MIGRation pATterns in Europe: Geomatics and gamification techniques to raise the awareness of European citizens on migration flows

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The enormous migratory flows in the European Union and in the Mediterranean area are influencing the lives of people residing in the hosting countries. Nevertheless, the real magnitude of this phenomenon often remains unknown to citizens and can generate erroneous perceptions. MIGRation pATterns in Europe (MIGRATE) is a Web Mapping application whose goal is to educate and raise the awareness of citizens on this topic. To our best knowledge, this is the first attempt to apply in a modern way the methods and tools of Geomatics to migration-related themes. MIGRATE was developed within the MYGEOSS project of the European Commission-Joint Research Center (JRC), which has received funding from the Horizon 2020 Programme. Completely based on open data and open source technologies and designed with a gamification approach, MIGRATE engages players to learn while playing a map-based trivia game. The architecture of the application is based on the Django framework and makes use of a PostgreSQL database for the server side. The client side is built through HTML5, CSS3 and Bootstrap and makes use of OpenLayers for map management and jQuery for the interface. The analysis of the players' answers clearly shows how their awareness of migration-related issues overall increased after playing several times to MIGRATE.
Keywords: *Geomatics, Web Mapping, gamification, open data, open source software, migration.*

MIGRation pATterns in Europe: tecniche geomatiche e di gamification per sensibilizzare i cittadini europei sui flussi migratori. *Le dimensioni ragguardevoli dei flussi migratori nell'Unione Europea e nell'area mediterranea stanno influenzando la vita delle popolazioni delle nazioni ospitanti. Tuttavia, spesso i cittadini conoscono solo parzialmente le reali dimensioni di questo fenomeno, divenendo quindi soggetti a percezioni errate. MIGRation pATterns in Europe (MIGRATE) è un'applicazione di Web Mapping il cui scopo è educare e sensibilizzare la popolazione su questo argomento. A conoscenza degli autori, si tratta del primo tentativo di applicare in modo moderno i metodi e gli strumenti della Geomatica ai temi inerenti l'immigrazione. MIGRATE è stato sviluppata nell'ambito del progetto MYGEOSS della Commissione Europea-Joint Research Center (JRC), finanziato dal programma Horizon 2020. Basato su tecniche di ludicizzazione (gamification), gli utenti sono coinvolti nell'apprendere nuove informazioni mentre si divertono a giocare con un quiz geografico. MIGRATE fa uso esclusivo di dati aperti e di software libero e a codice aperto. Dal punto di vista tecnico, la parte server di MIGRATE è basata sul framework Django ed utilizza un database PostgreSQL. La parte client fa invece uso di HTML5, CSS3 e Bootstrap, della libreria OpenLayers per la gestione della mappa e di jQuery per l'interfaccia. L'analisi delle risposte fornite dai giocatori mostra chiaramente come la loro consapevolezza sui temi legati alle migrazioni globalmente aumenti con il numero di partite giocate a MIGRATE.*
Parole chiave: *Geomatica, Web Mapping, ludicizzazione, dati aperti, software libero, migrazione.*

1. Introduction

1.1. Migration patterns

The International Organization for Migration (IOM) defines as migrant any person who is moving (or has moved) away from their habitual residence, within a State or across international borders, regardless of i) the person's legal status, ii) whether the movement is voluntary or not, iii) what the causes for the movement are, or iv) what the length of the stay is (https://www.iom.int/key-migration-terms, accessed on April 1st 2017).

People generally move, or are forced to move, as a result of political instability, conflicts, human rights violations or violence. Sometimes, the migration from poor countries to developed economies is one the few options while searching for a better future, to gain access to better opportunities or to escape extreme weather. Since the beginning of the century, the number of international migrants quickly grew up worldwide and now 244 million people (3.3% of the world's population) are living outside their country of origin (http://www.unfpa.org/migration, accessed on April 3rd 2017). However, recently the Arab Spring and the conflicts in the Syrian Arab Republic and Iraq have significantly raised the global number of displacements. According to the Global Trends 2015 report of the United Nations High Commissioner for Refugees (UNHCR), we are now witnessing the biggest refugee and displacement cri-

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sis ever recorded. During 2015, 65.3 million people have been globally displaced from home because of conflicts or persecutions. Among them, almost 21.3 million are refugees, more than half of them are under the age of 18 and at least 10 million people are stateless (UNHCR Global Trends 2015, http://www.unhcr.org/statistics/unhcrstats/576408cd7/unhcr-global-trends-2015.html, accessed on March 28th, 2017).

With reference to the European Union, since 2014 Europe has witnessed a dramatic increase in the number of people crossing the Mediterranean Sea. Over 1 million people landed in 2015, which is more than 350% compared to 2014 and over 14 times greater than in 2011 (Brian and Laczko, 2016). At the time of writing (April 2017), we have no official statistics for 2016. Nevertheless, a research of the IOM shows that Europe is the world's most dangerous destination for irregular migrants and the death toll to the Mediterranean Sea was estimated being 68% of total (worldwide) deaths in 2016. The same proportion was recorded in the first few months of 2017 (https://missingmigrants.iom.int/latest-global-figures, accessed on April 1st 2017).

1.2. State of the art

A number of apps related to the theme of migration is currently available online. Nevertheless, existing apps are specifically addressed to migrants arriving in a specific country to help them finding first assistance, recovery, legal documents for asylum requests and basic learning of the host country language. Some examples are 'ASYLUMDK' (https://drc.dk/asylumdk, accessed on March 29th, 2017), 'Refugee Aid' (http://refugeeaidapp.com/, accessed on April 2nd, 2017) and 'Refugee.Info' (https://www.refugee.info/, accessed on April 2nd, 2017). Examples of apps with a different purpose are 'My Life as a Refugee' (http://mylifeasarefugee.org/, accessed on April 1st 2017) developed by UNHCR and the online quiz developed by Open Migration (http://openmigration.org/quiz/, accessed on March 26th, 2017). The first is a role-playing Web Mapping application in which the player faces the same tough difficulties that refugees experience when they are threatened by conflicts and persecutions, while the second is a quiz to make people aware on how much they know about the refugee crisis.

Gamification refers to the use of game-design elements in non-game contexts (Deterding *et al.*, 2011). The goal is to maximize the players' enjoyment and engagement through capturing their interest and to inspire them to continue learning, presenting a set of motivating challenges to them. When used in education, gamification allows users to deal with their knowledge through the learn-by-failure technique that is popular in game-like environments (Huang and Soman, 2013). Even though this technique is most prominently used in education environments, the interest in gamification is quickly growing also in the industrial and academic contexts (Huotari and Hamari, 2012; Dicheva *et al.* 2015). This is confirmed by the increasing number of successful startups that focus their core business on gamified services or assist companies in gamifying their existing services and by the number of papers published on gamification (Huotari and Hamari, 2012).

Most of the studies on gamification in education/learning contexts highlight very positive outcomes in terms of increased motivation and engagement in learning, as well as enjoyment (Hamari *et al.*, 2014). However, these studies denote that engagement induced by gamification is dependant on several different factors and authors claim that the context to which gamification is applied can influence the outcomes. Besides, attention has to be paid to drawbacks such as increased competition (Hamari *et al.*, 2014). Some main tendencies in using specific game design elements have been identified in gamification approaches devoted to learning: according to Dicheva *et al.* (2015), the most popular game mechanisms as means of engagement include points, badges and leader boards.

Gamified apps offer a unique opportunity to gather data and information. Thanks to the increased number of smartphones and access points to the Internet, the amount of currently available apps to collect data is countless and spreads to a number of various themes. Thus, crowd-generated data have seen a noticeable growth in the last year and are subject to an expanding importance in everyday life.

1.3. Research objectives and novelty

Migration through the Mediterranean Sea hit the headlines and attracted public attention. However, the general attitudes of people living in the hosting countries are sometimes driven by erroneous convictions, thus generating stereotypes and prejudices. MIGRation pATterns in Europe (MIGRATE) is a Web Mapping application (http://geomobile.como.polimi.it/migrate, accessed on May 1st 2017), based on a gamification approach, whose main purpose is to educate the European citizens and raise their awareness of the migration flows in Europe. Its secondary aim is to provide an insight into the public perception of migration to support governments and organizations in developing proper communication strategies shaped by evidences, rather than by fears and misconceptions.

Thanks to a well-balanced trade-off between enjoyment and user-friendliness, MIGRATE was thought for non-expert users and is addressed to all citizens, regardless of their level of education, country or age. Thus, MI-

GRATE also aims at making citizens active volunteer participants and contributors in the collection of data. In the end, MIGRATE is an attempt to use the methods and tools of Geomatics in a modern way for supporting policy-makers. To our best knowledge, this approach has not yet been applied to migration-related themes.

2. Methods

2.1. Open data

Census agencies provide population statistics and data about population growth or decline as a consequence of immigration/emigration fluxes. On the other hand, non-governmental organizations usually provide estimates on migrants, refugees and asylum seekers arrivals and deaths, their origins, destinations and routes, and try to outline any changes in time and space. Besides, the web has turned out to be the media used by journalists and researchers to collect data, statistics or migrants' stories and share this information in the form of blogs (e.g. http://fortresseurope.blogspot.it/, accessed on April 1st 2017), websites or graphs (e.g. http://www.global-migration.info/, http://www.therefugeeproject.org/#/2015, accessed on April 2nd, 2017).

To comply with the guidelines of the MYGEOSS call, all the data used in MIGRATE are open access with no restrictions for reuse (data are provided with the ODbL, CC-BY, CC-BY-IGO, CC-BY-SA, ODC-ODbL, ODC-BY, PDDL, CC0 licences or with a customized open license policy). Consequently:

- population data are derived from Eurostat (http://ec.europa.eu/eurostat, accessed on April 13th, 2017), the statistical office of the European Union;
- the spatial distribution and temporal trends of migration patterns are extracted from the database of UNHCR and from the Humanitarian Data Exchange portal (https://data.humdata.org, accessed on April 13th, 2017). These databases allow to classify the migrants entering the European Union according to their origin, status, age and sex;
- the IOM's databases 'Migration Flows-Europe' (http://migration.iom.int/Europe, accessed on April 14th, 2017) and the 'Missing Migrants Project' (http://missingmigrants.iom.int, accessed on April 15th, 2017) are used to provide up-to-date statistics on migration flows and routes towards Europe. The first database summarizes information collected by field staff in cooperation with the Ministries of Interior, coast guards, police forces and other relevant national authorities, while the second database records the number of deaths and missing migrants (from October 2013);
- some other information is extracted from The 'Migrants' Files' (http://www.themigrantsfiles.com, accessed on April 15th, 2017). This project was started in mid-2013 and includes data gathered from non-profit organizations, online blogs, media reports, government publications and real-time news on asylum seekers, migration and human trafficking activities in Europe. In addition, it includes some data about money spent both by migrants to reach Europe and by the European governments to stop/limit migration and to deport migrants.

2.2. Architecture of the Web Mapping application

MIGRATE is a cross-platform Web Mapping application. Its development made use of tools to promote the cooperation within the team, such as Trello for project management (https://trello.com/, accessed on April 6th, 2017), Git as version control system (https://git-scm.com/, accessed on April 6th, 2017), Scrum as development framework (Schwaber, 2004) and the Django framework (https://www.djangoproject.com/, accessed on April 6th, 2017) which is the foundation of the application. Django uses a Model View Controller pattern – MVC (Deacon, 2009), that allows separating between the logical components, database storage and querying operations as well as presentation of the application to clients.

The use of frameworks that seamlessly integrate backend and client-side architectures provides an organized structure that serves for an uncoupled development. This reflects on a process where project managers, designers and programmers can gather an overall perspective and accountability of the project at all stages, enabling to contribute autonomously on their corresponding tasks. The software contributions were handled with the Git version control manager along with the online GitHub repository to keep contributors' updates synchronized during the development stage.

PostgreSQL was used for storing both questions and answers, while the Django models and its administration module allowed a scalable architecture, offered intuitive tools to check the status of the players during the challenge and reported overall statistics without performing a deep analysis on the database. Other benefits of using Django were a straightforward management of users' accounts, agile development and easy code reuse.

The security protocols already implemented in the framework guaranteed the protection of all the information provided by competitors. The anonymization of users' data was conceived from the early stage of the project. Thus, no real name or e-mail address were asked and personal data useful for statistical analysis were requested as aggregated values (ranges). Consequently, the real identities of all players and

other sensitive information were not stored in the database.

The strategy for avoiding the game becoming monotonous after a few games played relied on the use of different kinds of questions (i.e. true/false, map-based, multiple-choice and text-based), their randomization and shuffling after each game. For the look and feel of the game, the Bootstrap framework for responsive development was used (http://getbootstrap.com/, accessed on March 28th, 2017), this gave the game the right adjustments to be displayed on any kind of device; whether it is a PC, a tablet or a cell phone with different screen dimensions and interaction modes.

On the client-side the OpenLayers JavaScript (JS) library was used to display the boundaries of countries (available in GeoJSON format) in map-based questions. The overall flow of the trivia game was done using JS libraries, along with Ajax JSON requests to securely communicate with the server-side and avoid cheating from the client-side by SQL injections (https://www.w3schools.com/sql/sql_injection.asp, accessed on April 4th, 2017). The source code of MIGRATE is released under the European Union Public License (EUPL) and is available at the following page: https://github.com/kilsedar/migrate (accessed on April 2nd, 2017).

The questions were designed and classified by macro-regions, then associated to players according to their country of origin. This was done with the purpose of presenting relevant questions to the player's context and making the game engaging.

Figure 1 shows some screenshots from MIGRATE. The game has the following outline: the main screen displays a map related to the question on the left text box. On top of it, a countdown shows the time left to answer. When the player replies, MIGRATE outlines the correct answer in green and the wrong answer (if any) in red, also providing a short explanation and a link to the data source in the bottom of the text box. Further details about the structure of the game and questions are described in Brovelli *et al.*, 2017) and a short video tutorial is available at https://www.youtube.com/watch?v=Z5789ijmyxU (accessed on May 4th, 2017)

3. Results and discussion

MIGRation pATterns in Europe (MIGRATE) is a first attempt to bring Geomatics methods into gamification to inform the public opinion on the real extent of migration towards Europe. This exercise provided an interesting insight into the perception of citizens and, to our best knowledge, a similar approach has never been applied to migration-related themes.

On December 6th, 2016 the first MIGRATE challenge was officially launched and the top ten players were awarded with Amazon vouchers (http://geomobile.como.polimi.it/migrate/challenge/, accessed on May 4th, 2017). At the time of writing, more than 300 people from 44 countries played about 15,000

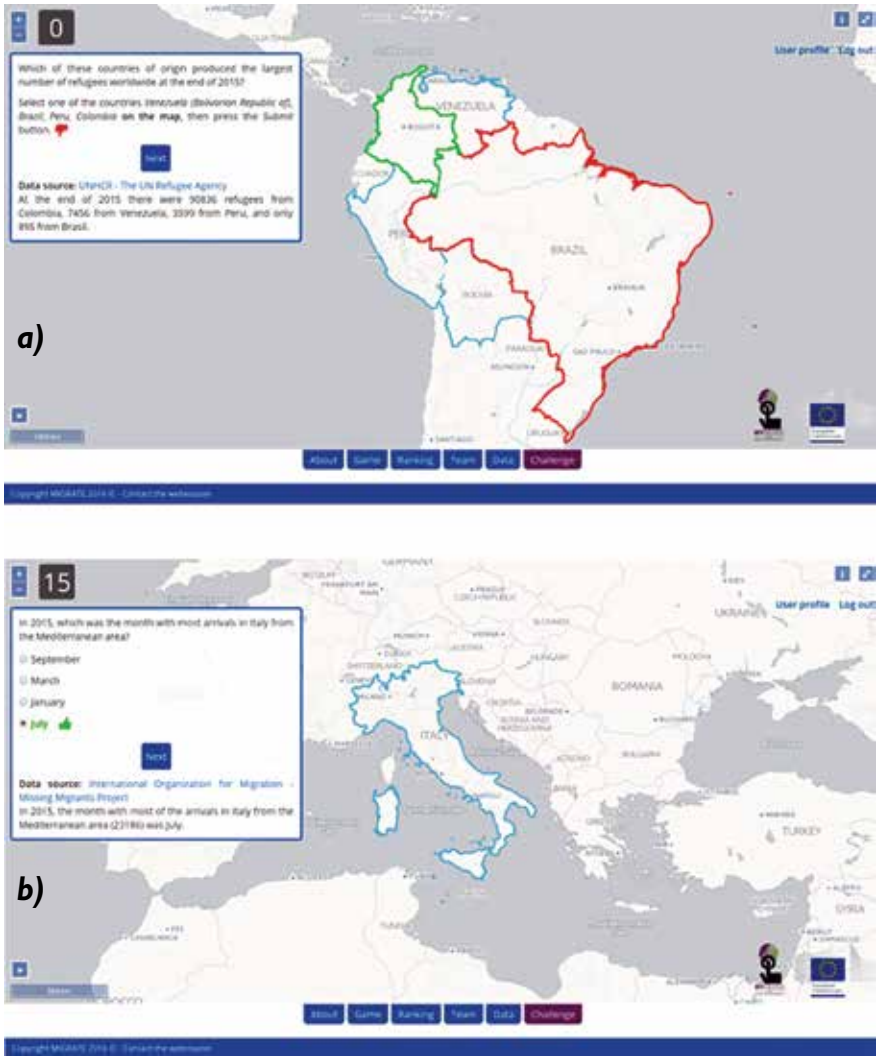

Fig. 1. Examples of map-based question (a) and multiple-choice question (b). If the player provides a wrong answer, MIGRATE outlines in red the error and highlights in green the correct answer, providing a short explanation and a link to the data source. *Esempio di domanda su base geografica (a) e di domanda a risposta multipla (b). Se il giocatore risponde erroneamente, MIGRATE evidenzia in rosso la risposta errata e in verde quella corretta, fornendo una breve spiegazione e un link alla fonte dei dati.*

games. Players were roughly 60% male and 40% female, mainly between 18 and 34 years old and four out of five had a University degree (from Bachelor degree to PhD).

The answers of all players given in their first ten games were examined to evaluate the effectiveness of MIGRATE. Results show that the players' overall starting knowledge of migration-related matters was substantially erroneous and in their first game they correctly replied to only one third of questions (Fig. 2a). On the other hand, at the tenth game the number of correct answers increased to almost 50% (Fig. 2a), thus they learnt while playing MIGRATE. Statistics presented in Figure 2b reveal that people's awareness and bias differ according to age. While senior players (55-64 age class) did not significantly improved their replies, thus their knowledge, from the first to the tenth game, younger players proved to be more keen to learn. The most significant improvement was achieved by users belonging to the 35-44 age class (+25% of correct answers), followed by 25-34 age class (+15% of correct answers) and 18-24 age class (+11% of correct answers).

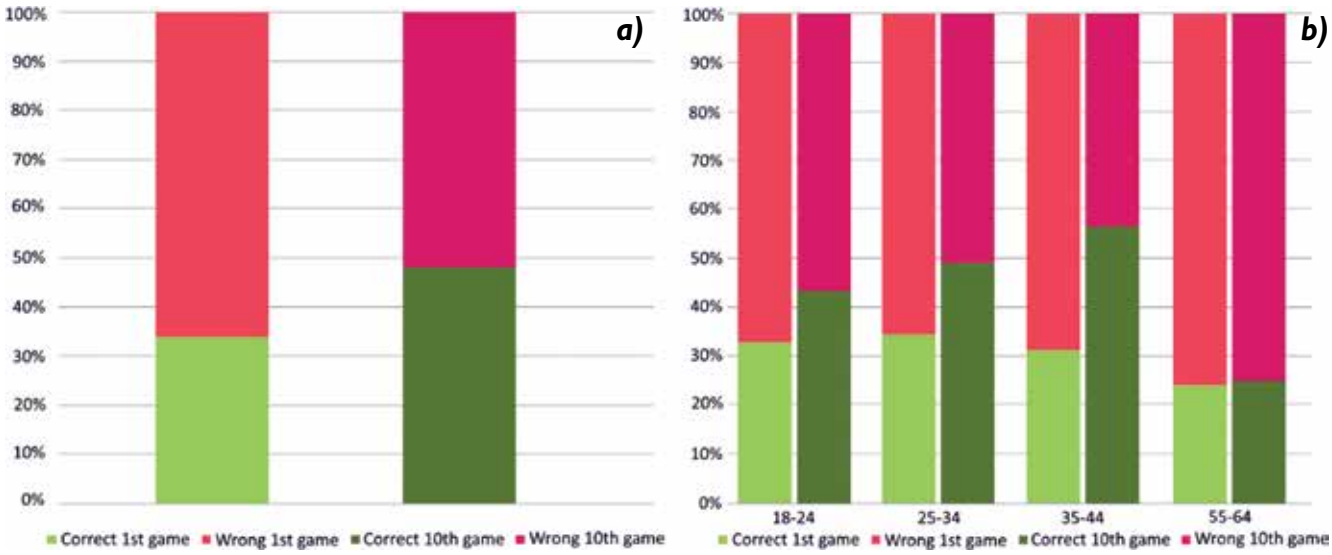

Fig. 2. Percentage of correct and wrong answers given by all the players at the first game and at the tenth game (a) and detailed replies according to players' age classes (b). Age classes 45-54 and ≥65 were excluded from the analysis because very small.
Percentuale di risposte corrette ed errate fornite alla prima e alla decima partita da tutti i giocatori (a) e risposte dettagliate in funzione delle classi di età (b). Le classi di età 45-54 e ≥65 sono state escluse dall'analisi perché poco numerose.

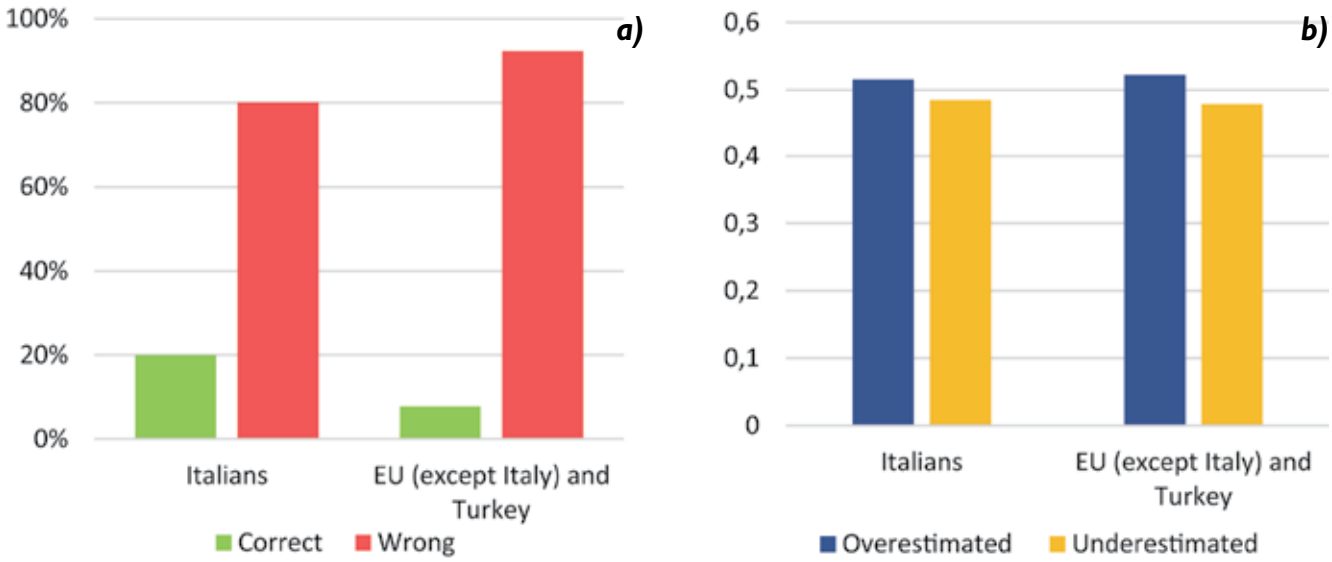

Fig. 3. Percentage of correct and wrong text-based answers provided by Italian and European players within the first ten games (a). The analysis of wrong answers provides the percentage of overestimation and underestimation (b).
Percentuale di risposte corrette ed errate fornite dai giocatori Italiani ed Europei alle domande basate su testo libero nelle prime dieci partite (a). L'analisi delle risposte sbagliate fornisce la percentuale di sovrastima e sottostima (b).

With reference to text-based questions, which players pointed out as the most challenging (among true/false, map-based, multiple-choice and text-based questions), results show a substantial different knowledge between Italian and European (including Turkish) players. Figure 3a shows how the percentage of correct answers of Italian players were more than double compared to those of the other European players, thus suggesting their higher consciousness about real numbers of migration. With respect to wrong text-based answers, players have slightly overestimated the phenomena (Fig. 3b), showing that a moderately negative perception about migration flows is common among European people.

According to the survey carried out after the challenge among the top players, their answers clearly give an impressive overview about how little they really knew on migration-related topics and how their perception was wrong. Some players said:

"I learnt many information on the migration flows in Europe and worldwide. Now I know the magnitude of this phenomenon and I can only imagine how challenging can be to handle it."

"I learnt many things about the migration phenomenon that I did not know before playing. I think this is a very interesting and instructive game."

"I learnt more about current issues that affect Europe and Italy too. I also realized that some of my previous knowledge about some topics was wrong. Playing MIGRATE helped me to have a clear idea about these problems."

The majority of the players said their previous knowledge about migration flows and related problems was substantially wrong, even when referring to their own country. Overall, the interviewed players acknowledged that MIGRATE was very useful to draw a clear picture of migration phenomena in the European Union and to make them aware.

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