

# A Serious Game Powered by Semantic Web technologies

Bernardo Pereira Nunes  
Department of Informatics – PUC-Rio  
Rio de Janeiro, Brazil  
bnunes@inf.puc-rio.br

Giseli Rabello Lopes  
Federal University of Rio de Janeiro – UFRJ  
Rio de Janeiro, Brazil  
giseli@dcc.ufrj.br

Terhi Nurmikko-Fuller  
Oxford e-Research Centre – Oxford University  
Oxford/OX1 3QG, UK  
terhi.nurmikko-fuller@oerc.ox.ac.uk

Chiara Renso  
ISTI – CNR  
Pisa, Italy  
chiara.renso@isti.cnr.it

## ABSTRACT

ISCOOL is an interactive educational platform that helps users develop their skills for objective text analysis and interpretation. The tools incorporated into ISCOOL bridge various disparate sources, including reference datasets for people, and organizations, as well as gazetteers, dictionaries and collections of historical facts. This data serves as the basis for educating learners about the processes of evaluating the implicit and implied content of written material, whilst also providing a wider context in which this information is accessed, interpreted and understood. In the course of gameplay, the user is prompted to choose images that best capture content of a read passage. The interactive features of the game simultaneously test the user's existing knowledge, and ability to critically analyse the text. Results can be saved and shared, allowing the players to continue to interact with the data through conversations with their peers, friends, and family members, and to disseminate information throughout their communities. Users will be able to draw connections between the information they encounter in ISCOOL, and their daily realities - participants are empowered, informed and educated.

## Categories and Subject Descriptors

K.3.1 [Computers and Education]: Computer Uses in Education;  
K.8 [Personal Computing]: Games

## Keywords

Semantic technologies, text interpretation, text analysis, e-learning, games with a purpose

## 1. INTRODUCTION

ISCOOL is an informal, interactive learning environment, which encourages participants to engage in the critical analysis of text (see Figure 1). It is a Web-based game, created under the Creative Commons licence by-nc and free of limitations and copyright restrictions. All data used in the game and the application has been

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Figure 1: ISCOOL's opening screen.

published on the Web, classified as freely available for educational purposes.

The system was developed to address an identified gap in educational resources. Rather than add to existing tools that support learners by helping them develop their skills with a specific regard to the “Three R’s” of education (reading, writing and arithmetic), ISCOOL is a tool for developing the analytical skills of critical thinking and information processing as part of opinion formation and informed decision-making. Although applicable to many disparate demographics, two audiences in particular have been identified in the first instance: Firstly, people of low income households with limited access to educational facilities, and secondly, those with disabilities (hearing impairment in particular). Both groups represent a disadvantaged niche in the context of the wider community.

In the case of the former, many have limited levels of literacy, and may be unable to effectively assess the correctness and accuracy of long documents, or those written in specialist jargon. For the latter (those with a hearing impairment), the issue is somewhat different, as they are engaging with material that, in many ways, constitutes a second language (their native tongue being that of sign language). The interpretation of the material and the exchange of ideas related to it can be significantly supported by the addition of images to accompany the text.

The rest of the paper is organised as follows: Section 2 reviews related literature. Section 3 overviews ISCOOL. Section 4 describes the most relevant features of ISCOOL. Section 5 discusses the importance of using images in learning and teaching process. Finally, Section 6 concludes the paper.

## 2. RELATED WORK

In recent years, several online approaches have been developed to support distance education, many of which have only been possible due to the development of semantic technologies and the adaptation of existing tools to a dynamic hyper-text environment. To cite a familiar example, the traditional highlighter pen was reimagined as an online version to support students enrolled in online courses [9]. The online highlighter pen has several advantages over the original one: it can be shared between students, used to improve course contents and serve as an anchor to link to new resources on the Web. It can also help students to better understand course contents. Other e-learning tools [11] semantically analyse the content of posts on educational forums, many of which have hundreds of individual messages. Instructors can gain an overview of these discussions by the use of semantic technologies, which enable the summarising of forum content into topics extracted from DBpedia. Another approach [8, 10] uses extracted topics from forum posts to recommend other discussions that may enrich the current one. ISCOOL uses similar methods to retrieve images from search engines to help and support students in text interpretation and analysis.

Serious games have begun to emerge as complementary or alternative approaches to traditional learning activities. The combination of entertainment and educational activities engages learners and encourages them to achieve learning goals, consequently impacting on their academic performance in a positive manner[2]. Serious games have been able to captivate and engage students for a specific purpose such as developing new knowledge or acquiring specific skill sets. Moreover, Kurkovsky [6] shows that games can also contribute to improve retention rates: difficult subjects often experience high drop-out rates, but these have been observed to decrease when games are used to supplement the course material[7]. Several works have discussed identifying the optimal balance of learning and entertainment that a game must have in order to be most effective [3, 4, 5]. Other studies have discussed the necessary components of games and how they impact education [1].

## 3. SYSTEM DESCRIPTION

ISCOOL's inherently flexible educational game platform was created primarily to assist people in improving their abilities and skills in learning new languages, text analysis and text interpretation. Depending on the players' input, ISCOOL automatically produces a new and unique image-based game instance that can be applied in numerous different learning contexts. The dynamic nature and flexibility of ISCOOL enables users (usually teachers) to easily create learning games to fulfill the specific needs of their students.

In this section, we briefly describe the architecture of the ISCOOL platform. The game architecture is divided into two key components: (i) text processing; and (ii) game creation (see Figure 2). In both processes, ISCOOL takes advantage of semantic technologies, reference datasets and online thesauri to create and populate the game and its elements.

### 3.1 Text Processing

The player begins by adding an excerpt of text as an input in to ISCOOL, to initiate the process to locate and classify relevant elements within it. Thus, text processing begins with named-entity recognition (NER) over the text, where specific identifiable entities (e.g. people, organisations, and locations) are linked to reference datasets. As a NER tool, we used DBpedia Spotlight<sup>1</sup>, which links

<sup>1</sup><http://dbpedia-spotlight.github.io/demo/>

the entities found in the text inputted by the players to the pages in DBpedia<sup>2</sup> that describe them.

The numerous words or sets of words which are not recognised as entities as part of this initial procedure are processed and linked to other external data sources where a definition can be found and shown to the player, with potential of expanding and diversifying their active vocabularies. ISCOOL uses thesauri and dictionaries such as Wordnet<sup>3</sup> and Wiktionary<sup>4</sup>, to extract, identify and provide the correct definition for each word found in the text.

After the text is processed, a link is drawn between the two (the word in the text and its definition), providing information regarding the use and meaning of the lexical item in question. Clicking on an entity brings up a dialogue box with information regarding that entity/word definition/event. This step is fundamental to the creation of games, and is crucial in the formation and production of the following stage. Based on the information recognised, queries with the entity labels will be issued to retrieve images that will compose the game.

ISCOOL is centred around the concepts of reading comprehension, text interpretation and analysis, as well as language learning and vocabulary expansion. Traditional modes and methods for acquiring learning exclusively through audio-visual learning may not suit all students, and in the case of those with, for example, hearing impediments, some traditional modes of education are evidently unsuitable. The addition of visual material as a supporting element to language interpretation in an informal multi-player environment allows students to support their education through peer-learning, and by both providing and receiving additional support from other learners in ways that are more in line with visual and interpersonal learning styles.

Assigning relevant images to uploaded texts requires the learners to engage with the text on several levels. The first and most straightforward step is to assign images to clearly defined and identified tangible entities in the text: nouns (places, people, things) and simple adjectives (colours). Intangible concepts (emotions, abstract notions) constitute the second stage of cognitive analysis, and requires the student to engage more fully with the task of understanding both the context and the content of the uploaded text.

### 3.2 Game Creation

The images to create each interactive game are retrieved using the Bing search engine and external sources (such as Bing Image API<sup>5</sup> and Flickr<sup>6</sup>), the labels of the entities found in the first step functioning as query terms. Moreover, to ensure a broader representation and to diversity the returned images, the categories of the entities (up to four levels up in the category tree) are also used as query terms to retrieve images.

The retrieval of categorised terms is important, because ISCOOL players can identify both general and specific topics described in the text while playing. For instance, given a text "Michael Jordan" (a famous former basketball player), the player can select as a representative image a picture of Michael Jordan or a picture of one of its categories, i.e., a generic image of a basketball court or even a basketball. Depending on the proposed learning task by the teacher, (s)he may expect the player to select more general topics or more specific ones, and thus be able to evaluate whether the player was able to correctly identify relevant images amongst irrelevant ones. The categories associated with each entity in the text serves as the

<sup>2</sup><http://dbpedia.org/>

<sup>3</sup><http://wordnet.princeton.edu>

<sup>4</sup><http://www.wiktionary.org>

<sup>5</sup><http://www.bing.com/toolbox/bingsearchapi>

<sup>6</sup><https://www.flickr.com/services/api/>

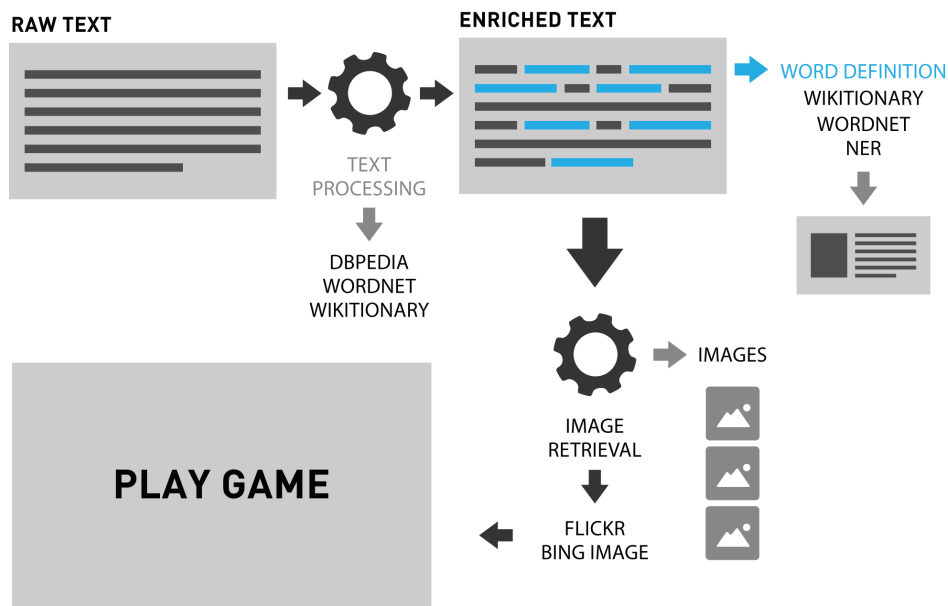


Figure 2: Game workflow.

basis for the retrieval of further images to create the game. A relevance score is assigned (and used to score the game as it is played) for each image retrieved from Bing.

### 3.3 The game

One of the underlying assumptions on which ISCOOL is based is that if the player is able to identify entities represented as images in the game, they must have at least some degree of comprehension as to the content. Diversity in the choice of marked entity is awarded in the game: if a player chooses a number of representations for the same entity (one occurring in the text), other equally important aspect of the text might be overlooked.

A level-specific timer limits the scope of each individual game. The more complicated the level, the shorter the time available to complete the task - for beginners, there are five minutes, for intermediate and advanced, three and one minute respectively. The greater the level of difficulty, and the extent of diversity of both the selected entities and images, the higher the resulting points for the player. The number of correct answers by the user also contributes towards their high score.

The game has a simple 8-bit interface with a retro aspect. Instructions for the player (explaining how to engage with the game) are also provided (see Figure 3).

## 4. DISTINGUISHING FEATURES - INNOVATION IN EDUCATION

Although ISCOOL can be utilised in diverse educational contexts, there are two which have been identified, in the first instance, as being particularly likely to benefit from the tool:

- People with Low Literacy – a common problem in third world countries and one often overlooked by governments. People with low levels of literacy may struggle to read and understand long and complex pieces of text, as well as those written in demanding registers or utilising specialist jargon. ISCOOL enables vocabulary enrichment and text interpretation through an interactive game in a friendly but competitive



Figure 3: The Game.

environment which motivates students to learn and interact with other users.

- Those with disabilities (Hearing Impairment in particular). People with hearing impairments can feel isolated due to language barriers and communication difficulties - in order to communicate through written mediums, they must acquire what is essentially a second language (the first one being sign language). ISCOOL uses images to help students with disabilities with the learning process: images are more accessible and more familiar in the context of their daily lives; engaging with the game is comfortable, and motivates users to learn through the mode of illustrating texts with images rather than writing in (essentially) a second language.

The versatility of ISCOOL ensures that it could be used and even repurposed in various different educational settings in primary and secondary education, as well as adult learners of various abilities, and linguistic backgrounds. The tool could be used to support not only those with limited literacy or disabilities, but also those learning a secondary or other language.

## 5. DISCUSSION

Images play a crucially important role in the processes of teaching, learning and text interpretation at all levels of education. This is particularly true in the case of the two identified user demographics - for those with hearing impediments, verbal queues cannot at any stage, be included into the learning environment, and for those with limited levels of literacy, visual aids are irreplaceable as a tool for deriving meaning from the writing. The incorporation of images into ISCOOL enables these underprivileged groups to engage with an educational tool and to acquire new skills and levels of competence. It also opens up the tool to a wider range of content, one which is arguably less precisely defined from the onset (images can be interpreted in different, but equally valid ways). Preliminary tests that were carried out with the help of representative user groups from Group 1 (People with Low Literacy) were successful and the second stage of testing and evaluation (currently underway) includes trials with persons with disabilities such as hearing impediment.

## 6. CONCLUSION

The aim of ISCOOL has been to create a tool that would help the development of a country, by enabling, empowering and enriching the lives of those who are most disadvantaged. People with low literacy and those who have disabilities are often confined to the periphery of social and political change and motivations - it is the belief of this research group that simple computing techniques, alongside semantic technologies and serious games can be brought together to create a resource that will have genuine and measurable positive influences on those who engage with it. ISCOOL is a tool that supports the first step in the long-term process of learning for a range of different types of learners, including those least supported by the traditional education system. The tool is available at <http://research.ccead.puc-rio.br/iscool>.

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