Merging Education and Brain Science: Exploring the academic landscape and identifying the common ground

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Abstract

In 2016 MIT established the MIT Integrated Learning Initiative (MITili). The mission of MITili is to study learning the MIT way: through rigorous, interdisciplinary research on the fundamental mechanisms of learning and how it can be improved. The Learning x Scales (LxS) project has been developed under the umbrella of MITili. The goal of the LxS project is to support MITili's mission by suggesting new approaches to learning, while bridging the gap between the disciplines of traditional education and brain science. This technical report presents the group's first pilot study aiming to acquire a better understanding of the current academic landscape and identify common research ground that can be further used to initiate a possible collaboration or even a merge across the fields studying learning.

In order to start exploring the current landscape of research on learning, the group started by mapping out of the most common themes that appeared to be researched, by exploring journals and conferences related to the education and the brain science communities. As a next step the identified themes were qualitatively analyzed to form wider research categories. The analyzed data were then inserted into the Gephi software to create visual representations of the common research ground between the two fields. As a final step a program was developed that allows for a manual search of research topics of interest across both fields.

1. Introduction

1.1 Transforming Learning through Research and Applied Practice

Learning has been explored by different disciplines, such as education, cognitive psychology, and neuroscience, in different ways over the previous centuries. However these disciplines commonly operate in silos and very rarely, if at all, inform each other. As technology and research regarding learning advance faster than ever, "there is a pressing need in higher education for deeper integration of research across the fields that impact learning" [1]. As a response to this need, the MIT Integrated Learning Initiative (MITili), founded in 2016, aims to study and improve learning through rigorous and interdisciplinary research by using fundamental mechanisms of learning, which is the MIT way. [2] According to the MITili founding declaration, "MITili will draw from fields as wide ranging as cognitive psychology, neuroscience, economics, health, design, engineering, architecture and discipline-based education research (DBER). The effort will study learning from several perspectives. MITili will consider the fundamental processes behind motivation, curiosity, knowledge acquisition, retention, mastery, integration, creativity, transfer, and self-efficacy at the individual level from pre-kindergarten to adulthood. At the system level, MITili researchers will consider topics such as school effectiveness, school system design, social factors, education policy, the economics of education, and the impact of socio-economic status." [2]

1.2 Learning X Scales

The Learning X Scales (LxS) project was initiated in February 2016, and aims to support the MITili mission.

More specifically the LxS project aims to

- **Explore** the cross-disciplinary landscape of learning at different scales [Neuron, Brain, Classroom, MOOCs, Global Education]
- **Map** the existing learning related research approaches and identify unexplored areas that will allow for cross-disciplinary research opportunities.
- **Create** interdisciplinary pathways, such as a cross-disciplinary research repository, to inform new MIT educational & research initiatives.
- **Bridge** the gap between traditional education and the brain sciences.
- **Highlight** actionable implementations for the real world.

1.3 First pilot study: Exploring the academic landscape and identifying common research ground between education and brain science

In the summer of 2016, the first pilot study within the LxS project was designed and implemented. The scope of this pilot study was to provide an initial understanding of the most commonly researched topics within the communities of education and brain science, to explore potential common research ground, and to use both info-graphics and a website to communicate the results.

2.Methodology

2.1 Data Collection

Data collection for this study involved the recording and examination of "call for papers" of conferences and journals representing numerous subfields of education, as well as brain science. A maximum of 5 conferences or journals were first identified for every one of the following subfields: math education, physics education, engineering education, biology education, history education, music education, computer science education, e-learning, and MOOCs. 7 conferences and journals were identified under the more generic term of "education"; 11 conferences and journals were identified under the field of "brain and cognition", and 3 additional conferences and journals were identified and included under the term "neuroscience". A different data set was collected for the fields of e-learning and MOOCs due to the very special nature of the latter that calls for a distinct pedagogical approach. The conferences and journals were identified through a Google search via relevant terms such as *[subject name] education conference call for papers*, or *[subject area] education journal call for papers.* Experts in every field were also contacted within MIT in order to contribute towards the data collection. To further establish validity, in this first pilot study, only conferences organized by universities or entities formally related to education were included. For every conference or journal included in the data set, the research topics identified under the "call for papers" section were further catalogued.

2.2 Data Analysis

Mixed methods were used for analyzing the data. As a first step, the data was split onto 2 groups, namely data from the fields of education, and data from brain science. Due to the particular nature of the subfield, a separate group emerged out of the *education* data that includes data related to e-learning with MOOCs. A general inductive open coding qualitative method [3] was used to identify larger thematic research categories. Two researchers initially examined approximately 50% of the data. Research topics were color-coded to form larger research themes (same color for topics that could possibly be merged into one greater category), and so an initial set of thematic categories were identified. Table 1 presents a sample of 3 conferences on physics education, and includes identified research topics, along with highlighting the color-coding scheme that was first applied.

Table 1. Color-coded data sample representing research topics identified by 3 conferences in the field of physics education

Conference/ Journals	**2016 International Conference on Physics and Physics Education**	**ICPE 2016: 18th International Conference on Physics Education**	**2nd WCPE (World Conference on Physics Education)**
Research topic	Teaching Strategies	Physics Teaching and Learning at Elementary, Secondary and University Levels	ICT and Multi-Media in Physics Education
	Physics Experiments	Physics Teaching and Learning in Informal Settings	Motivational Strategies and Metacognition
	Physics Course Reform	In-service and Pre-service Teacher Education	Physics Curriculum
	Educational Technology	Physics Curriculum and Content Organization	Socio-cultural Issues
	Physics Education Research	Pedagogical Methods and Strategies	Primary School Physics
	Physical Problems and Research	History of Physics in Physics Education	Secondary School Physics
	Physics and Information Technology	ICT and Multi-Media in Physics Education	University Physics
		Motivational Strategies and Metacognition	Various Topics on Physics Education
		Socio-Cultural Issues	Teacher Professional Development
			International Perspectives

The two researchers then met with an expert who had separately analyzed a sample of the data. The thematic categories were further discussed and redefined until the whole group came to a consensus with regards to the definitions. At the end, as presented in Table 2, 16 thematic categories were defined and the whole data set was again analyzed according to the new definitions. Research topics that did not fit in any of the thematic categories were not included in this pilot study but will be incorporated at a future point.

Table 2: The 16 thematic categories that emerged from the data analysis

Research Thematic Category	**Definition**
Technology	Research regarding how technology can be used to enhance the learning experience.
Sociocultural Issues	Research regarding sociocultural issues (of, or relating to, to a combination of social cultural elements such as socioeconomic status, race, religion, age, etc.).
Gender	Research regarding how gender affects education.
Innovations	Research regarding innovations that develop within/for the delivery or creation of content and curriculum in the classroom.
Ethics	Research regarding ethical considerations in education (both regarding the practice and the content to be taught).
Student Psychology	Research regarding student psychology factors, such as motivation, that influence students while they are learning and ultimately affect retention and understanding.
Assessment of Learning	Research regarding how teachers or a MOOCs platform test whether someone has learned their material.
Assessment of Teaching	Research regarding how a teacher can be assessed for the way he/she maintains a classroom and teaches.
Assessment & Accreditation of Programs	Research regarding program assessment or accreditation.
Teacher Development	Research topics related to how teachers get further educated with regards to development of new content, or new delivery and assessment methods.
Collaborative Learning	Research regarding collaborative learning.
Curriculum design	Research regarding curriculum design.
Business Opportunities	Research topics related to ~~the~~ business models, partnerships, and opportunities for funding that emerge within education, especially through e-learning.
Connections with Industry/Job Market	Research regarding how education connects to the real world, and ~~on~~ how education translates to the job market or further employment.
Policy	Research regarding principles and government policy-making in the educational sphere, as well as the collection of laws and rules that govern the operation of education systems.
How Learning Works	Research regarding how the brain processes the information received to form learning.

As the point of this pilot study was to identify potential common research ground between different fields studying learning, an info-graphic was selected by the group as a medium to communicate the results. After examining various available software packages, the group decided to use Gephi, an opensource software for visualizing and analyzing large networks graphs. All data was manually imported into the gephi software. Five interactive graphs were extracted from gephi. The first three independently present the research in the field of brain science, education, and MOOCs in relation to the 16 thematic categories. The last two are comparative interactive graphs. The first compares the fields of brain science and education. The second compares brain science, education, and MOOCs. Once the graphs were completed, they were shared on a website created for the project. Additional code was then written and added to the website to make the graphs fully searchable, so the user can either search for a particular conference or theme, and identify what other conferences from different fields include the same research themes as well. Once completed, all data was exported to an excel file for further analysis.

Figures 1,2, and 3 illustrate the interactive graphs created for the field of education and how the user can interact with this graph. In these Figures, blue represents conferences and journals on STEM education, pink represents Music and Language education, green represents Online Education in class, while red represents all remaining conferences and journals. The 16 gray circles represent the 16 research thematic categories identified.

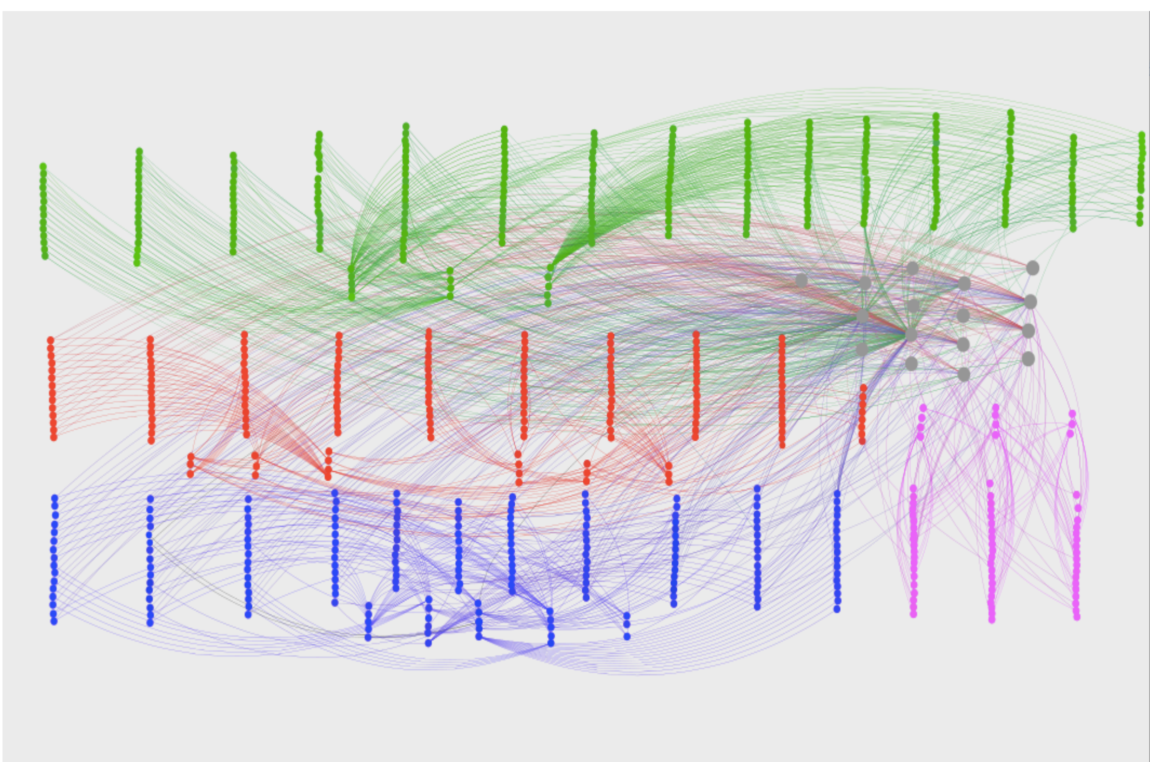

Figure 1: Interactive graph presenting all data gathered for the field of education.

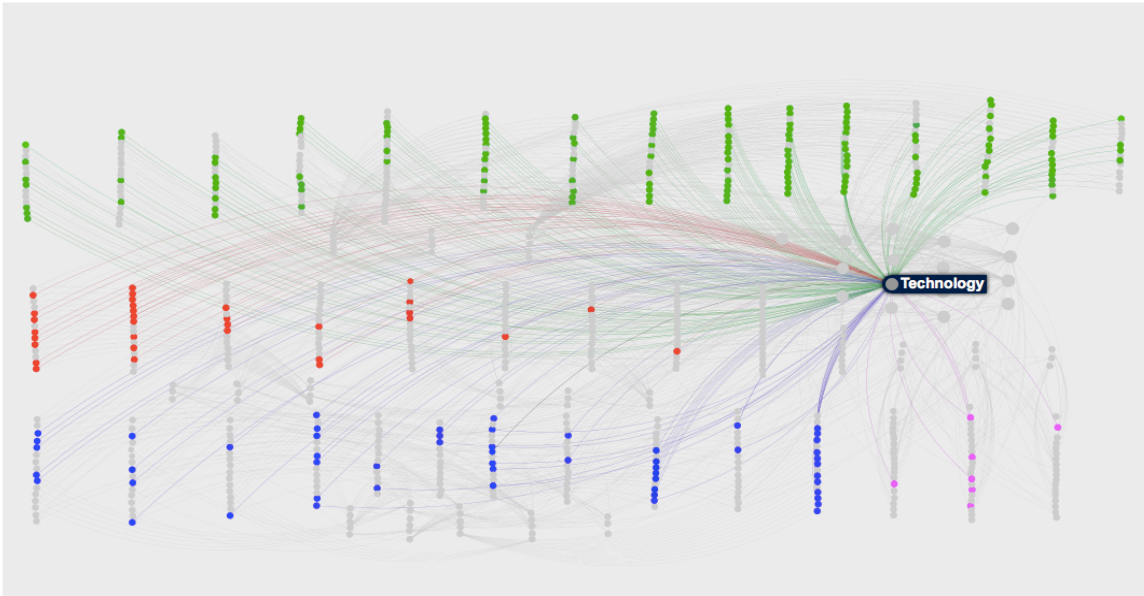

Figure 2: Interactive graph highlighting conferences and journals that include the research theme of technology

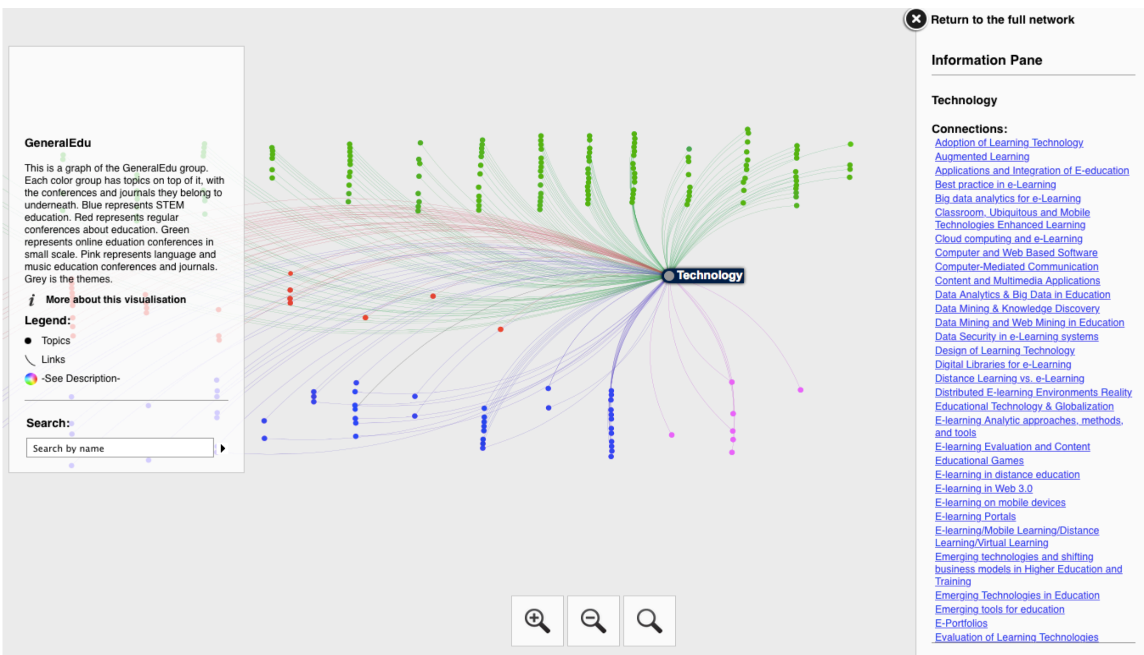

Figure 3: The complete searchable list as presented on the developed website. List on the right presents all conferences and journals that include research on technology

Figures 4, 5, and 6 present the comparative interactive graphs between the fields of brain science, education, and MOOCs. In the following Figures, yellow represents conferences and journals from the field of brain science, green represents conferences and journals from the field of education, and orange represents conferences and journals on MOOCs. The 16 gray circles represent the 16 research thematic categories identified.

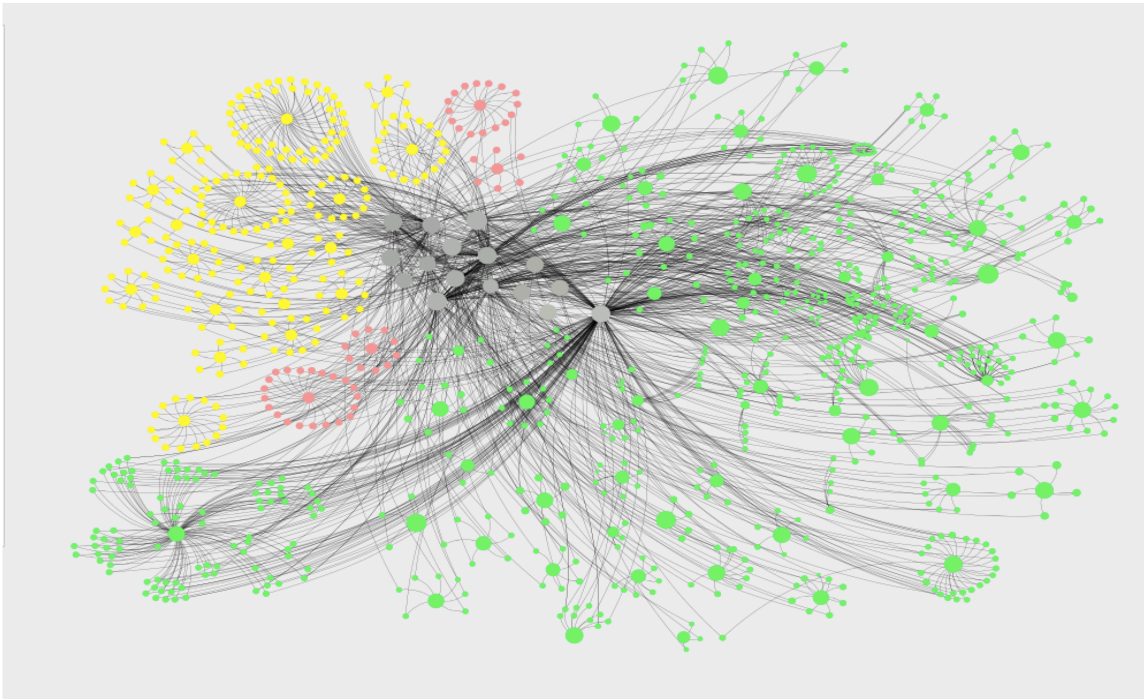

Figure 4: Comparative interactive map representing all conferences and journals gathered for the fields of brain science, education, and MOOCs

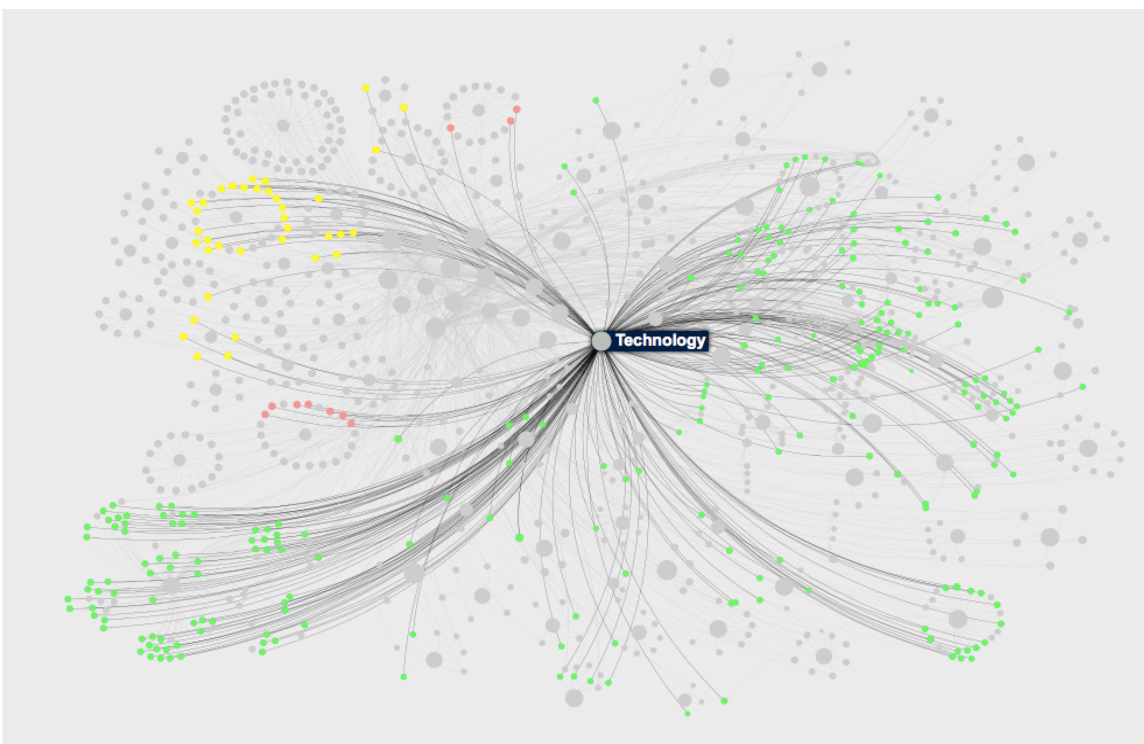

Figure 5: Interactive comparative graph highlighting all conferences and journals within the 3 fields that include the research theme of technology

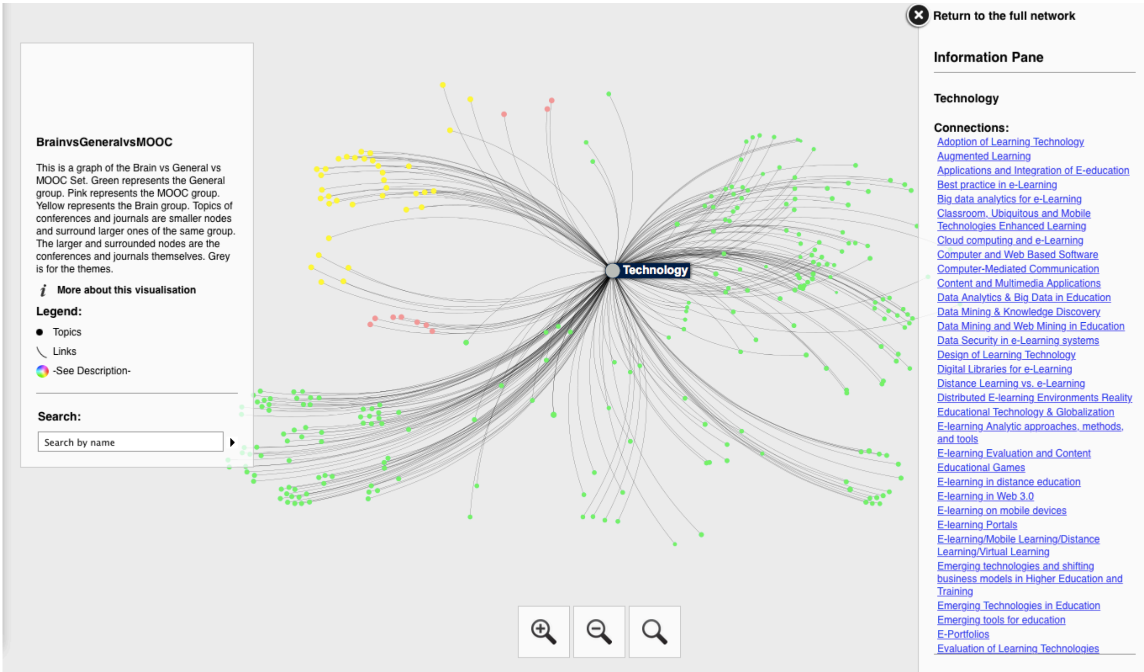

Figure 6: The complete searchable list as presented on the developed website. List on the right presents all conferences and journals that include research on technology among the fields of brain science, education, and MOOCs

3. Findings

In this first pilot study that included a maximum of 6 conferences and journals per group in our data collection, a total of 217 different research topics were identified in the field of brain science, a total of 652 topics were identified in the field of education, and 53 were specifically identified as research topics in MOOCs. The large discrepancy was expected, considering the long history of the field of education in academia compared to the relatively shorter existence of the other two fields, especially the field of MOOCs.

When comparing the research that appears to be more prominent within the 3 fields as presented in Figure 7, some research themes appear to be of common interest. Considering that the scope of this project is to identify and highlight possible research themes that can serve as a starting ground for collaboration across the different fields that study learning, the topics of *Technology*, *Assessment of Learning*, *Policy*, *Sociocultural Issues*, *Student Psychology*, *Teacher Training* and *Collaborative Learning* appear to be of interest to all fields. The themes of *Innovation* and *Business Opportunities* appear to be attractive in the fields of education and MOOCs.

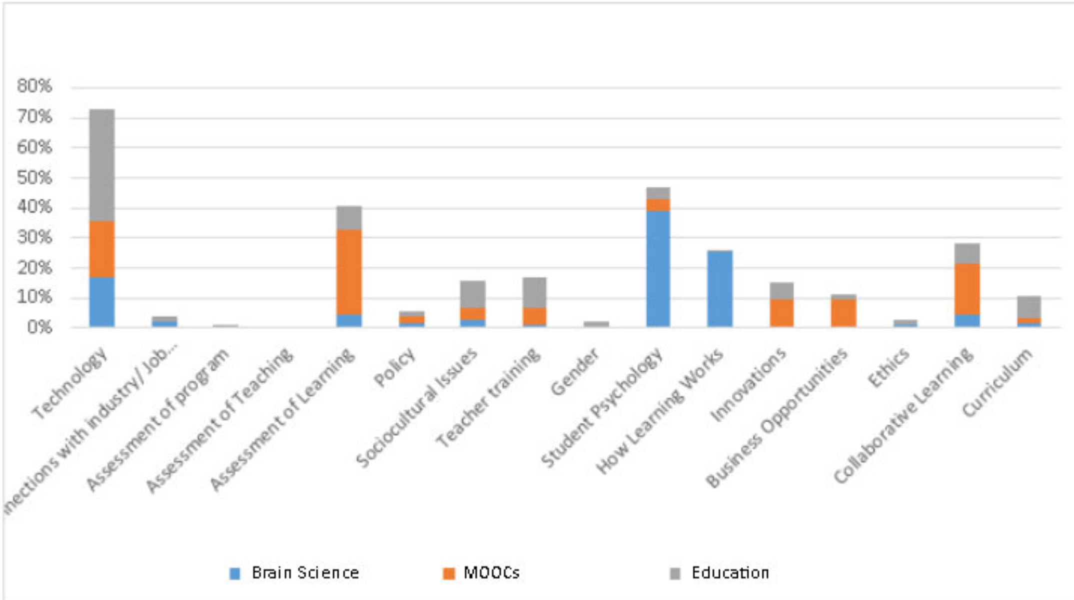

Figure 7: Percentages of conferences and journals within the fields of brain science, education, and MOOCS, including research on the 16 research themes identified.

4. Future Steps

As this is a pilot study with a limited set of data collected for each field, a study including a more comprehensive data collection will follow. The next step of the research group is to write the code that will automatize the process of data collection and store the data in a database. This can then be sent as an input to the final dynamic website, where it will remain constantly updated.

References

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