Second Language Tutoring using Social Robots

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L2TOR

Second Language Tutoring using Social Robots

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Executive Summary

This document captures the state of play for educational and robotics industry at the end of the L2TOR project. It identifies market opportunities and low hanging fruit in social robots for language tutoring, as well as a description of design features to develop such robots. This report is the final version of a preliminary report which was released midway the project (June 2017).
Principal Contributors

Raphael Tassart, Wim Van Hove (QBMT)
Revision History

Version 1.0 (WVH 06-2017)

Preliminary version

Version 2.0 (RT 12-2018)

Final version
1. Opportunities in technology for second language learning

3.1 Second Languages and the challenge new mobility

Second language learning has become an important element of formal education for many children in Europe and beyond. For some children, the language used at school is a second language (noted as L2), as they speak a different language or dialect at home. This is not only the case for immigrant children, but also for children speaking an official minority language of their country of residence. Preschool years are important to develop adequate knowledge of the academic language, as later educational success builds on it. It is therefore essential that children with a different home language than the dominant one receive “sensitive” bilingual input and interaction in day care and preschool. The robot tutor we propose here serves that crucial aim.

98% of the Europeans hope their children will master a foreign language

Due to increased mobility of European citizens and increasing internationalisation, most children in Europe will be required to fluently use two or more languages. Figures are undeniable: the number of first-time asylum applicants in the EU-28 (the current 28 member states of the European Union, not including Turkey) rose from less than 200 thousand in 2009, to more than 1.20 million in 2015 and 2016, equivalent to 0.2 % of the EU’s total population (Source Eurostat, Key Figures on Europe 2018). One of the results of this increase is that just above four out of five (80.6 % or 18 million) primary school pupils in the EU-28 were studying English as a foreign language in 2016.

Over 100 different countries are represented in the European population, many of which have an official language that was not previously spoken by a lot of people in Europe. Moreover, 98% of the respondents from a recent survey consider mastering a foreign language useful for their children’s future (Eurobarometer, 2012b).

3.2 Robots are becoming an integral component of our society

The L2TOR project is considering the benefits of using humanoid robots to help young children learn a foreign language, and to help tutors and language teachers of all types in their teaching. But are these target groups ready to accept the presence of a robot in their daily life? Are they ready to enjoy and accept the assistance of humanoid robots? The answer is undeniable: the majority is clearly in favour of living alongside robots.

A recent study in Norway about user acceptance of social robots shows that the public is quite ready for, and enthusiastic about working and living with personal robots. This study also observes that children are more interested in experiencing new technology and therefore they should be involved more in the design and development of such technology.

Personal robots are a very well-accepted product and therefore they can be employed to work
with humans in challenging environments such as in classrooms for educating children and in nursing homes for elderly care giving. (source: Aalborg University, Denmark and NTNU in Ålesund, Norway. “User acceptance of social robots,” Norway, 2016)

3.3 Strengths, limitations and challenges of new technologies

Being optimistic about robotics doesn’t mean being blind to the real strengths and weaknesses. To paint an honest picture of these, a short and comprehensive overview of today’s technologies in education will be given in the next section.

3.3.1 Strengths

The technological developments have caused an increase in the use of multi-media tools in education, which means that commercial robots are entering classrooms at every level throughout Europe. According to the study “Understanding how children understand robots: Perceived animism in child–robot interaction”, children are also playing with robotics during their play-time. For this reason, the development of the commercial robots in education is considered necessary. Investigating the influence of robotics on children’s language is not an option but a real challenge.

According to the research described in “Social Robotics in Education: State-of-the-Art and Directions” (supported by the EU Interreg, and the Danube Strategic Project Fund (DSPF)), “it is obvious that meaningful benefits will only be obtained if technology is used skillfully by teachers, aligning the provided tools with each student’s educational needs”.

Results regarding the use of robotics in education are generally positive. Recent studies reported that in education, the use of robots can potentially help children to develop various academic skills like understanding science and mathematical concepts, and can cause an improvement of achievement scores.

According to a study led in Taïwan: “Using Tangible Companions for Enhancing Learning English Conversation”, learners see the tangible learning companion as an interesting toy, robot, peer-partner or patient instructor for learning English. Pupils feel more comfortable speaking English, and experience less fear of making mistakes. “For beginners, this is an exciting and important step to take when the tangible learning companions play the scaffolding role in helping the students learning a foreign language. It is important that the psychological learning barrier, caused by the language ego, could be reduced by using the tangible learning companions so that they could actively engage in learning English.” Overall, the English instructor and students agreed that uses of the tangible learning companions effectively improve the class atmosphere, learning interest, and attitude of the learners in English learning. (source: “Using Tangible Companions for Enhancing Learning English Conversation» Taïwan)”
3.3.2 Limitations
First attempts and experiences in the field of educational robotics are really promising. But at the same time, the lack of investment in well-trained educators who are truly comfortable with robots and programming tasks, is a well-known issue.

With the technology that is available today, it is impossible for a robot to take on the role of an autonomous mentor. To make this happen, technological advancements are necessary. One of the major shortcomings of robots in education is the absence of a well-defined curriculum and learning material for teachers. Robotics education is still seen as an extra-curricular activity and a part of informal education, rather than as an integral part of formal education.

For students to have a satisfying user experience with robots, efforts must be devoted to improving the capabilities of robots to understand speech and to reproduce human-like behaviour (in light of the uncanny valley).

Improvements in the field of speech recognition technology, like enabling the robot to understand and correct unexpected mistakes in pronunciation from the students, have to be made to fully meet the ambition of robot assisted language learning.

According to a recent research (Source: Social Robotics in Education: State-of-the-Art and Directions) investment in training educators, in addition to the purchase cost of robots, is needed. “Moreover, innovative teaching strategies and methodologies in terms of well-defined curriculum and learning material, transferable across the regions to support effective learning need to be developed”.

4 Objectives of the L2TOR project

The central goal of the L2TOR project was to develop an embodied digital learning environment in which a child-friendly, social humanoid robot serves as a tutor to assist children in acquiring a second language. This robot may be used in the school environment to assist teachers during group exercises or in practicing with a child individually. But the L2TOR robot is also expected to achieve tasks in a private environment, for example at home or in language learning institutes.

This robot will be able to interact with the child naturally at a level that challenges the child to learn new words and grammar, while still allowing the child to feel like they are talking to a friend. The robot will keep track of individual children’s development and will adapt its own interaction to facilitate the child to advance to the next level. As such, the robot will construct a “scaffold” that allows the child to acquire new skills in interaction. Since the robot will teach the child a second language, it is desirable for the robot to be fluent in the child’s native language, so it can provide explanations and instructions that the child can readily understand.

More than a robot, more than a software… An embodied digital learning environment
The L2TOR embodied digital learning environment will not only consist of the robot, but it is a complete learning environment that also includes a table-top environment that represents the contextual content of the system.

### Allow real interactions between the child and the robot

The primary requirement for building common ground is to design child-robot interactions that allow for mutual understanding of the communicative acts and the environment in which the robot and child are situated. For the L2TOR robot, this means that the robot should be able to

- perceive and recognize the objects and events that occur in the environment,
- perceive and recognize the verbal and nonverbal signals produced by the child,
- use Theory of Mind to take the child’s perspective,
- be able to monitor linguistic/behavioural errors produced by the child,
- respond to the child in a contingent manner, both temporally and semantically, and
- produce appropriate utterances in different modalities, particularly speech and gesture

### 5 The Uniqueness of L2TOR approach

**ROBOTS FOR EARLY LEARNING IN THE NATIVE SPEAKING LANGUAGE**

This is one of the main assets of the project. The L2TOR robot is designed to interact naturally with children aged four years old in both the second language and the child’s native language. The robot’s social behaviour will be based on how human tutors interact with children and will not only use verbal communication, but also nonverbal communication such as gestures and other forms of body language.

**ROBOTS TO GO FURTHER** L2TOR improves the state of the art in robotic tutoring by mapping how the robot should behave in order to optimise learning through rigorously exploring the impact of different robot behaviours. While earlier work has relied extensively on remotely operating the robot, L2TOR moves towards autonomous robotic tutors. In addition, L2TOR innovates the unmapped terrain of using robots for younger children, specifically at the age of four when the effectiveness of language tutoring can be relatively easily tested and when language tutoring is potentially at its most effective.

**ROBOTS TO LEARN DIFFERENTLY** The L2TOR lessons innovate digital learning environments by stimulating children to engage in hands-on sensory-motor activity to build word meaning in a concrete physical environment, rather than a digital one. Moreover, the L2TOR system is the first that aims to combine the previously mentioned critical features
in a system that can use pointing, gesturing and object-exploration to explain meaning, both in L1 and in L2 fluently.

INSPIRED BY TEACHERS Our proposed study of naturalistic and experimentally elicited interactions between young L2 learners and teachers helps determine the multimodal features that lead to effective communication and targeted learning outcomes in current human L2 teaching situations. Three different defined content areas of mathematics, spatial knowledge and narratives have been utilized to elicit interactions between child learners and teachers, and these interactions are used to innovate interactions between child learners and the L2TOR robot.

ROBOTICS MEANS ETHICS TOO We have charted the ethical and societal climate of robotic tutors. An External Ethics Advisor and L2TOR monitored the development and practice of L2TOR over the duration of the project. We formulated actions and responses to ethical issues. This extends far beyond ethics in scientific experimentation. The ethical and legal aspects of using robots and AI to substitute for human interaction are high on L2TOR’s agenda, as are the societal perception of the use of these technologies and how academia and industry need to engage with the public on these matters.

6 Insights

Children respond well to robots and are very enthusiastic about them: robots also encourage things that are important to learning, such as paying attention, following instructions, enthusiasm.

Robots have the potential to deliver one-to-one tutoring of different subjects (e.g mathematics), but are particularly promising for language tutoring.

At the beginning of the project, we believed that children aged 4 or 5 would be a good target for learning a language. L2TOR now believe that 8 or older could be a better age.

The combination of the robot and a tablet is a winning one. Tools are complimentary.

What we know now is that social robots show great promise for education
Social robots seem to have a distinct advantage over alternative digital one-to-one tutoring technologies, such as screens and tablets. When tutoring is delivered by a social robot this leads to greater learning gains compared to the same content delivered on-screen.

**In contrast to chatbots or avatars, social robots are physically embodied.** They interact and communicate with humans or other autonomous physical agents by following social behaviours and rules. There is a shift towards the use of fully embodied robots/agents in both formal and informal education such as the Nao humanoid robot, robots embodied as pet animals or toy characters. These robots have the ability to engage what we could call a social interaction, by virtue of being able to talk and exhibit facial expressions.

**Nao is the “humanoid for the job”**

The humanoid robot, and especially Nao, is the appropriate hardware to create an efficient interaction and a joyful experience for children. It’s one of the most accepted and popular humanoid robots in the world since it is the first humanoid robot to be used in a non-academic field (healthcare, education, retail & tourism) and one of the top selling models.

**Robots tutors can be ready for the market**

The following table captures the main technological innovations and critical technology elements, their Technology Readiness Levels (TRL) at the beginning of the project, where the TRL was predicted to be at the end of L2TOR, and where we are now the first phase project is achieved. It shows what L2TOR has managed to accomplish with its partners and how ready the solution is to be brought to the market.

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<tr>
<th>Technology</th>
<th>TRL* at the beginning of L2TOR project</th>
<th>Predicted TRL</th>
<th>Current TRL</th>
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<tr>
<td>Robots used as tutoring tools</td>
<td>TRL 5</td>
<td>TRL 7</td>
<td>TRL 6 to 7</td>
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<tr>
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<td>TRL 7-9</td>
<td>TRL 8-9</td>
<td>TRL 7-9</td>
</tr>
<tr>
<td>Multimodal input processing</td>
<td>TRL 3-9</td>
<td>TRL 4-9</td>
<td>TRL 5-9</td>
</tr>
<tr>
<td>Multimodal output generation</td>
<td>TRL 4-7</td>
<td>TRL 6-8</td>
<td>TRL 6-9</td>
</tr>
<tr>
<td>Interaction management and tutoring behaviour</td>
<td>TRL 5</td>
<td>TRL 7</td>
<td>TRL 7</td>
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*Technology Readiness Level*
7 Open questions

Are robots ready for being used as tutoring tools?

Yes, they are. L2TOR achieved its goals on this subject. To be more specific, L2TOR, together with many other projects in the last few years, has demonstrated that robots can indeed be used as tutors or teacher. There is now a large amount of evaluation data available showing that the technology is viable and with the right investment could be brought to market.

Did L2TOR meet the challenge of hardware and middleware?

We used existing commercial products, such as the Nao robot and the NaoQi middleware to make quick progress. However, the software interfacing the robot to the tablet had to be written from the ground up, and still is not at a level where it could be considered at production TRL (i.e. 9). The main reason is that the software contains a number of experimental components, such as the Underworlds components which allow the AI to reason about spatial positioning in the virtual world. While these components are functional, they are too slow to offer a smooth user experience.

Is the multimodal input processing performing?

The interaction predominantly happens through reading touch events on the tablet screen, augmented by Voice Activity Detection, computer vision and speech recognition of a few key words. However, in terms of visual processing, better than expected progress has been made due to the arrival of Deep Learning and Convolutional Neural Networks in specific. The CMU OpenPose library now allows for the tracking of the children’s movements without the need to resort to external 3D cameras.

Did L2TOR find the good combination for multimodal output?

The output on the one hand consists of the behaviour of the robot, and on the other hand of the content displayed on the tablet. In terms of the robot we use products developed by Softbank Robotics, which only require minor modification, and specially built animations to teach particular words to the children. The speech output, which enables fast switching between different languages, was solved well. The tablet shows an attractive game-like environment, which forms the focus of attention for the language lessons and is the main way of interacting with the children.

Are the answers to interaction management questions, and is tutoring behaviour satisfactory?

The interaction management relies heavily on insights offered by pedagogy and developmental psychology. The robot is now presented as a knowledgeable peer (rather than a teacher) with which the young learner goes on a learning journey. We have explored
various ways of adapting the tutoring behaviour to the progress made by the child, and while open questions remain, the consensus in L2TOR and in the research field is that judicious design and adaptation of the tutoring behaviour of the robot will lead to greater learning gains.

8 Different educational drivers of using a social robot in language learning

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<th>AS A PEER</th>
<th>AS A TOOL</th>
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<td>When a student pronounces a word correctly, the robot says well done</td>
<td>When a student learns certain phrases in a non-native language by playing a game with a robot</td>
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9 Testimonials

We collected testimonials from parents and teachers whose children and pupils worked with a robot tutor for a period of 12 weeks learning English.

9.1 From parents

What did your child tell you about the lessons with the robot?

Almost half of the parents (7) reported that their children told them nothing or not much about the lessons with the robot. Some children (4) told their parents that the lessons with the robot were fun, which English words they learned (3) and that the robot was dancing (2). Two children told their parents that they found the lessons with the robot exciting. One parent voiced their concern the fact that the researchers were mostly focused on the robot rather than on the children, and that they felt that their daughter didn’t get sufficient reassurance when she was scared that she was doing something wrong.

Did your child ask for more lessons with the robot?

Eleven parents reported that their children did not ask for more lessons with the robot, though one of the parents stressed that their child had enjoyed the lessons. Six children told their parents that they wanted more lessons with the robot.

Do you think that the robot increased your child’s motivation to learn English?

Almost half of the parents (8) didn’t think that their child was more motivated to learn English because of the robot. Five parents reported that they noticed an increase in
motivation for learning English in their children, which they linked to the lessons with the robot. Some parents (4) didn’t know whether the robot increased the motivation, or weren’t sure whether any increase in motivation would be linked to the robot. Some parents (2) also reported that their children were already motivated to learn English before.

Do you think that your child learned more because of the robot?
Most of the parents found it hard to estimate whether their children learned more because of the robot (9). Four parents reported that they didn’t think their child learned more. Some parents (6) thought that their child learned more because of the robot, because it was more interesting to learn from a robot, or because the child would be focused more if taught by a robot.

If it was affordable, and the robot was easy to use, would you consider renting a robot for your child to learn English with?
Nine of the parents reported that they would consider renting a robot for their child to learn with, some adding that it would be dependent on the motivation or interest of their child (2). Seven parents reported that they would not consider renting a robot, though one of them added that they thought it would be nice if the school could have a robot teaching programme.

9.2 Coordinators in primary schools

Would your school consider starting earlier with foreign language education?
One of the coordinators answered that it would not be possible to start earlier with foreign language education. One answered that their school was already working on it, and planned to start at the age of 4. One respondent said that they might consider starting earlier, but that they already use a lot of foreign language informally, for example in songs, in the years where the children do not yet receive formal foreign language education.

Roughly how many children at your school speak Dutch as a second language?
All of the respondents answered the same here: less than 10%.

If the school could afford robots, would you use it as a language tutor?
One of the coordinators reported that they could use the robot as an assistant. The other coordinators said that they might consider it. One added that they thought the children enjoy learning with the robot, the other respondent said that their consideration would depend on whether the robot could be of any added value to their educational process.

Would your school have the human resources necessary to operate the robot?
All of the coordinators were confident that their school would be able to manage, two specified that they have ICT-coordinators at their school. One of the respondents also added that their school has a very young and eager team, that would definitely be able to manage.
What was your first reaction when you were asked to participate in the L2TOR study?
All of the respondents reported that they thought it was interesting, and that their school loves to participate in scientific research projects.

What was your first impression when you saw the robot?
The respondents all had positive reactions to the robot. One of them said it looked like what they had imagined, but with softer curves. They also thought that it looked lifelike, funny and friendly, and that they could imagine that the children liked it.

What was the first reaction of your students when they saw the robot?
One of the coordinators was not present when the robot arrived, but heard that the children were excited and that they liked the robot. One other respondent said that the children loved the robot.

Would you say that the robot helps the teacher to encourage the students?
Two of the respondents thought that the robot helps the teacher encourage the students. One respondents answered that they couldn’t be sure.

Would you say that the robot helps to make a real and measurable progress in language learning?
One of the respondents didn’t think that the robot would help make a real and measurable progress. One of the respondents said that they didn’t know.

Do you think that the students got used to the presence of the robot relatively easily?
Two of the respondents thought that the students got used to the robot easily, because they think it is fun to work with the robot, the third respondent wasn’t sure.

Do you think that the students quickly got tired of the robot?
The respondents don’t think that the students got tired quickly, though one added that the novelty effect should be taken into account and that the robot should use a variety of methods to be able to keep the attention of the children, especially the younger children who can lose interest quickly.

Would you recommend your organisation to rent or purchase a tutor robot?
The respondents answered that this would depend on different things, like how long it would take to program the robot for a lesson, on the results of the research or on the progress that is made with the development of the robot.

In your opinion, would your organisation be ready to buy or rent a robot tutor (for the school or for home use by children)?
One respondent said that their school would be ready. The other respondents said it would be dependent on the teachers, or on the results of the research.
10 The need for pedagogical content

As L2TOR is an innovative solution with no real historical or comparable product, one of the challenges to meet was, and still is, to build up relevant pedagogical contents in lessons that allow the final user to reach a significant level. The way we teach and learn foreign language through a robot combined with a tablet is entirely different than other, more conventional, methods of learning.

The L2TOR teams designed the lessons themselves: developmental psychologists designed the lessons, the graphical content of what was shown on the tablet was built by a graphics designer, and the game logic was implemented by L2TOR as well.

In order to propose for L2TOR a marketable product and solution, we need to provide a language learning programme with a first package of minimum 1,000 words to teach, discover and play with. This is of course a base that needs to be understood with its full list of scenarios allowing both the learning of words and the understanding of various constructions (such as “the toy is under the bed” or “the monkey plays behind the tree”…). To fulfill this need, the L2TOR team will need additional budget and more time (5 months) to make and code pedagogical contents (see the chapters “launching plan” and “financial costs”)

11 High demand and high potential

11.1 Market analysis: positive acceptance and expectations

All studies show that robots attract considerable attention and become ever more popular in numerous applications, especially educational robotics are gaining increased interest. The Japan Robotics Association (JRS), the United Nations Economic Commission (UNEC) and the International Federation of Robotics (IFR) report an increase in the market of personal robots, including educational robots (source: Social Robotics in Education: State-of-the-Art and Directions). The interest of the European Union in social and educational robotics also increases steadily.

The educational robot market will grow at a CAGR of 16.8% between 2018 and 2023

To quote just one figure from one of the numerous studies, the educational robot market is expected to grow from USD 688.3 Million in 2017 to USD 1,689.2 Million by 2023, at a CAGR of 16.8% between 2018 and 2023. The educational robot market is mainly driven by the factors such as the use of robots for educational purposes and technological advancements in the field of robotics. (source Educational Robot Market by Component (Hardware and Software), Type (Humanoid and Non-Humanoid), Education Level (Elementary and High School Education, Higher Education, and Special Education), and Geography – Global Forecast to 2023 / Markets&Markets)
At the same time, it has been shown that young children performed better on post-learning examinations and generated more interest when language learning took place with the help of a robot as compared to audiotapes and books. (*IJCSNS International Journal of Computer Science and Network Security, VOL.17 No.8, August 2017*)

**Surveys show people feel learning languages is important**

Public opinion supports the Barcelona objective and the EU policies, as confirmed by the recent opinion poll, the 2012 Eurobarometer: 77% of respondents believe that “improving language skills should be a policy priority” and 72% agree that “everyone in the EU should be able to speak more than one language in addition to their mother tongue.”

More than eight out of ten respondents consider that languages could be useful for themselves and almost all agree they might be useful for the future of their children.

If the future of the labour market is full of uncertainties, there is no doubt that language skills will be an asset for the years to come.

**The European Political Strategy Centre pleads for a more digitalized and customised education thinking**

The European Political Strategy Centre recently confirmed that personalisation of learning requires a major change in the organisation and delivery of education and on-the-job learning: “Learning can be transformed into a customised experience where individuals approach problems in their own way, acquire knowledge and skills at their own pace, maximising outcomes not only for the most talented students, but also helping to bring those lagging behind up to speed.”

Now is the time we can truly imagine making the dream of one-to-one teaching almost reachable and affordable. Introducing a truly individual approach on a large scale was until now considered impossible, as the costs of hiring enough teachers alone would be impossibly high. Thanks to new technologies and resources like L2TOR, this may no longer be the case.

“Learning can be transformed into a customised experience where individuals approach problems in their own way, acquire knowledge and skills at their own pace, maximising outcomes not only for the most talented students, but also helping to bring those lagging behind up to speed”.

(source: The European Political Strategy Center, 10 Trends in Education )

12 Multicultural background and multilingual needs throughout Europe

Many recent studies (Language at preschool in Europe: Early years professionals in the spotlight) show that education throughout Europe has experienced many changes due to higher numbers of children attending centres for early childhood education and care (ECEC). For L2TOR, it’s quite relevant to see that the multilingual and multicultural background becomes apparent in the educational system, when children come to school speaking another language or language variety, and have grown up with a different culture at home than the one they are confronted with at school. In Amsterdam, for example, more than 50% of the inhabitants are of non-Dutch origin, while the number of pupils with a migrant background at school is around 60%. Similar figures hold for urban centres in Belgium, England, France and Germany and other European countries (Thürmann et al. 2010; Vetter 2013).

5.4 million child migrants in Europe

Education systems are faced with the responsibility and the challenging task of teaching and integrating newly arrived migrant students. With no doubt, a solution like L2TOR could support the European Union vision. The EU actually claims to promote “policies which strengthen linguistic diversity and language rights, deepen mutual understanding, consolidate democratic citizenship and sustain social cohesion” (Council of Europe 2012a). In 2003, the European Commission wanted every citizen to “master at least two foreign languages, with the emphasis on effective communicative ability” in addition to the mother tongue (European Commission 2003: 8).

13 A new niche in the market of foreign language teaching

13.1.1 Next step after self-paced e-learning
If we look at the current foreign language learning market, we clearly see that there is some room for new offers. As outlined above, the demand and expectations in that field are very high. But at the same time, it will be noted that e-learning is currently decreasing since self-learning through online solutions (apps, subscription-based websites…) does not meet public expectations.

The worldwide five-year compound annual growth rate (CAGR) for Self-paced eLearning is distinctly negative at -6.4%; global revenues for self-paced courseware are dropping fast. In 2016, global revenues for Self-paced eLearning reached $46.6 billion, down slightly from the $46.9 billion in 2015. By 2021, worldwide revenues for eLearning will plummet to $33.4 billion. (source: Ambient Insight The Worldwide Self-paced eLearning Market, 2016)
D8.4 White paper for industrial stakeholders

At the same time, we see that efficient solutions like language travels are still too expensive to address a mainstream market, meaning there is also a role to play for more reasonable solutions like L2TOR. Although billions of people are now learning a foreign language, only 0.25% of them travel abroad to learn in a local, native environment. This equates to a market of 2.28 million language students abroad per year. English language travel comprises an estimated 61% of this market2.

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Table 1: Percentage of age groups of children with a migrant background (1st or 2nd generation) in the countries covered in this special issue

<table>
<thead>
<tr>
<th>Country</th>
<th>EU</th>
<th>Belgium</th>
<th>France</th>
<th>Germany</th>
<th>Netherlands</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>5–9 year olds¹</td>
<td>x</td>
<td>6.6</td>
<td>4.5</td>
<td>2.8</td>
<td>3.3</td>
<td>5.7</td>
</tr>
<tr>
<td>10–14 year olds²</td>
<td>x</td>
<td>8.4</td>
<td>3.5</td>
<td>4.3</td>
<td>4.9</td>
<td>6.5</td>
</tr>
<tr>
<td>15 year olds³</td>
<td>9.3⁴</td>
<td>15.1</td>
<td>13.2⁵</td>
<td>13.1</td>
<td>10.6</td>
<td>12.7</td>
</tr>
</tbody>
</table>

Note: ¹ Eurostat 2012, figures based on children born abroad (for younger age groups no EU numbers available); ² OECD 2013b, figures based on students’ self-report data on immigrant status in the PISA 2012 results; ³ Eurostat 2012, figures based on PISA 2009 results – data from PISA 2012 not available for EU average and France.

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Table 1 - 2016-2021 Worldwide Revenue Forecasts for Self-paced eLearning Products and Services by Region (in US$ Millions)

<table>
<thead>
<tr>
<th>Region</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>5-Year CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>$23,337.4</td>
<td>$22,258.8</td>
<td>$21,605.2</td>
<td>$20,003.6</td>
<td>$18,357.0</td>
<td>$16,967.0</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Latin America</td>
<td>$2,198.0</td>
<td>$1,900.4</td>
<td>$1,732.9</td>
<td>$1,565.0</td>
<td>$1,328.4</td>
<td>$1,189.0</td>
<td>-10.8%</td>
</tr>
<tr>
<td>Western Europe</td>
<td>$7,976.6</td>
<td>$8,318.7</td>
<td>$8,386.1</td>
<td>$8,096.4</td>
<td>$7,703.8</td>
<td>$7,403.0</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>$1,024.8</td>
<td>$1,125.9</td>
<td>$1,208.8</td>
<td>$1,221.7</td>
<td>$1,116.9</td>
<td>$967.5</td>
<td>-1.1%</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>$10,936.5</td>
<td>$10,757.8</td>
<td>$9,208.8</td>
<td>$8,245.4</td>
<td>$6,848.2</td>
<td>$5,874.5</td>
<td>-17.7%</td>
</tr>
<tr>
<td>Middle East</td>
<td>$683.7</td>
<td>$708.3</td>
<td>$729.4</td>
<td>$700.1</td>
<td>$568.3</td>
<td>$460.4</td>
<td>-7.6%</td>
</tr>
<tr>
<td>Africa</td>
<td>$697.7</td>
<td>$716.0</td>
<td>$806.3</td>
<td>$833.2</td>
<td>$754.6</td>
<td>$836.3</td>
<td>0.9%</td>
</tr>
<tr>
<td>Totals</td>
<td>$46,674.7</td>
<td>$45,815.7</td>
<td>$43,840.2</td>
<td>$40,665.4</td>
<td>$36,695.2</td>
<td>$33,498.3</td>
<td>-6.4%</td>
</tr>
</tbody>
</table>
13.1.2 Home education on the rise in Europe

Despite many European countries’ policies making home education difficult or even illegal, homeschooling appears to be on the rise in Europe. In England, data recently gathered by the BBC show a 65 percent increase over the last six years in students learning at home. The UK now has more than 36,000 home-educated children, a number likely understated. Other countries in Europe are following the trend.

“According to the information volunteered by local British authorities, more parents are choosing to educate their children at home because of conflicts with local schools, children’s special needs, bullying, religion, and lifestyle factors”.

For this growing target audience in the UK and throughout the EU, L2TOR could also be a new solution, allowing parents or private tutors to enhance the learning programme of children from 4 to 8 year old.

![Home-education in the UK](image)

Source: Local authorities (Figures are for 177 councils that gave full data)

14 Size & potential of the targets, country by country

14.1.1 8.5 million potential students

If we just look at the figures in Turkey, the Flemish community of Belgium and the Netherlands, which are the main territorial targets of the project, the number of students potentially reachable by L2TOR is around 8.5 million.

Based on the number of primary schools in Belgium and the Netherlands, and an extrapolation of these numbers on European level based on the number of children in the age

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3 [https://world.wng.org/2016/01/home_education_on_the_rise_in_europe](https://world.wng.org/2016/01/home_education_on_the_rise_in_europe)
group of primary schools, the full potential market in EU-28 for this target group is about 175,609 schools.

In the graph below, the number of students is defined as the number of enrolments at a given level of education in 2016. This indicator is measured as an index, base year 2010, divided into pre-primary, primary and lower secondary, upper secondary and post-secondary non-tertiary, and tertiary levels.

If we look at the distribution of public expenditure on education by education level (figures of 2014), we clearly see that the targets of the L2TOR solution (in yellow and orange below) have one of the best income support programme. In the United Kingdom, Belgium and the Netherlands, investments in pre-primary and primary levels represent more than half of the total investments in education.
15 Expenditures in primary school: key figures

Turkey allocates a budget of 4134 USD per student per year, the Netherlands allocates a budget of 8778 USD per student per year, Belgium allocates a budget of 10211 USD per student per year, the United Kingdom allocates a budget of 11630 USD per student per year.
As L2TOR will address both the public and private school market, it is crucial to consider the importance of financial support behind these structures, since they often need to compete for project funding.

Financial aid to students as a share of public expenditure for each level in 2014 (%)

Concerning the foreign language learning market, it is important to note that linguistic diversity is actively encouraged by policies. Schools and other educational institutions provide the main opportunity for the vast majority of people to learn languages.

The most common way foreign languages are learned is at school. Two thirds of Europeans (68%) have learned a language in this way. Other methods are much less widely adopted but are growing.
16 Potential market

We illustrate the potential for robot tutors by looking at four countries: Belgium, The Netherlands, Turkey and the United Kingdom. These countries were involved in the L2TOR project, but also provide a representative sample of potential Eurasian markets.

16.1 Potential users in Belgium

Our current target audience in Belgium only consists of the Flemish community, as L2TOR isn’t available for native French speakers at this stage. The Belgian potential market represents 58% of the students in Belgium who attend the Flemish pre-schools and schools (source: oecd, Education-Policy- Outlook-Country-Profile-Belgium.pdf).

![](image)

16.1.1 The shortage of teachers: a real threat!

One of the most promising facts about the Belgian market for L2TOR as a product is that the projected growth of the school population in Belgium is among the largest in Europe. The strong demographic pressure, in particular among disadvantaged groups, risks an increase in infrastructure deficiencies and teacher shortages, notably in major cities. In Belgium preparing and supporting teachers to deal with an increasingly diverse student population is a growing concern. Increasing child poverty and greater diversity in language, culture and family structure further compound the equity challenge. Divergent levels in poverty amongst the school population reinforce educational disparities between communities and regions. The problem is especially acute in the Brussels region. Addressing educational inequality will thus require a broad policy response going beyond the educational system.

16.1.2 Public expenditures on education are higher

Another encouraging factor is the high autonomy that the Flemish Community’s education system provides at the school level. This means investments in new methods and new technologies that assist both teachers and students are more easily made than in most other countries in Europe. For instance, Belgium has become one of the first countries in the world in terms of humanoid robot assistance and education robots in STEM programmes are widely adopted in comparison to the rest of EU. The town of Ostende (Flanders), for example, is
the first town in the world to have one or two humanoid robots for each secondary school of the city. Consequently, both public acceptance and the education system pave the way for L2TOR’s introduction to the market.

Furthermore, public expenditures on educational institutions are comparatively high, with the annual expense per student in primary, secondary and post-secondary non-tertiary education (USD 11,856) significantly above the OECD average (USD 9,258) in 2013.

In 2015 and 2016, a series of special measures was passed by the Flemish Parliament to enhance integration of refugees in the education system, including new funding initiatives for language support in pre-primary schools and an increase of resources for “welcoming classes” for refugee children in school education. (source: oecd, Education-Policy-Outlook-Country-Profile-Belgium.pdf).

16.2 About the potential users in the Netherlands

16.2.1 The Importance of English language acquisition

Although the English language skills of Dutch students leaving lower secondary education are above-average compared to other non-English speaking countries, a recent survey from the Platform Onderwijs2032 claims that schools should start teaching English earlier. This widely shared vision could promote the commercial development of the L2TOR solution in a country which serves as a model for standards in the area of education. English lessons are currently only compulsory in the last two years of primary school and throughout secondary education. But many schools have already anticipated the importance of second language acquisition at a young age. Thus, most primary schools teach English, usually starting at the age of 4. “Both the number of schools and the number of pupils in primary education engaged in early second language acquisition have increased over the last few years”.4

Since 2006 new developments in language teaching in pre-primary schools got very popular. To put the trend in perspective, in 2007 English was taught at 121 pre-primary schools, in 2008 at 168 and in 2010 at more than 500 pre-primary schools. The following years, the number of primary schools teaching their pupils foreign languages from 4 years of age kept growing rapidly. As L2TOR has first been developed to support early language learning, this trend makes the Netherlands an even more strategic place to propose the L2TOR product. In the Netherlands, children start pre-primary instruction at age 4 and primary school at age 6.

Another challenge to meet is that the Netherlands promotes some special programmes in pre-primary education for children of a migrant background, which is a strong reality in this multicultural country (as outlined above). The idea of these programmes is that these children would be able to receive extra language training in Dutch in order to stimulate language development and Dutch fluency. According to a European survey, it is a challenge

to reach the migrant children and to get them to join these language programmes. One of the problems is that “there are a lot of different organisations involved in pre-primary education and childcare which makes it difficult to set up a programme for all children”.

New methods and technological solutions like L2TOR could make this challenge easier, since the product offers a recreational and educational way of teaching.

16.3 Potential users in Turkey

Turkey has a total of 14,187,000 pupils enrolled in primary and secondary education. Of these pupils, about 6,430,000 (45%) are enrolled in primary education. The special nature of the Turkish education system is the growing gap between public and private schools. Even if both systems are potential clients for a commercial version of L2TOR, private schools, with higher autonomy and investment capacity, seem to be real relevant target group.

According to Turkey’s latest National Statistics Report (2016), the private education sector in Turkey is truly on the rise. The number of schools in the country has increased 40 percent in the last year to 10,525, with around 1.2 million students enrolled and almost 134,000 teachers.
It also must be noted that the investment per student by private schools is higher than by public schools. World Bank’s study (2002) shows that the expenditure per student is $516 in public primary schools and $1,524 in private primary schools.

Because administrators at private schools have more managerial liberty compared to their counterparts at public schools, the acquisition of a tool such as L2TOR could be easier and faster. The number of private schools is expected to increase its share of the schools market from 10 per cent to 15 per cent by 2023, likely resulting in an increased demand for new teachers and new methods of education.

One other indicator of Turkey being a country to really look at is the situation surrounding migration. On one hand, Turkey hosts the largest number of refugees worldwide, which means there is a high demand in foreign language learning, and, on the other hand, Turk has one of the largest communities living throughout Europe, especially in Belgium, Germany, the Netherlands and the United Kingdom if we just consider the countries within the scope of L2TOR.

Finally, due to the trend towards internationalisation in the country, causing a rise in the amount of international schools, we note that there is an increasing demand for digital English language learning products and tools in Turkey. That’s why Turkey is now in the top ten countries worldwide when it comes to these products and tools, which is again a favourable factor in regard to bringing a L2TOR commercial product to Turkey.

### New business booming in education

Experts estimate the teacher training sector will give rise to a $60 million industry in Turkey. Interest is also considered very high among local and international providers of education-focused products and solutions, as the burgeoning education market in Turkey is forecast to open up new business opportunities for suppliers who are keen on entering or growing their existing market in the country.⁵

### 16.4 Potential users in the United Kingdom

Besides the fact that the United Kingdom is an unavoidable country to be when you’re about to enter the language learning market, it’s interesting to see that the United Kingdom is not only a top spender in education but also sees a high demand for private tutoring.

16.4.1 The British are top spender in education
When it comes to investing in a child's education, parents in the United Kingdom spend the most in comparison to parents in the rest of Europe. Looking at private education as a whole – which includes schooling as well as tuition – Britain spends the highest amounts in Europe, at 4.8% of the GDP, compared to the OECD average of 3.6%. In addition, the nation’s private tutoring market is valued at £2 billion per year (€2,3 billions). Private lessons are often taught by students and teachers, working as personal tutors. This make the British a relevant target group for an L2TOR solution both in the business-to-business (BtoB) market and the business-to-consumer (BtoC) market. Private schools, private tutors, language learning companies and parents indirectly, are prepared to spend over 24.862 USD on their children’s education. Minds are also well prepared in the UK for alternative teaching solutions in the foreign language domain.\(^6\)

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\(^6\) [https://www.weforum.org/agenda/2017/08/parents-in-these-countries-spend-the-most-on-their-childrens-education/](https://www.weforum.org/agenda/2017/08/parents-in-these-countries-spend-the-most-on-their-childrens-education/)
16.4.2 Other positive cyclical indicators
National governments in the EU are moving forward in the domain of foreign language learning. For instance, Italy and Malta introduced reforms in the last few years to make the learning of a second foreign language compulsory. In other countries, such as the Flemish Community of Belgium, Greece and Poland, the onset of compulsory learning of a second foreign language has been brought forward. Slovenia and Slovakia are currently implementing similar measures.

17 Private expenditures in education

Another positive indicator is related to private spending in the field of education, which clearly shows that the public is quite ready to spend money to ensure the best training. In Turkey, spending in education support from private sources and entities represents 0.59% of the GDP, which in 2016 represented a market estimated at 5.09 billion USD. In the Netherlands, these expenses represent 0.51% of the GDP, which in 2016 represented a market estimated at 3.9 billion USD. In Belgium, spending in education support represents 0.14% of the GDP, meaning a market estimated at 0.65 billion USD for 2016. In the case of Belgium, we have to cut the amount in 2 to approximatively isolate the Flemish community, which leaves a 0.33 billion USD potential market. In the United Kingdom, expenses in education support represent 0.58% of the GDP, which for 2016 represents a market estimated at 15.2 billion USD.

Private spending on education refers to expenditure funded by private sources which are households and other private entities. This indicator is shown as a percentage of GDP, divided into primary, primary to post-secondary non-tertiary and tertiary levels. Private spending on education includes all direct expenditure on educational institutions, net of public subsidies, also excluding expenditure outside educational institutions such as textbooks purchased by families, private tutoring for students and student living costs. Private spending includes expenditure on schools, universities and other public and private institutions delivering or supporting educational services.
18 Pupil-teacher ratio and the need for rise of one-to-one teaching

One of the advantages of L2TOR is the fact that it allows for a one-to-one approach of foreign language teaching. It’s well known that in education the more individualised you teach, the more the children learn. Due to the current pupil-teacher ratios, a more individual approach to teaching is not yet attainable in most countries in Europe. In the United Kingdom, the pupil-teacher ratio in primary education is especially high: around 22 pupils for one teacher.

The pupil-teacher ratio is calculated by dividing the number of full-time equivalent pupils by the number of full-time equivalent teachers teaching at ISCED level 1. Only teachers in service (including special education teachers) are taken into account. The pupil-teacher ratio should not be confused with average class size as it does not take into account special cases, like the small size of groups of special needs pupils or specialised/minority subject areas, or the difference between the number of hours of teaching provided by teachers and the number of hours of instruction prescribed for pupils for example in the case a teacher is working in a shift system.

19 Our industry vision

As language acquisition benefits from early, personalised and interactive tutoring, tutors and robot tutors in this perspective offer a solution. As outlined above, it’s also a product that really answers to an increasing demand for Robot assisted Language Learning (RALL). We believe is that social robots can contribute to Europe’s aim to teach every child a second language through one-to-one tutoring.

After considering the current state-of-the-art and the demands from the customer, we believe a robot language tutor solution will consist of the following components:

An internet enabled robot and tablet interface, software with language learning packs (and potentially other applications), after sale and back-office services, and access to an online community.
Bringing a robot language tutor to market means providing different services alongside the product itself. It must be a full experience, and technical assistance and community support should not be neglected.

Whether as an institution, a company, a tutor or a family, when you purchase a robot language tutor you should have access to:

- Upgrades and options to expand the robot offer and to access more languages or applications
- Help desk and back office, providing support and customer service. Updates and bug fixes should be pushed to the client, preferably without the need for customer intervention.
- The online community allows adult users (teacher and parents) to stay tuned, share ideas with other users, share content and good practices, and receive tips for the use of the robot.
- It should be noted that the system will have a two-year warranty on the hardware, repairs, replacements and after service should not be an afterthought.

20 The target market of robot language tutors

20.1 BtoB

In terms of market, we expect robot language tutors to be mainly focused on the BtoB market. One of the reasons the initial push will not address the BtoC market (especially schools and preschools) first, is the cost of the solution which requires a significant investment that can mostly be supported by companies and public funds. Apart from the cost, the clients of the BtoB market are those with the highest number of final and concrete users, which means they will be able to recoup their investment in a shorter time. Usability is more important in this field and will take place on a large scale. The target groups for purchasing a robot language tutor solution are private language tutors, non-profit organisations, public libraries, rental companies, day care facilities, preschools, primary schools and private companies.

20.2 BtoC

As a second step, or alongside the BtoB actions, robot language tutors will also enter the BtoC market for families with foreign language learning needs and issues. We expect customers to come from the top 20% highest income families.
21 Marketing

Family Packs
- Direct sales & rentals
- Local distributors
- 2 year warranty
- Ongoing update service with paying subscription
- Additional language to purchase
- Back office assistance service for free in full version

Pro Premium
- Direct sales
- Local distributors
- 2 year warranty
- Ongoing update service for free
- Additional language to purchase

Pro custom
- Direct sales
- Local distributors
- 2 year warranty
- Ongoing update service with paying subscription (special pro price)
- Additional language to purchase

MARKETING
21.1 Price setting

A Pro Custom Pack, dedicated at the BtoB market, will only be used for second language teaching and not for other purposes. This pack has all the possibilities for language teaching, with a package of 1, 2 or 3 languages included, but is limited to this functionality only. That means that with this pack, we can generate additional revenue by selling additional languages. Based on current market conditions, we expect that such an offer can be sold for €8.500 excl VAT.

### Pro premium Pack
- 11.500 € excl. tva with one language
- 1.500 € for an additional language

### Pro custom Pack
- 8.500 € excl. tva
- 1.500 € for an additional language

### Family Packs
- L2TOR basic pack > 160 €/month excl. tva with one language and in Open learning version.
- L2TOR basic pack > 160 €/month excl. tva with one language + extra 240 € for a 6 months learning program.
- L2TOR Full family Pack > 280 €/month with one language, including the 6 months learning program + Zora licence
- 45 €/month for an additional language

A Pro Premium Pack is aimed to the BtoB market. The main advantage of this pack over the pro custom pack is that besides the use of the robot language tutor, the full capacity of the social robot can be used, for example thanks to the composer solution of Zora Bots. This pack will be sold for €11.500 excl. tax.

The Family Pack is aimed to the BtoC market. Two offers are available: the family pack and the full family pack. To give an idea of scale and to compare the offer to what we could call a more “traditional” business: the average price of a private lesson for language learning in Europe is between 30 and 40 euros/hour. If we consider that the average pace of language learning for early childhood is at least 1 hour a week but could be around 2 hours a week for motivated families with higher incomes, we can say that a private language learning budget could be between 140 and 320 euros (for 4 to 8 hours/month). As a robot language tutor will allow for unlimited human-robot learning, the added value of the solution in terms of costs is undeniable and will clearly be a commercial argument in addition to other assets.
The family pack comes with one language learning programme of courses and games. Additional languages (L3 or L4) can be purchased in option. Rental price: €160/month excl. tax and before options (average lease term 6 months).

The full family pack comes with the features and services of the L2TOR family pack + an exclusive access to the ZORA solution for a complete humanoid robot experience in the whole family. In comparison, the average price of private tutoring for language learning in Europe is around €38. Considering a two hours/week commitment for students, the average cost of a traditional language learning method is around 304€/month. With a robot language tutor, which allows for unlimited learning time, the price will be lower. Rental price: €280/month excl. tax and before options.

It should be noted that the price setting depends to a very large extent on the technical abilities of the robot. The prices suggested above assume a robot which has technical abilities beyond what is currently available: the robot should be able to converse in a first and second language and should offer a fully autonomous interaction.

22 SWOT analysis

Strengths
- New and unique solution
- One-to-one tutoring
- High demand
- Promising and poised market
- Combination of a robot, a tablet and contents
- Usability
- Nao is well adopted to and accepted in public opinion

Weaknesses
- Cost of the solution for BtoC market
- No clear policy about educational robots and robotics in general
- Lack of speech recognition prevents conversation
- Pedagogical materials not ready yet and still to be made

Opportunities
- Partnership with SMEs, strong presence in Europe
- Public aids and ongoing support programmes in assisted robots learning

Threats
- Competitors in Finland, Singapore and Japan have started to enter the market
- Investors reluctant to commit
- A new and still unexplored technology
23 Communication strategy

A communication plan will be needed to raise awareness about robot language tutors. This will to a large extent require the support of the press to bring both attention and credibility to the product, and to make the public aware of the opportunities offered by robots for learning.

Existing materials, including surveys and research, should be used and optimised. It is also necessary to build on current forces of the research projects, such as L2TOR. The research team, the strength and reputation of each participant and partners, and the testimonials from the field can be used to promote the use of robots for learning.