# AI based algorithms for teaching method selection: Using tandem learning in mathematics.

## Abstract

### Background

The main objective of highereducation institutions is to provide quality education to its students. One way to achieve this is is by introducing various teaching methods, one of which is tandem learning. Not everyone responds well to said method, so discovering knowledge for predicition regarding model selection. The knowledge is hidden among the educational data set and is extractable through data mining techniques.

### Methods

A sample of N\_0 high school students and N\_1 predictor variables has been used. The outcome of interest was a three state variable indicating whether the student responded well to implementation of tandem learning into education environment or not. N\_2 predictor variables were selected using mutual information score with the outcome. In this paper, we implemented N\_3 classification machine learning algorithms that can be used to predict a target variable with three states and evaluated their performance with a n by k-fold cross-validation with stratified folds.

### Results

Predstavitev dobljenih rezultatov (v cifrah).

### Keywords

Assessment, education, machine learning, tandem learning, data mining, teching methods

### Math subject classification, MSC2020

97D40, 97D60, 62P99

## Introduction

- Kateri je problem, ki ga želimo rešiti? - Zakaj je ta problem tako pomembno znati rešiti? - Kako so ta problem reševali pred to raziskavo? - Katere so težave prej uporabljenih metod? Ali so te metode objektivne? Ali so zanesljive? - Kaj se predlaga? - Zakaj ta metoda BI LAHKO bila boljša? - Kaj o tem trdi literatura?

## Theoretical framework

### Teaching methods and tandem learning

Critic of frontal teaching and new theoretical didactics, pszchological, pedagogic, sociologic findings and positive experience in practical work have lead to the development of new indirect forms of education process (Blažič et al., 2003). Based on strong research literatures various forms of small-group learning are effective in promoting greater academic achievement, more favorable attitudes toward learning, and increased persistence through SMET courses and programs (Roschelle et al., 2010).

### Machine learning and classification

Data mining is the process of uncovering hidden patterns, relationships, or insights within vast datasets through techniques from statistics and database management(Baradwaj & Pal, 2012). It involves data preprocessing to prepare information for analysis and utilizes methods such as clustering and association rule mining. In contrast, machine learning, a subset of artificial intelligence, focuses on building predictive models by allowing computers to learn from data and make decisions or predictions. The sequences of steps identified in extracting knowledge from data is shown in figure below.

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Description automatically generated

Machine learning encompasses various learning paradigms, including classification process and finds applications in areas like recommendation systems. Classification, a fundamental task in both data mining and machine learning, involves categorizing data into predefined classes, such as binary or three-state classification, based on patterns learned from labeled data. This classification process is employed in various domains, such as healthcare and sentiment analysis, to make data-driven decisions(Baradwaj & Pal, 2012). Goal of classification is to build a model based on input data, that explains said data. If we put new data in our model, the model outputs a solution based on input data it was built on. Usually, we have training data where are attributes and is a value of uknown function . Our goal is to findc a function h that is the best approximation of function . Attributes (predictor variables) are independent (vectors), are target variables, function is called a model. Space of hypothesis expands very rapidly. If we have binary attributes, we would have different learning inputs and possible hypothesis.

## Empirical work

## Methodology

In the present research, the causal non-experimental method of pedagogical research is applied.

## Sample

The sample was comprised of N students from 11th and 12th grade of a Slovenian Gymnasium (i.e., high school).

## Procedure

After obtaining students’ (or their parents’, if the students were minors) signed informed consent and the school principals’ approval, we collected and examined the success of tandem learning in regards to several variables. Success was measured in 3 states (good, neutral and bad) and in 3 different forms (regarding learning, diversification and overall). (V članku bomo verjetno izbrali le najbolh statistično uspešno). Independent variables were in general sense (gender, class, professor, previous grade) in psychological sense (extroversion, personality type) and in regards to tandem learning (qualitytive interaction, quantitativy interaction, whether student performed more than their partner and teacher presence at tandem station). Data was anonymized using a coding scheme, such that anonymity and objectiveness were assured in every step of the research. The collected data were accessible only to the researcher.

Data was collected following after students included in research were involved in tandem learning environment during the course of approximately one week.

## Data analysis

The gathered data was analysed using Python programming language, primarily using pandas and scikit-learn libraries. Raw dataset can be found on Zenodo, while statistical code is openly accessible on [GitHub](https://github.com/borbregant/ai_tandem_learning).

In suma, we modified all categorical data into integer type in the form of tidy data. Firstly, we performed machine learning classification task, classifying student performance regarding predictor variables. We used N methods: Random forest classifier, …. . Models were evaluated with accuracy, precision, recall and area under ROC curve statistics using nxk cross validation scoring. The latter was used as final determination of model performance. Secondly, Mutual information was performed for evaluation of feature importance. Furthermore, we tried clustering using … methods and lastly, PCA and t-SNE tests were used for dimensionality reduction and data visualization.

## Results

### Student sample

Statističen opis kakšen je bil vzorec (intervali zaupanja za npr. cilnje spremenljivke, …)

A group of blue and white bars

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### Variable importance

Mutual information, hi kvadrat in ostali testi za določitev pomembnih spremenljivk

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A diagram of different colored squares

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### Model performance

Rezultati izbranih modelov

Table : Related variables

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Description | Possible values | Variable type |
| Gender |  | 0-1 (Male, female) | A priori state |
| Class |  | 0-6 (7 present classes) |  |
| Teacher |  | 0-3 (4 teachers) |  |
| Extroversion score | From online test:  [Extroversion Introversion Test (psychologytoday.com)](https://www.psychologytoday.com/us/tests/personality/extroversion-introversion-test) | 0-100 | Psychological background |
| … |  | … | … |

Table : Dataset

|  |  |  |  |
| --- | --- | --- | --- |
| Student number | Gender | Class | Extroversion score |
| 0 | M | 3B | 86 |
| 1 | F | 3B | 76 |
| .. |  |  |  |

## Discussion

…

## Conclusions and limitations

…

## References

Baradwaj, B. K., & Pal, S. (2012). *Mining Educational Data to Analyze Students’ Performance* (arXiv:1201.3417). arXiv. https://doi.org/10.48550/arXiv.1201.3417

Blažič, M., Ivanuš-Grmek, M., Kramar, M., & Strmčnik, F. (2003). *Didaktika: Visokošolski učbenik*. Visokošolsko središče, Inštitut za raziskovalno in razvojno delo.

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial Intelligence in Education. Promise and Implications for Teaching and Learning.*

Roschelle, J., Rafanan, K., Bhanot, R., Estrella, G., Penuel, B., Nussbaum, M., & Claro, S. (2010). Scaffolding group explanation and feedback with handheld technology: Impact on students’ mathematics learning. *Educational Technology Research and Development*, *58*(4), 399–419. https://doi.org/10.1007/s11423-009-9142-9

(Holmes et al., 2019) (sam da je vec k en vir)

## Povzetek

Navadno prispevki imajo obliko: Naslov Abstract Keywords: (okoli 5 ključnih besed) Introduction Theoretical framework (tukaj notri date literaturo o učnih metodah, tristopenjske klasifikacije in strojnega učenja) Empirical work - Methodoloy - Sample - Procedure - Data analysis Results Discussion Conclusions and limitations

## Uvod

V poučevanju matematike opazimo, da je delo v tandemu pogosto vezano na izboljšanje učenca. Izbira, za kakšne učence pa ta metoda deluje bolje, pa je pogosto predmet razprave.

- Kateri je problem, ki ga želimo rešiti? - Zakaj je ta problem tako pomembno znati rešiti? - Kako so ta problem reševali pred to raziskavo? - Katere so težave prej uporabljenih metod? Ali so te metode objektivne? Ali so zanesljive? - Kaj se predlaga? - Zakaj ta metoda BI LAHKO bila boljša? - Kaj o tem trdi literatura?

## Izbira učne metode

Teoretično ozadje zakaj so nekatere metode boljše glede na določeno snov ali pa tip osebe (na to se skoncentriramo mi v članku)

## Učenje v tandemu

Teoretično ozadje glede učenja in poučevanja matematike v tandemski obliki.

## Tristopenjska klasifikacija in strojno učenje

Teoretično ozadje glede napovedovanja s pomočjo strojnega učenja.

## Empirični del

### Namen raziskave

V članku združiti namene, cilje in hipoteze. Napiše se lahko: Study Aims (ali Aims of the Research) in se združi namene in raziskovalne hipoteze

Z raziskavo želimo ugotoviti, ali lahko na podlagi karakteristike dijaka in nekaterih ostalih dejavnikov dela v tandemski obliki napovemo, ali se bo ta dijak dobro odzval na tandemsko delo. Dobljeni rezultati naj bi pomagali oblikovati drugačne učne oblike pouka matematike.

### Raziskovalna hipoteza

Dijaku lahko glede na določene attribute (tip človeka,…) napovemo, ali bo tandemsko delo zanj primerno ali ne.

### Raziskovalne metode

Uporabljena bo kavzalna neeksperimentalna metoda?

V članku to preimenujemo "Methodoloy"

In the present research, the causal non-experimental method of pedagogical research is applied.

### Vzorec raziskave

The sample was comprised of N students from 11th and 12th grade of a Slovenian Gymnasium (i.e., high school). show less

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V raziskavi bo sodelovalo n dijakov 2. In 3. letnika gimnazije na kateri učim v razponu (npr.) enega tedna. Randomizacije glede na posamezne razrede ni. Delitve na kontrolno skupino in eksperimentalno skupino ni, saj ne raziskujemo ali se metoda dobro obnese ampak ali je posameznik zanjo bolj primeren (Tega ni treba eksplicitno napisati).

### Model eksperimenta

Uporabljenih je bilo … metod za klasifikacijo spremenljivke treh stanj: Random Forest Classifier, Support Vector Machine … Za izbiro parametrov so bile uporabljene Mutual information, …

### Spremenljivke

Odvisna spremenljivka je uspešnost metode. Preizkušali smo 3 načine le tega. Uspešnost glede na rezultat, uspešnost glede na počutje v razredu in uspešnost na splošno. V članku bomo izbrali le najbolj statistično uspešno. Uspešnost bodo predstavljala 3 (lahko tudi več, glede tega nisem vešč 😊) stanja: Metoda je (subjektivno gledano) dobra / za njo je vseeno / škodljiva.

Neodvisne spremenljivke so spol, razred, učeči professor, dosedanja ocena pri matematiki, ekstravertiranost, tip osebnosti, interakcija v tandemu kvalitativno in kvantitativno, ali je pripomogel več kot partner v tandemu in prisotnost učitelja pri postaji tandema.

Prvi sklop so spremenljivke vezane na a priori stanje in je njihova skala očitna. Drugi sklop so spremenljivke vezane na psihološki profil dijaka in bodo pridobljene s pomočjo zunanjega vprašalnika npr. [Extroversion Introversion Test (psychologytoday.com)](https://www.psychologytoday.com/us/tests/personality/extroversion-introversion-test) na njihovi skali (v tem primeru 1-100). Tretji sklop pa so spremenljivke vezane na samo delo v tandemu in bodo tri stopenjske (npr. interakcije je bilo veliko / srednje / malo).

### Potek raziskave in zbiranje podatkov (Tega ponavadi ne pišemo v članek)

1. Pridobitev ustreznih soglasij s strani šole, učiteljev in dijakov ter etične komisije.
2. Pilotna študija.
3. Izobraževanje raziskovalcev in seznanitev učiteljev s potekom raziskave.
4. Izvedba raziskave in zbiranje podatkov
5. Analiza podatkov

After obtaining the school principals' written consent, students and their parents expressed their willingness to participate in the present study with a written informed consent

Profesorji na gimnaziji 2. in 3. letnika predavajo en sklop snovi v čim večji obliki s tandemskim delom (seveda v mejah normale po njihovem občutku). Ob koncu sklopa snovi pripravijo še evalvacijski test, ki pa je namenjen zgolj dijaku (da dobi občutek, če se mu zdi metoda OK, a morda vseeno ni veliko odnesel v smislu znanja…). Za tem dijaki izpolnjejo vprašalnik za zgornje spremenljivke.

Te vprašalnike jaz nato s programiranjem obdelam tako, da z različnimi metodami napovem, ali za določenega dijaka lahko predvidimo, ali se na to metodo dobro odzove. Standarden test je, da vzamemo npr. 80% podatkov, iz njih postavimo model in slednjega testiramo na preostalih 20%, koliko je natančen (tu so v igri napredne statistične metode). Možno je tudi gledati, katere spremenljivke imajo večji vpliv in še marsikaj, kar bodo pokazali podatki. Bojim se le, da obstaja (ne mala) verjetnost, da bo točnost modela slaba (npr. zelo podoben uspeh, kot bi ga dobili z ugibanjem torej 50% (možno je tudi slabše…)). V vedah, kjer so taki eksperimenti bolj popularni (npr. medicina, kjer preverjamo uspešnost zdravila), je sicer “slab” rezultat še vedno vreden objave, saj vseeno marsikaj pove (že to, da modela ni bilo možno postaviti na podlagi dobljenih podatkov nosi veliko informacijo). Ne vem pa ali bi to sprejele pedagoške revije? Nadaljujemo lahko še z vprašalniki učečim profesorjem, ki pa bi bili bolj enostavnega statističnega tipa.

### Obdelava podatkov

Na kratko povzeti, katere so uporabljene metode in kako jih boste vi uporabili.

Kateri algoritmi so bili uporabljeni za strojno učenje, katere metode za izbiro spremenljivk (velikost prostora, …).

### Rezultati in interpretacija

Raje ločeno: - Results - Discussion

### Sklep

### Conclusions and Limitations

References Navesti uporabljene vire v APA style: torej citiranje v obliki (Avtor, 2019) v besedilu. Pomagajte si s prosto dostopnim programom Zotero za citiranje: res vam bo olajšalo življenje