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To define

COMPUTER-HUMAN INTERACTION IN LEARNING AND INSTRUCTION CHILI

École Polytechnique Fédérale de Lausanne

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Abstract

The goal of this project was to implement a web platform that teaches a set of concepts through different kind of material and to gather different information about the learner. Each sequence of learning material is called a learning path and the different learning paths are a video on the first concept than a video on the second concept, or a video than a text or a text than a video or two consecutive texts on both taught concepts. The project's purpose is to demonstrate a possible correlation between the learner's available information and his learning gain, the improvement he made before and after he was reached on the concepts, in order to build afterwards, an adaptive learning platform. This platform would propose the best learning path based on the gathered learner informations.

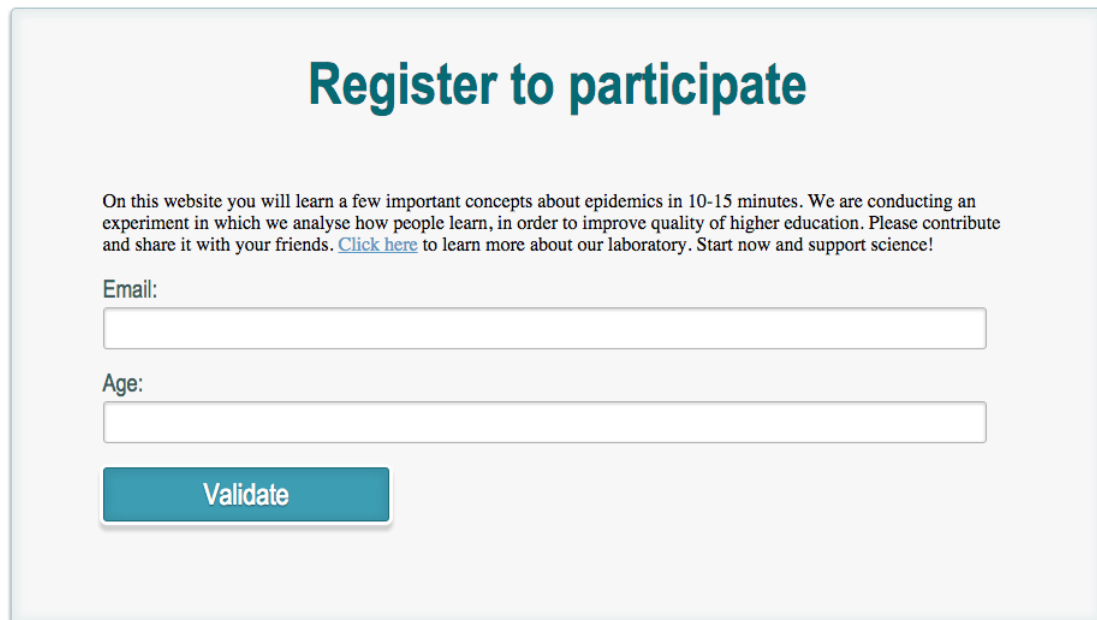
Contents

1	Introduction	4
2	Learning platform	4
2.1	Psychological test interface	5
2.2	Website Hierarchy	6
3	Data description	7
4	Data visualization	7
5	Building a regression model	9
6	Work limitations	11

1 Introduction

This project is trying to establish a relationship between a learner profile and the learning gain he achieves depending on the different style of teaching activities he takes. Later, this could be used to construct an adaptive learning platform based on a set of selected features of the learner constituting, as named previously, his profile. For this project we tested the difference between two equivalent explanations of the same concept, one presented with a text in an encyclopedia fashion and the other presented with a video selected from a MOOC. Previous research have proven that we can classify learners based on common sense, such as high-aptitude versus low-aptitude, highly motivated versus poorly motivated. Each category of learner is then proposed a different learning strategy and psychological tests are available to identify the different styles of learners. But the goal would be to find automatically the best teaching material corresponding to each style and to widen the understanding of a learners' profile not only basing it on one common sens criteria. In fact, thanks to machine learning we can classify learners based on wider criteria as we collect information on different aspects of a person and we test the correlation of a combination of all of these aspects or just a subset of them to predict the learning gain a learner would achieve with a given learning path.

2 Learning platform



Register to participate

On this website you will learn a few important concepts about epidemics in 10-15 minutes. We are conducting an experiment in which we analyse how people learn, in order to improve quality of higher education. Please contribute and share it with your friends. [Click here](#) to learn more about our laboratory. Start now and support science!

Email:

Age:

Figure 1: Learning interface

2.1 Psychological test interface

In order to gather the data for our analysis, we had to develop a learning web platform¹ coded in Django, inspired from a code on Github for a survey form². In the following paragraph we would call a "user" the person that participates to the experiment.

To meet the idea of having wider understanding of a learner profile, we tried a set of different questions that could be related to different aspects of a person: psychological, demographic or IQ estimation. We list them below together with the corresponding rating system:

- Two questions derived from IQ tests that would be grouped together in a variable named "IQ". -1 was attributed to any wrong answer and +1 was attributed to the good answer.
- Ten personality questions from the International Personality Item Pool³. Five questions are related to the conscientiousness of a person and five questions related to the openness of a person. This two criteria have proven, in previous research⁴, that they are correlated to a person learning process. For each case, three items were positively marked and two negatively marked. For this part of the test, the answer varied from "I strongly disagree" to "I strongly agree" and the points ranged from 1 to 5 or -1 to -5 in the case we gave negative marks. The result for the consciousness was stored in the column named "conscious" whereas the openness' results was stored in a variable named "open".
- Five questions related to the logic and the imagination capacity of a person. These five questions were taken from the paper folding test⁵. +1 was attributed to the right answer while -1 was attributed to a false one. The results were stored as a variable named "paperFolding".

Besides some information about the users is gathered by the following questions:

- One question about the academic level of the test taker. The possibilities to pick from were: "Haven't graduated high school", "High school graduate", "Apprenticeship", "College student", "Bachelors", "Masters", "Doctorate". The answers in this order were assigned a number from 1 to 7. The results were saved as a variable named "level" and treated as a categorical variable in the data mining process.

¹<https://github.com/chili-epfl/learning-platform>

²<https://github.com/jessykate/django-survey>

³<http://ipip.ori.org> The Big-Five Factor Structure

⁴Linking proactive personality and the Big Five to motivation to learn and development activity. Major, Debra A.; Turner, Jonathan E.; Fletcher, Thomas D. Journal of Applied Psychology, Vol 91(4), Jul 2006, 927-935. <http://dx.doi.org/10.1037/0021-9010.91.4.927>

⁵<http://steinhardtapps.es.its.nyu.edu/create/assessment/vz2/start.html>

- One question about the gender of the person. We asked if the person was a Male or a Female during the first test the user had and the answers were stored in the column named "gender".
- One question asking in which country the test taker is living.
- One question about the age of the person saved as the variable "age".

Other implied features used were the time a person takes to accomplish a test or an activity or the whole experiment.

The developed website guides you through different steps in a precise order explained later in section 2.2. The goal of this experiment is to teach a new concept through different paths assigned randomly and in a uniform way to each visitor of the web page.

At the end of the experiment, we also ask questions about how the test went and how people felt about it to have additional information that could infer relevant psychological features.

The taught concept is "Epidemics" and users are asked the same set of questions about this theme before and after they learn about it so that we could calculate the learning gain of a person as the difference between the scores he gets at the two tests.

2.2 Website Hierarchy

1. The registration form: It is the first step of the experiment where the user needs to register entering his email and his age. The email is an assertion that the user has a unique identifier. A user could take only once the test in order to measure his learning gain when he goes only once through the teaching activities. Note that the user is free to have the activities more than one time during this one time experiment meaning that he could watch a video more than once while in the video page, pause it, move forward etc... Equally the user could read a text as much times as he wishes.
Besides, doing the experiment only one time permits us to measure the time it takes a person to go through all the steps.
2. The psychological test: The questions of this test are enumerated in section 2.1 and the answer of the user to them constitutes the features that would help us search for patterns among people and to imply the best path for them to improve their learning experience.
3. The pretest: It is the same as the post test and is composed of six questions with different degrees of difficulty about "Epidemics", the theme treated in the learning activities of this experiment. The user is not supposed to have previous knowledge on the subject. Thus, for each question, a user could always select the answer "I don't know" to avoid random guessing.

4. The activities: There is two successive activities each one aims to teach one concept. The first concept is the epidemic's definition and causes and the second one is the epidemic's reproductive number. Each concept could be explained with a video or a text. In that way, we had four different teaching paths: text-text, text-video, video-text, text-text.
5. The post test: see pretest.
6. The assessment form: It is composed of some of the NASA-TLX ⁶ questions and gathering the opinion of the user about different aspects of the experiment taken. This questionnaire is known as an assessment tool that rates the perceived workload in order to assess a certain task.

3 Data description

We gathered a total of 167 participants but only 77 of them accomplished both pre and post tests and went through all the experiment steps (from the registration to the assessment form). As our goal is related to the learning gain, we work with these 77 users. Among them, we have 25 female user and 52 male user. We have also the following distribution for the possible learning paths:

- 27 users for text-text.
- 20 users for text-video.
- 12 users for video-text.
- 18 users for video-video.

4 Data visualization

As we have few observations, we try to limit ourselves to a reasonable number of variables to avoid building bad models of regression due to the curse of dimensionality. The curse of dimensionality could be due to a large number of variables for a small number of observations. We choose 13 variables, among them 11 (open, conscious, IQ, PaperFolding, age, timePretest, timePosttest, timeAct1, timeAct2 and totalTime) are continuous and two (gender and education level) are categorical. We start by visualizing the box plot of the learning gain as a function of the learning path showed in figure 2. We observe that we cannot see a significant change in the learning gain that could support the hypothesis that one path is always the best for all types of learners.

We try now to see if the learning gain is correlated to some variable or some subset of variables given a learning path. For this experiment, we didn't try to use predefined categories of learners. Our approach was to collect as much data on the

⁶<http://humansystems.arc.nasa.gov/groups/tlx/>

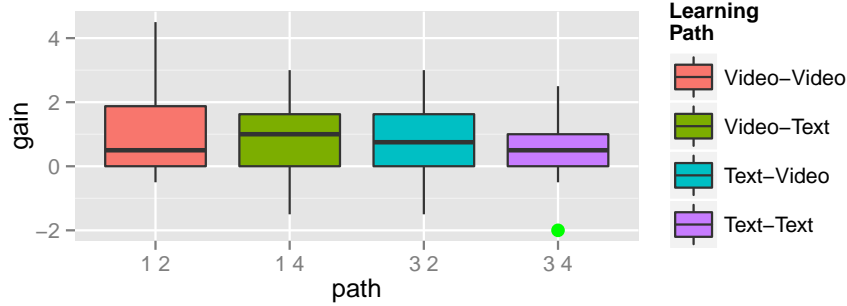


Figure 2: Learning gain according to the learning path

user's learning behavior as possible without assumed correlation between them. We then tried plotting each variable against the learning gain achieved by the user and compare it for the four possible paths that a user could get. Figure 3 show the box plot of the learning gain depending on the gender. The results cannot be fully trusted to make direct comparison between genders because of the high proportion of males regarding to the number of female participants. But we can see that, within our observations, the video-video path and the text-video path worked better for females whereas video-text path was more successful around males.

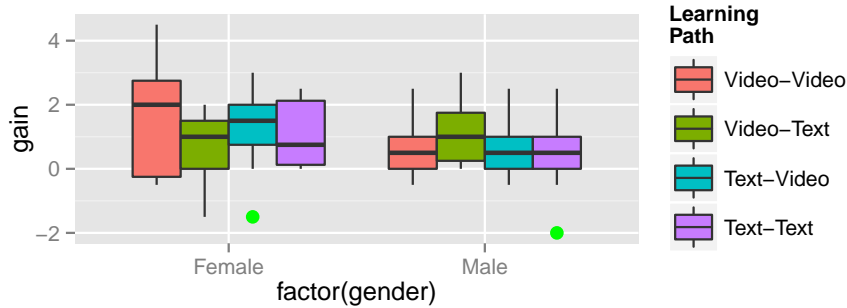


Figure 3: Learning gain according to the learning path

Thereafter, we decided to focus only on the video-video path and the text-text path to make the first comparisons and find the variables' correlations with the learning gain. In some cases we can observe a potential relation between the variable and the obtained learning gain. For instance, we can see that in figure 4a representing the case of the text only path, the learning gain doesn't seem to be impacted by the openness of the person whereas for the video path showed in figure 4b we get better results the more the user is open.

We can also observe in figures 5a and 5b that the highest the educational level of the learner is the better his learning gain is, and this is more obvious in the case of the video only learning material. In fact, people with a doctorate perform much better than the other categories. Again, for the users that are assigned video only paths, we have a correlation of 0.4986 between the time they spend watching the

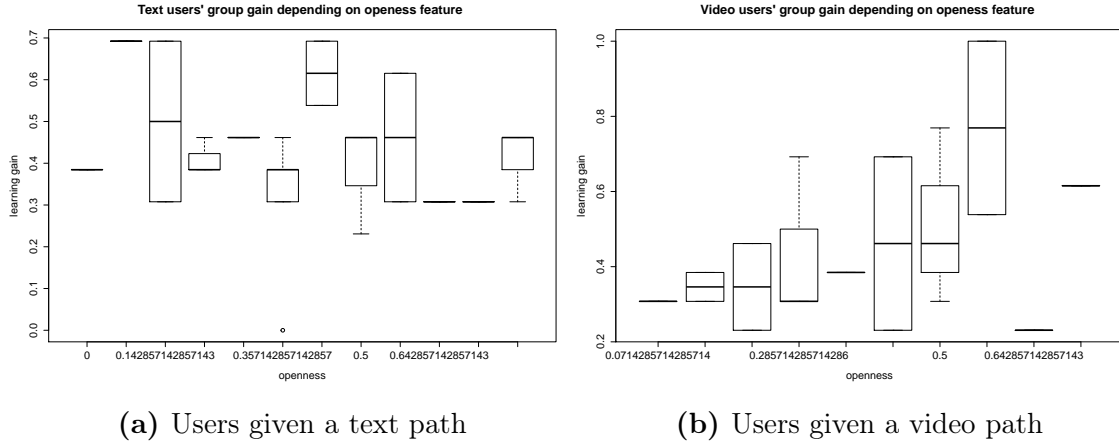


Figure 4: Learning gain depending on openness

first video and their learning gain. This result is quite logical as people that doesn't watch the whole video won't achieve good results in the post test. In contrast, other

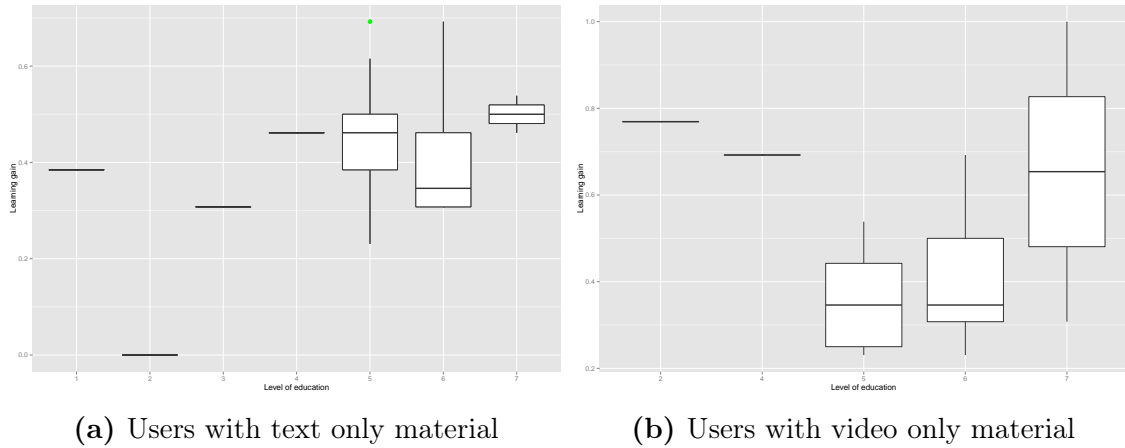


Figure 5: Learning gain depending on the achieved level of studies.

variables as the consciousness of the user doesn't seem to affect the learning gain for the observed cases. Thus, we could think that some variables could indicate a difference in the learning experience of the learner depending on the activities he undertake to learn the new concepts. Demographic factors as the gender or the level of studies of the learner as much as his psychological features could also influence his learning experience.

5 Building a regression model

In this step of the project, despite of the number of complete observations (77 complete experiment results), we try to build a regression model with machine learning algorithms to predict the learning gain of a user. If we achieve a good model, we

could prove that, with the gathered user information of our experiment, we could compare the learning gain that a person would have with the different possible paths. Then, in a second step, we can map back the results to the features' space to see if there is some regions performing better for one path more than another.

Before applying machine learning algorithms, we scale the data with the minimum and maximum values to obtain, in the case of the continuous variables, values between 0 and 1. The level and gender variables are considered as factors in R.

We tried then the Support Vector Machines (SVM) regression technique with the package `e1071` in R. SVM provides the usage of kernels what allow us to have a non-linear regression. The radial kernel had performed better for our model. After the tuning of the parameters, we obtain a Root Mean Squared Error (RMSE) of 0.14 for the text only path and of 0.2 for the video only path. We used a radial kernel and performed a 5-fold Cross Validation (CV) with 80% of the observations used for the train set and 20% of the observations for the test set. With dummy encoding of the categorical variable for SVM we don't achieve better results. We try then to perform simple feature selection, taking only variables that have correlation with the learning gain above 0.1 taking their absolute values. We again don't see an improvement in the predictions. We can think that the poor prediction results are due to the lack of data as we have only 27 observations for text-only path and 18 observations for video only path. In addition, the fact that we base our prediction on human variables could also introduce some unpredictability to our regression. Nonetheless, we use the model built for video only path to predict the learning gain of the users that had text only path to estimate their learning gain if they had a different path and compare the results. We can observe a change for certain users. In fact, when we plot the learning gain for a pair of variables as the variable "open" that indicates the openness of a person and the variable "timeAct2" for the time a person took for the second activity, certain points have different learning gain. In fact, figure 6b in comparison with figure 6a shows that people with high openness would have higher learning gain with video path while people with very low openness perform better with text material. This could confirm what we saw as correlation between the openness of the user and his learning gain and could suggest that we can adapt the activities proposed to the learner depending on this psychological feature.

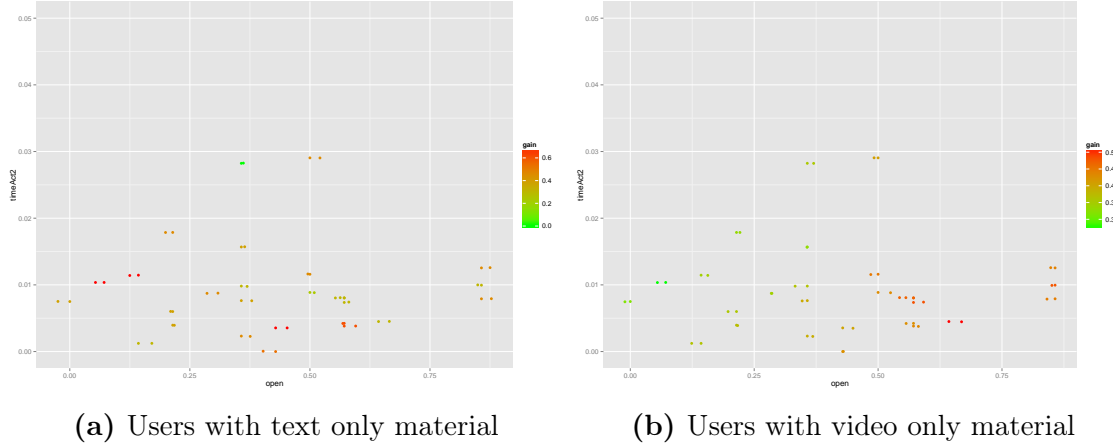


Figure 6: Comparison of the gain of the users that had text material with their estimated gain with video material.

6 Work limitations

Due to time limitation, the activities chosen differ simply in how they are presented and not in the content. Changing the content and the teaching style (visual vs aural) introduce two variables at a time. But our current paths could lead to very small changes on the learning gain results and makes harder the correlation of features to the results. Paths following the inductive or deductive approach for example could be more differentiating for learners' profile. We could also have opted for MOOC only material but some videos would have more graphs and photos than others. Besides, completely different features (time, demographics, psychological traits...) could lead to a kitchen sink effect, that doesn't help to find the right regression ⁷. This approach is still good for a first exploration as we didn't need to restrain ourselves with predefined learning styles and this work wanted to find new groups of relevant features that defines learners' styles. In future work, we could target more the wanted features to study. More importantly, we have to gather more data to improve the construction of regression models. Some rules of thumb indicate that we have to gather 10 observations for one predictor. The goal is to have a statistically sufficient number of observations by category for instance a good number of learners in both male and female categories or in all four paths.

For this experiment, the recruitment of users was done with social media advertisement. This could help us to have different styles of learners then if we constrained our users to one environment as EPFL. Some users feedback was with respect to the website is that they needed more explanation about the experiment steps by explaining more the experiment or by show the progress of the user with a progress bar or by numbering the steps out of the total steps to accomplish. In addition, the fact that the test about epidemics is taken twice before and after small lectures was not highlighted enough what would have encouraged more persons to pay attention

⁷<https://www.kellogg.northwestern.edu/faculty/dranove/htm/dranove/coursepages/Mgmt%20469/choosing%20va>

to the presented content and extract the useful information. Our concerns were more focused on doing an easy to follow not very time demanding learning platform. Some persons also asked for feedback what was not giving after the end of the test because in our view, scores to the test wasn't important but the improvement was. Even if emailing scores doesn't help the experiment results, it could encourage people to invite friends to take it.