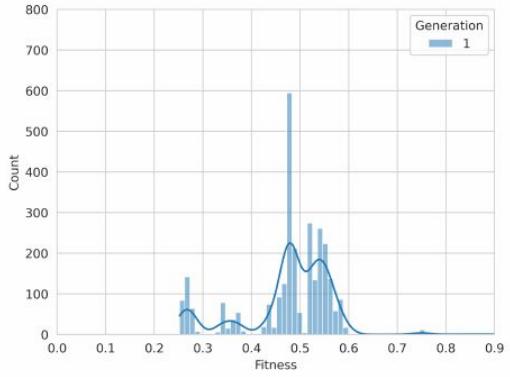
(e) $M = 0.50; X = 0.50$



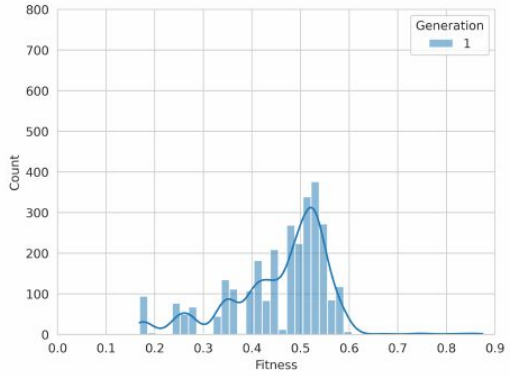
(f) $M = 0.50; X = 0.75$



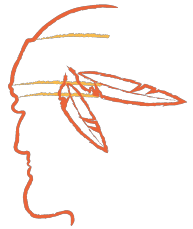
(g) $M = 0.75; X = 0.25$



(h) $M = 0.75; X = 0.50$



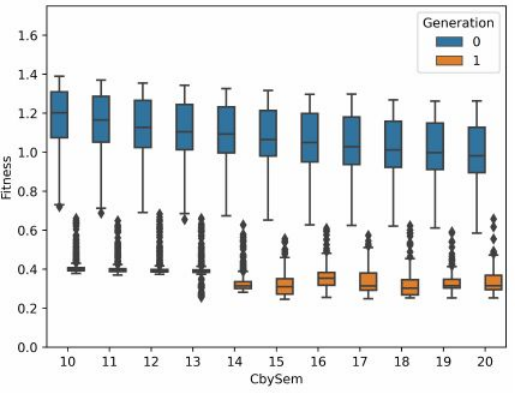
(i) $M = 0.75; X = 0.75$



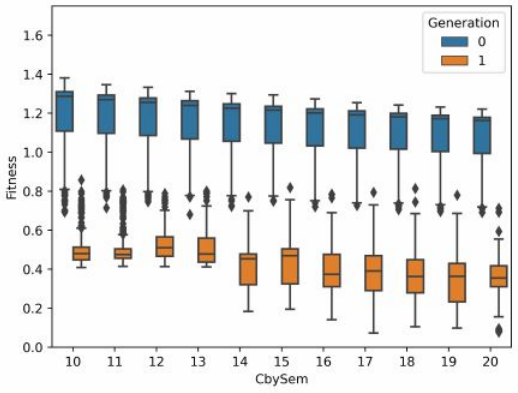
XP

- 124740 different problem instances (30 fois une même config)
- Minimum testable assignment : 10^241
- 9 year of computing on a single thread @ 2.10 GHz

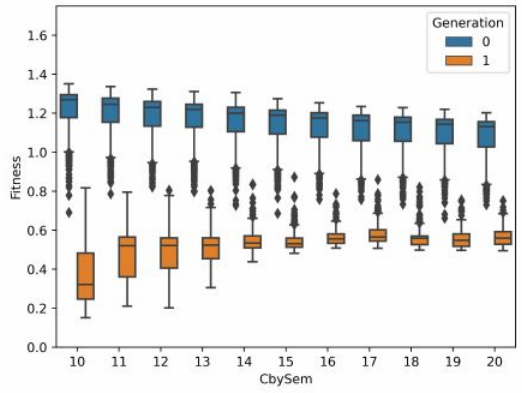
RÉSULTATS



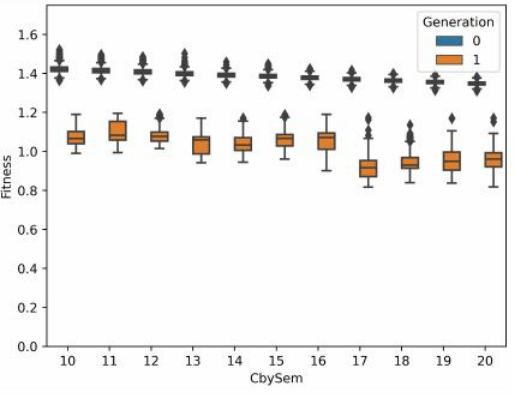
(a) $\mathfrak{C} = 300; \mathfrak{K} = 200$



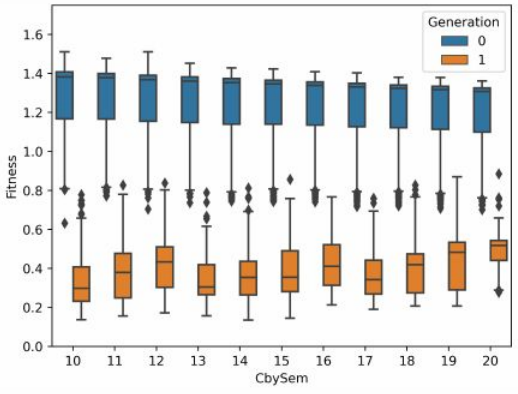
(b) $\mathfrak{C} = 400; \mathfrak{K} = 200$



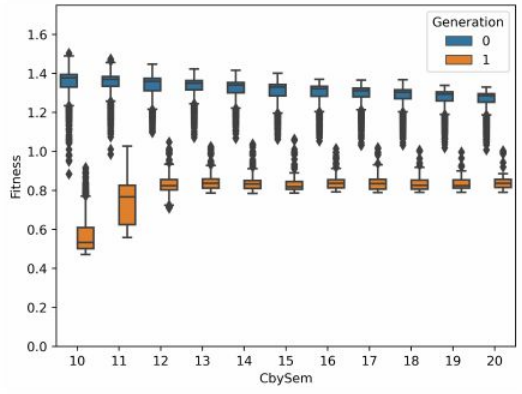
(c) $\mathfrak{C} = 500; \mathfrak{K} = 200$



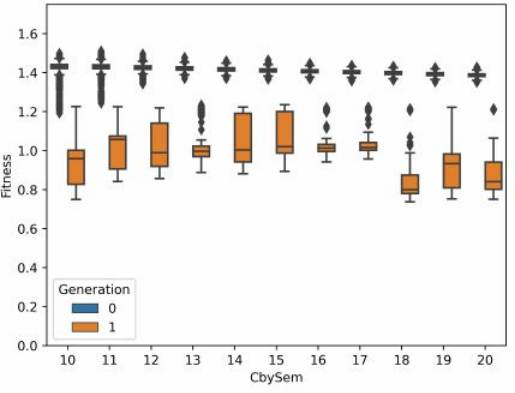
(d) $\mathfrak{C} = 300; \mathfrak{K} = 400$



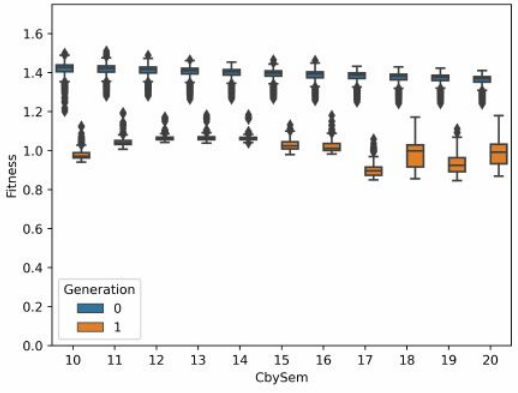
(e) $\mathfrak{C} = 400; \mathfrak{K} = 400$



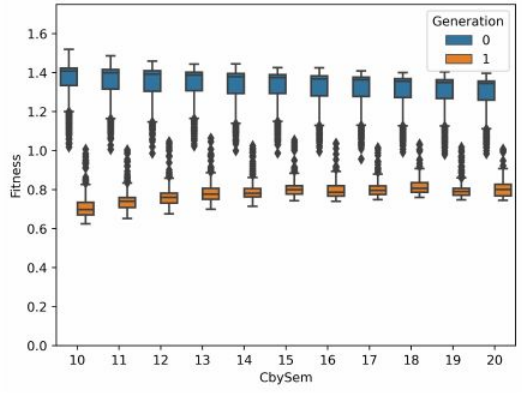
(f) $\mathfrak{C} = 500; \mathfrak{K} = 400$



(g) $\mathfrak{C} = 300; \mathfrak{K} = 600$

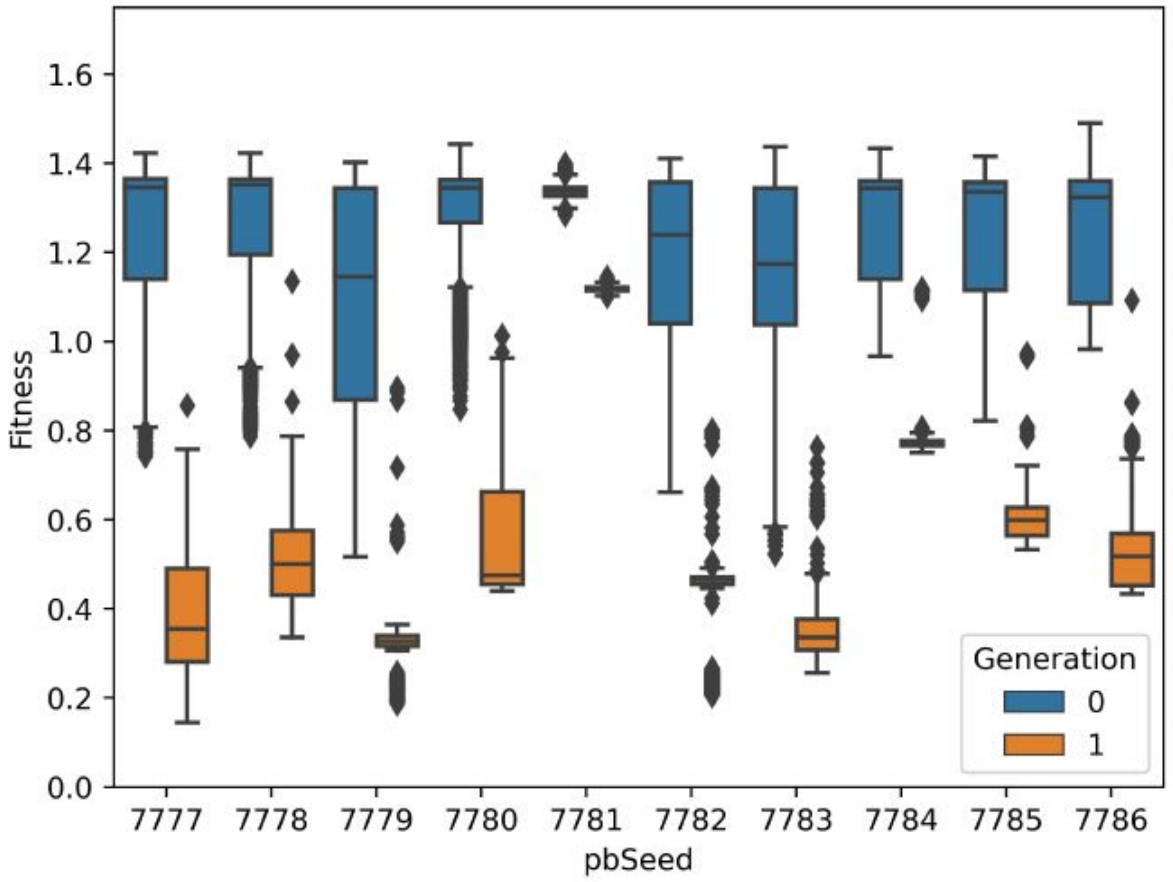


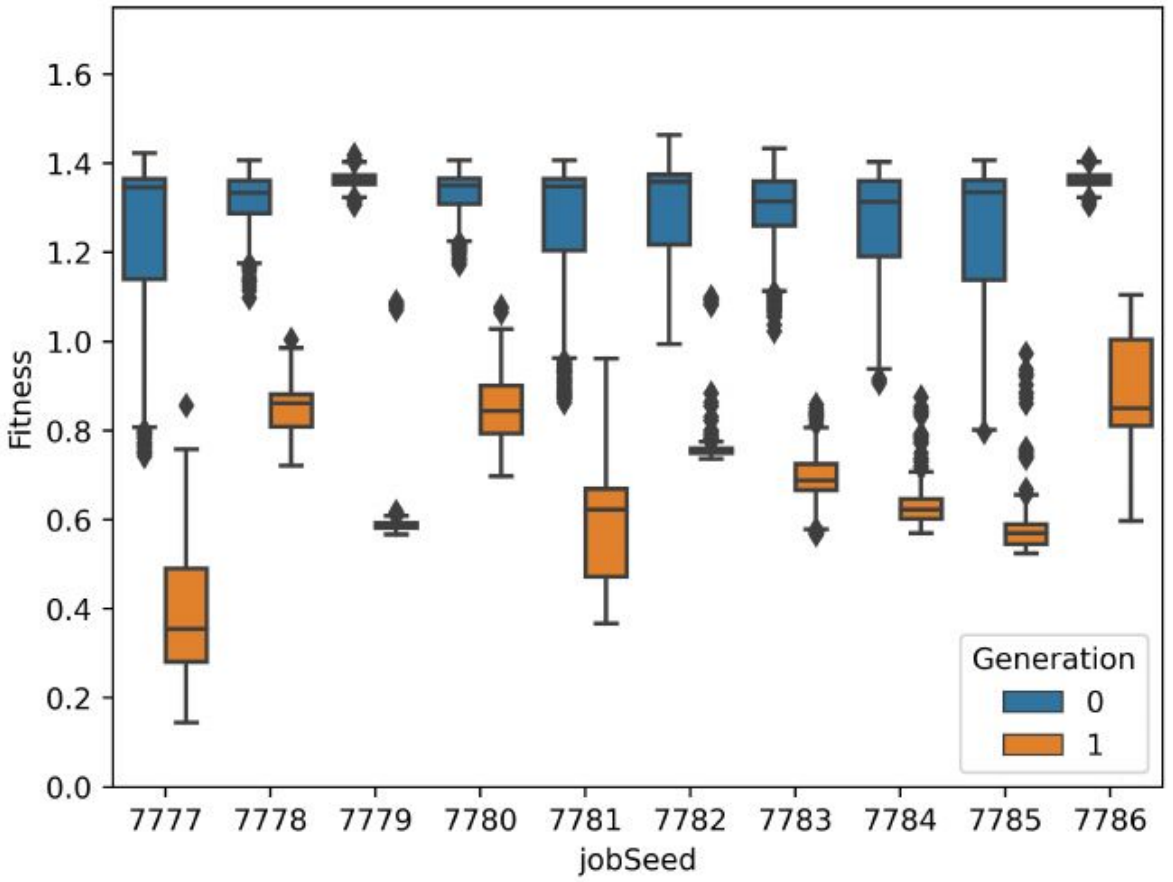
(h) $\mathfrak{C} = 400; \mathfrak{K} = 600$

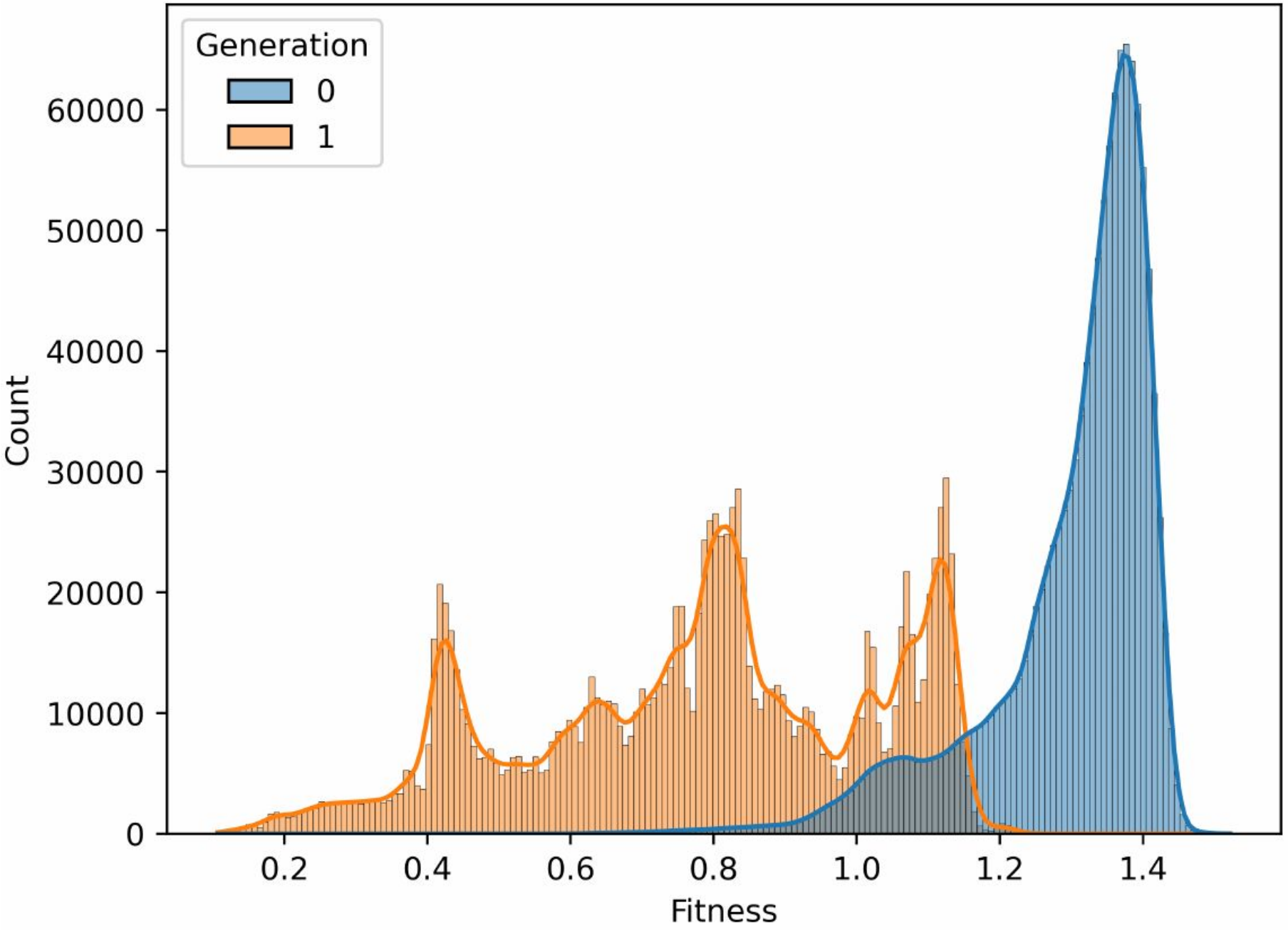


(i) $\mathfrak{C} = 500; \mathfrak{K} = 600$

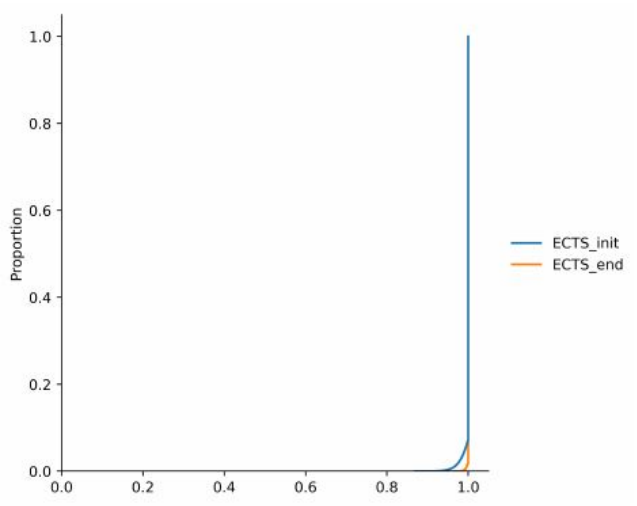
BENCH DEPENDENT



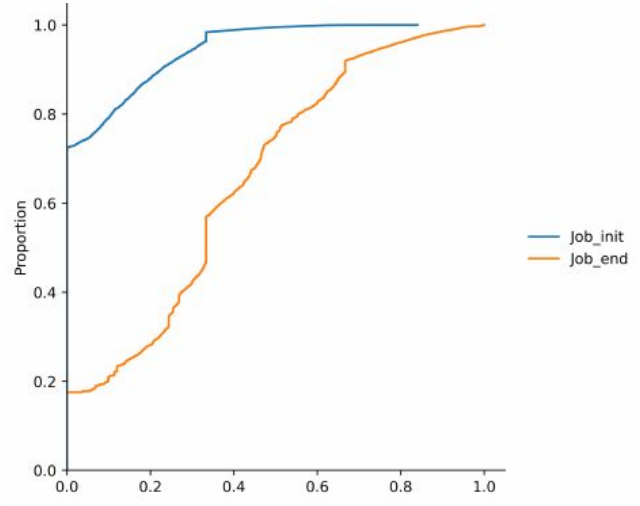




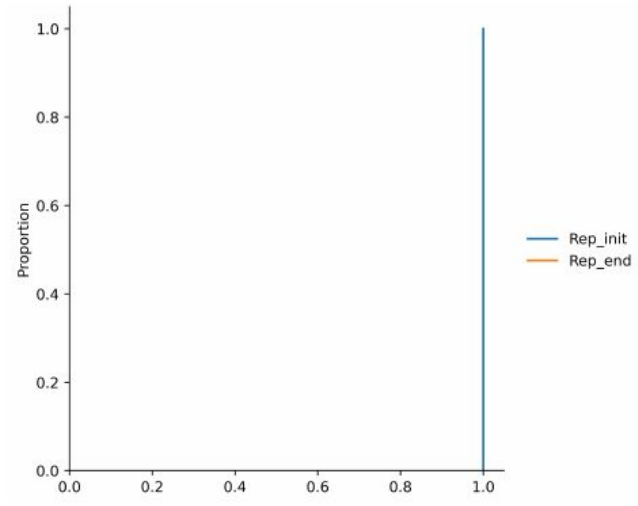
BUT !
Opti is possible



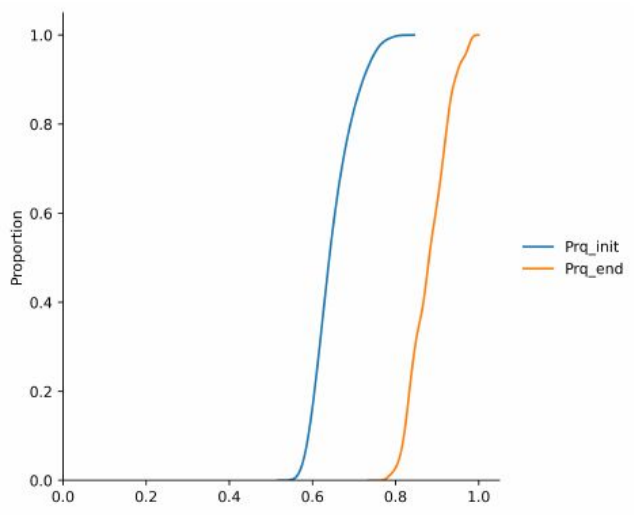
(a) ECTS init vs best



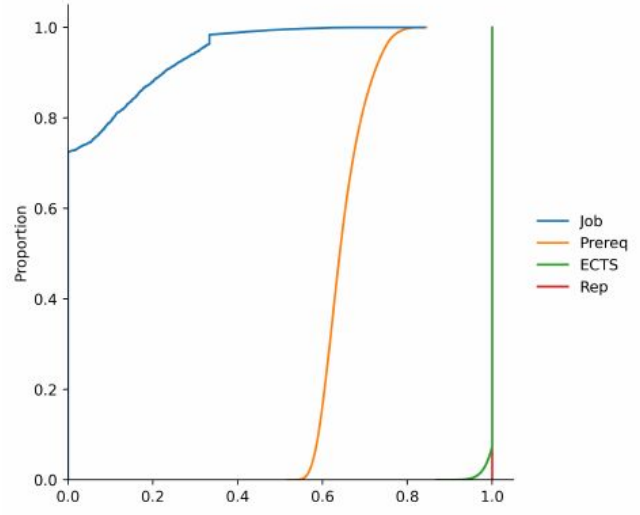
(b) Job init vs best



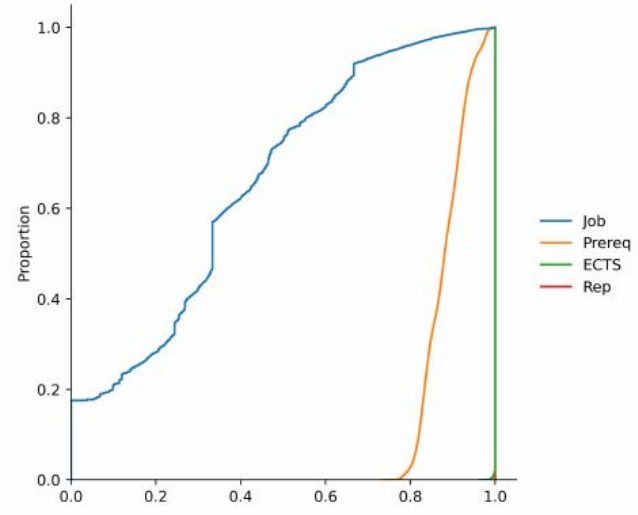
(c) Rep init vs best



(d) Prq init vs best



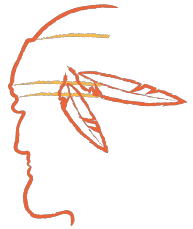
(e) Full init



(f) Full best

BUT !
Opti is possible

CONCLUSION



CONCLUSION

A new problem, very hard

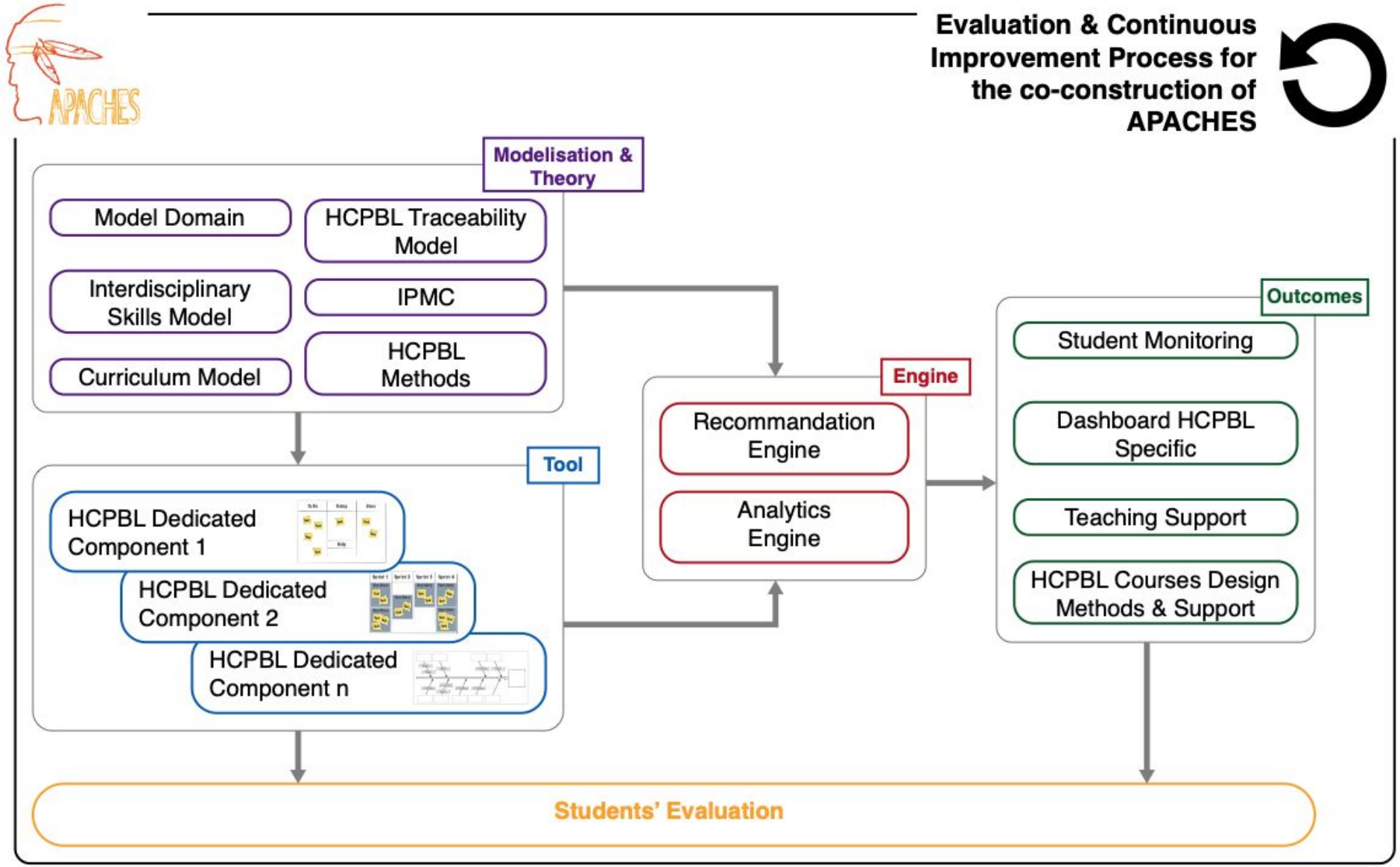
We must think about the decision support tools we can provide to decision makers

PERSPECTIVES

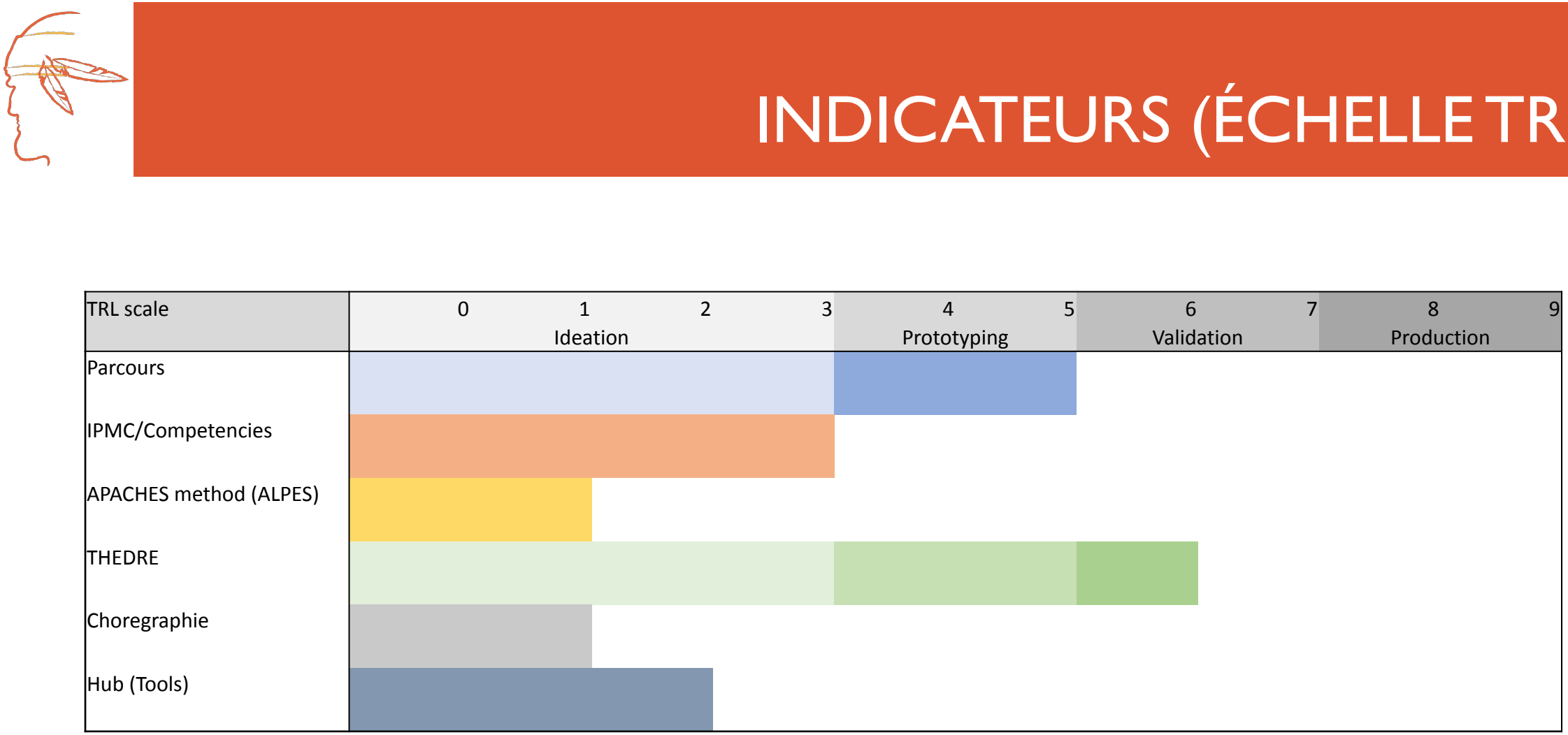
Optimization of our algo

Inform the institutional stakeholders of best choices, inconsistencies, and elements at risk in a curriculum

Automatically recalculate the curriculum in case of failure or reorientation


Evaluation & Continuous Improvement Process for the co-construction of APACHES
Modelisation & Theory
Model Domain
HCPBL Traceability Model
Interdisciplinary Skills Model
IPMC
Curriculum Model
HCPBL Methods
Tool
HCPBL Dedicated Component 1
HCPBL Dedicated Component 2
HCPBL Dedicated Component n
Engine
Recommandation Engine
Analytics Engine
Outcomes
Student Monitoring
Dashboard HCPBL Specific
Teaching Support
HCPBL Courses Design Methods & Support
Students' Evaluation

INDICATEURS (ÉCHELLE TRL)



Le cursus académique personnalisé dans une approche par compétences avec érosion : étude d'un nouveau problème fondamental

ALEXIS LEBIS, JEREMIE HUMEAU, ANTHONY FLEURY, MATHIEU VERMEULEN

I-SITE ULNE FIPE 2018 - APACHES.WP.IMT.FR

ALEXIS.LEBIS@IMT-LILLE-DOUAI.FR

I-SITE UNIVERSITÉ LILLE NORD-EUROPE

IMT Lille Douai
École Mines-Télécom
IMT-Université de Lille

SORBONNE UNIVERSITÉ
CRÉATEURS DE FUTURS DEPUIS 1257

Université de Lille

KU LEUVEN

UNIVERSITÉ CATHOLIQUE DE LILLE 1875

UNIVERSITÉ Grenoble Alpes

IUT Lumière LYON 2