Crowdsourcing and Education: Bridging the EdTech GAP

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Zviel-Girshin, Rina, Ruppin Academic Center, IL, rinazg@ruppin.ac.il

Rosenberg, Nathan, Paralex Research Institute, IL, paralex.research@gmail.com

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***“[Experto crede!”:](https://www.etymonline.com/word/experto%20crede" \l "etymonline_v_38620" \o "Origin and meaning of experto crede) "take it from one who knows" (Virgil, Aeneid, XI.283)***

***“Crede!”: "believe!" (in Latin)***

**Abstract**

As a result of COVID-19, in the area of EdTech we have witnessed an unprecedented two-year field test involving hundreds of millions of students. Unfortunately, reactions around the world have ranged from “COVID-19 remote education was not a success, despite the use of technology” to “It was a complete disaster; why did governments pour billions into developing the technology?” In this paper, we describe the gap between Ed and Tech, analyze its causes, and propose new models for dealing with it. We also describe the design principles and requirements of a real-life application which we have successfully used to bridge the gap: the CREDE (Crowdsourced Edutainment Environment) system for creation and approval of educational content. CREDE has already used been used to create applications, but here we describe a platform for the early stages of learning to read in Hebrew (kindergarten or the beginning of grade A) in the form of an autonomous system that uses gamification and crowdsourcing elements. Our field tests helped to refine the CREDE model. Using quantitative research methods, we analyzed the actions of 37 adult users of the system over a period of 3 months. Our results show that the crowd was willing to carry out crowdsourcing activities, although they preferred data evaluation (crowd-rating) to data creation. We conclude that it is possible to use crowdsourcing in education and to develop crowdsourced autonomous educational software. The next step is to move to a universal worldwide architecture for CREDE, an effort that is already underway in a pan-European research project, with representatives from every European country, and has been funded by the EU since 2016.

**Keywords:** *gamification, crowdsourcing, game-based learning, design of educational environment, language learning*

# Introduction

Since the beginning of the technological leap forward, there have been efforts to use technology to improve learning and teaching substantially, not least by moving away from the traditional frontal synchronous classroom model toward more flexible, individualized learning. Real-life applications of technology in education have been available since at least the 1950s (Skinner’s 1954 teaching machine is one prominent example). From the inception of EdTech, as educational technologies are known, there have been two competing fundamental approaches to research and the direction it should take. One approach puts the emphasis on developing better technology; the other approach focuses on adapting pedagogy to the new reality. Unfortunately, while the pedagogical approach was still a matter of theoretical research, the technological approach won out in the industry context.

Game-based learning (GBL), gamification, games with a purpose, and their use in education have been viewed in a new light because of the coronavirus (COVID-19) pandemic and its impact on the delivery of education, which has moved from instructional to alternative delivery modes. The term *edutainment*, defined in the 1980s as “the use of entertainment devices or activities to teach school-based and education subjects or concepts” (Gerber, 2014; Huotari & Hamari, 2017), now represents a market industry (Hildmann & Hildmann, 2011; Majuri, Koivisto, & Hamari, 2018). The goal of edutainment is to make learning enjoyable and fun (Resnick, 2004; Prensky, 2003; Aksakal, 2015), and the gamification of education has been found to have a positive impact on active learning (Raitskaya & Tikhonova, 2019; Oe, Takemoto, & Ridwan, 2020; Parra-González et al., 2020). According to Data Bridge Market Research, the global edutainment market is expected to continue to grow over the period 2019–2026, with a healthy CAGR of 15.8% (<https://www.databridgemarketresearch.com/reports/global-edutainment-market>). According to the Global [E-Learning Market](https://www.accurizemarketresearch.com/report/e-learning-market) Report published by Accurize Market Research, the global edutainment market is expected to reach $398.3 billion by 2026, growing at a CAGR of 9.6% since 2019 (https://www.accurizemarketresearch.com/report/e-learning-market).

The field of GBL is broad and includes a wide range of learning objectives, learning environments, and teaching techniques. GBL and educational games are part of EdTech, which in turn consists of synchronous and asynchronous learning, linear learning, or collaborative learning. All three types of learning are found in GBL. Educational games can be used at any time, in any place, in the classroom and/or at home, and on a range of devices from computers to smartphones. If implemented correctly, GBL enhances learning and increases student engagement and motivation. In general, computer-based games can be played online or offline, synchronously or asynchronously; some are single-player and others are dual- or multi-player games; some are free and others are paid for; some are collaborative and others are competitive; some are standalone and others are platform-based. In the field of learning to read, many free games can be found on line to help with learning the alphabet, spelling letters and words, and identifying phonemes in words. The player needs only to download a game or to connect to the Internet site and start playing.

Automated content generation for education and educational games has posed research problems for years, since manual authoring is often costly and time-consuming. In many cases, the creation of educational games and e-learning environments requires consultation and hiring an entire team of field-specific experts. The creation of valid and appropriate content for small or under-resourced languages, such as Hebrew, is even more challenging; existing techniques are not always applicable, and new approaches may be required. One such approach is crowdsourcing (CS), as user-generated content creation can be an effective way to use the crowd to create and/or evaluate educational resources for under-resourced languages.

The term *crowdsourcing* combines the concepts of “crowd” and “outsourcing,” and is a new technique for performing large-scale tasks, such as gathering data, by outsourcing them to a wider public. CS is often based on the framework of collective intelligence (Lévy, 1997) and can be defined as a tool for gathering collective intelligence to complete certain tasks. When applied in the right circumstances and to the right crowds, CS can deliver considerable benefits to firms in terms of inputs into innovation (Morschheuser et al., 2017). In terms of language learning, the use of CS has received little research attention, but there is a consensus that it is underused. This dissonance between the urgent need for and abundance of offline (and sometimes even online) resources, on the one hand, and the very limited use of existing resources, on the other, can be seen as a crisis.

The role of CS and its potential in language education has been investigated by enetCollect (the European Network for the Combination of Language Learning and Crowdsourcing Techniques), a large European network project funded as a COST action. The action addresses the pan-European challenge of fostering the language skills of all citizens regardless of their social, educational, and linguistic backgrounds. Its focus is to use CS to enhance the production of learning material in order to cope with both the increase in demand for learning a second language (for migration, business, and tourism purposes) and the demand for more accessible materials in the many languages that are of interest to learners. This article presents a crowdsourced autonomous gamified educational software system for learning to read in Hebrew, which is called CREDE (Crowdsourced Edutainment Environment) and based on the CREDE paradigm, which will be explained below. CREDE uses a CS approach to collect and rate educational materials for language learning. The first CREDE system was designed as part of the enetCollect COST action (Zviel Girshin & Raskin, 2019) to show that it is possible to build a GBL autonomous educational system for learning to read in which content is created by the crowd.

We argue that the COVID-19 pandemic, which enabled an educational trial on an unprecedented scale, demonstrated the serious limitations of the educational technologies that were available (Dhawan, 2020; Selwyn et al., 2020; Teräs et al., 2020; Doyumgaç, Tanhan, & Kiymaz, 2021). This trial provided clear evidence of the EdTech gap, especially in terms of lack of educational materials, deficiencies in resourcing, and a lack of methods customized to individual students to make them motivated and successful. There is thus a need for a new model that is pedagogy-based, and we present here one important aspect of such a model: *individualized crowdsourcing*. Despite the oxymoronic appearance of the term, here we report on a successful application of an individualized CS model.

This paper is structured as follows. Following a review of the relevant literature, we present the CREDE paradigm. We then explain the CREDE system and its requirements in terms of CS, gamification, and autonomy. Next, we report our experiment on CREDE use by a crowd. We conclude with a discussion of our findings and recommendations for creators of crowdsourced educational software.

# Literature review

Our literature review starts with what experts think about computer-based learning and GBL in early childhood. We move on to discussion of gamified computer-aided environments for the early stages of learning to read and CALL (computer assisted language learning). We then consider some issues specific to the creation of educational games and e-learning environments for small or under-resourced languages. Finally, we review work on the combination of CS and language learning.

## Computer-based and game-based learning in early childhood

For several decades, experts have debated the extent to which computers can support early literacy learning (Plowman & Stephen, 2003; Lankshear & Knobel, 2003; McCarrick & Li, 2007; Nolan & McBride, 2014; Montgomery, 2015). Although the debate over the potential benefits and hazards associated with computer use by young children continues, a majority of stakeholders agree that the use of information and communications technology (ICT) tools and educational software can contribute to and improve early childhood education. Educational games have been found to be effective teaching aids in a wide range of domains. They have been successfully used to teach students a range of school subjects, such as mathematics, reading, and biology (Murphy et al., 2002; Fokides, 2018; Russo, Bragg, & Russo, 2021). Many educators claim that there is nothing as important in early childhood learning as the learning of literacy and language, in particular having adequate reading skills (Baker & Scher, 2002; Wigfield et al., 2007; Lonigan & Shanahan, 2009; Shute, 2009; Plowman, Stephen, & McPake, 2010; Garrity et al., 2010; Grant et al., 2012; Kankaanranta et al., 2017; McTigue & Uppstad, 2019; Teale, Whittingham, & Hoffman, 2020). The use of computer-based instruction, connected toys, and educational games to accelerate the acquisition of reading skills has been widely studied (Charlton, Williams, & McLaughlin; 2005; Stephen & Plowman, 2014; Luo, Lee, & Molina, 2017; Schmitt et al., 2018; Amorim et al., 2020). In young children, games have been found to support the development of skills such as phonological awareness, use of memory enhancement strategies, motor skills, and coordination (Peirce, 2013). Several studies have indicated that educational systems and websites with a graded series of literacy-themed games promote early literacy, even when played at home (Mioduser, Tur‐Kaspa, & Leitner, 2000; Garrity et al., 2010; Grant et al., 2012; Luo, Lee, & Molina, 2017; Schmitt et al., 2018). Connected toys and ICT devices and systems can help to blur the boundaries between formal and informal learning (Montgomery, 2015), and Harris (1956) found that “Many kinds of drill can be disguised as games, becoming play rather than distasteful work.”

## Computer assisted language learning

CALL has been used in language classrooms since the 1960s. In the CALL context, the purpose of gamification is to apply a specific pedagogical strategy to engage and empower learners’ motivational skills for learning another language (the L2) (Flores, 2015; Dehghanzadeh et al., 2019). As well as keeping learners entertained, this strategy may motivate them to address further tasks, thereby enhancing learning. This is especially important in blended learning, in which the learner combines face-to-face learning with a tutor with individual use of the opportunities provided by the online environment (Hew & Cheung, 2014). During the individual part of learning, it is important to keep the learner motivated, and this can be done using, for instance, enriching educational applications or online learning platforms for features of gamification (Arce & Valdivia, 2020; Zou, Huang, & Xie, 2021). However, the effectiveness of these features depends on the context in which they are implemented and on the users using them (Hamari et al., 2014; Sun & Hsieh, 2018). Research attention has been given mostly to the learning of English, with GBL and CALL in other language classrooms playing only a very small role.

## Games and e-learning environments for small languages

The creation of e-learning environments with content-controlled materials is time-consuming and often requires consultation and hiring an entire team of field-specific and education experts. The number of apps available in the local language may differ according to a country’s prosperity or a language’s dispersion (Sari, Takacs, & Bus, 2019). For existing games, the addition of an oral foreign language explanation or a translation into the local language requires additional resources and team members. A study of best-selling apps for the 0–8 age group in four economically diverse European countries (Hungary, Turkey, Greece, and the Netherlands) showed that, on average, only 27% of the apps included oral language in the local language; there were also significant differences between countries. These findings confirm that there is variation in the quality of educational materials, often to the detriment of children growing up in less wealthy circumstances (Putnam, 2016; Sari, Takacs, & Bus, 2019). Therefore, content generation and/or automatic content generation for educational games or learning environments is an emerging area that many researchers are keen to address (Tseng et al., 2011; Hooshyar, Yousefi, & Lim, 2018). An additional solution for content generation for languages or countries that are poorly resourced is the use of CS.

## Crowdsourcing and language learning

CS is a technique for gathering data or performing large-scale tasks that is often based on the framework of collective intelligence (Lévy, 1997). Concepts related to CS include co-creation, open innovation, and user innovation (Prahalad & Ramaswamy, 2000; Chesbrough, 2003; Von Hippel, 2003). Although the benefits of CS have been thoroughly established (Von Ahn & Dabbish, 2008; Buecheler et al., 2010; Aitamurto, Leiponen, & Tee, 2011; Lew, 2013; Benjamin, 2015; Morschheuser et al., 2017), implementation lags behind. When applied in the right circumstances and to the right crowd, CS can deliver considerable outcomes. However, success requires careful analysis of goals, the problem-solving environment, the expertise required, complementary activities and capabilities, and the competitive environment (Aitamurto, Leiponen, & Tee, 2011; Pe-Than, Goh, & Lee, 2015; Morschheuser et al., 2017).

Combining CS and language learning is not a new undertaking, and it is possible to merge them to mass-produce language resources for any language for which a crowd of language learners can be involved (Lyding et al., 2018; Bédi et al., 2019; Nicolas et al., 2020; Arhar Holdt et al., 2021). Several language learning portals based on CS gather huge multilingual audiences. Although this is not the place for a detailed presentation of any of these portals, some data will provide an insight into the scale of the crowd they were able to reach in 2017–2018 (Gorovaia & Forascu, 2019). Busuu, which started in 2008, reached an audience of 70,000,000. Mango languages, launched in 2007, addressed 300,000 users. Duolingo, launched in 2011, reached 300,000,000 users. Duolingo is notable for having built one of the world’s most popular language learning apps while hiring only a handful of translators. Each day, it provides millions of sentences, almost all of them created by its 300 or so volunteers. Babbel, opened in 2007, gathered 20,000,000 users. Rosetta Stone (the oldest of the portals, founded in 1992), addressed 75,720,00 users. LiveMocha, which began in 2007, attracted 12,000,000 users in its final year, 2016. All of these portals are educational business entities, which confirms that educational businesses are able to attract users. The content they provide may facilitate and improve teaching, and CS may be used to help to create resources for additional educational areas or new languages.

# The CREDE paradigm

## The crowdsourcing paradigm shift

Traditional, simple CS was proved to have its limitations, among which we note the lack of participants and the low quality of crowdsourced work. CS in the field of education, known as crowdsourcing for education, has clear benefits, not least the capacity for innovation in education by means of large-scale learning resources, state-of-the-practice activities, and more accurate and diverse feedback (Jiang, Benatallah, & Schlagwein, 2018; Alenezi & Faisal, 2020). However, its design and implementation are not good enough: CS is not motivating enough for content providers (teachers/parents and students, also known as producers) and not fun enough or individualized enough for learners (users or students, also known as consumers).

More sophisticated CS is needed that provides models of all the requirements. For example, when building the content providers producers model (crowd-creation), we see the basic dichotomy of creators and critics (crowd-rating). This can be defined using a p+ to p- scale, where p+ denotes creation of new resources and p- means rating or evaluation of the resources. The task of CS should optimally be adapted to the p-scale mark. Producers can undertake other roles in CS, such as monitoring and managing.

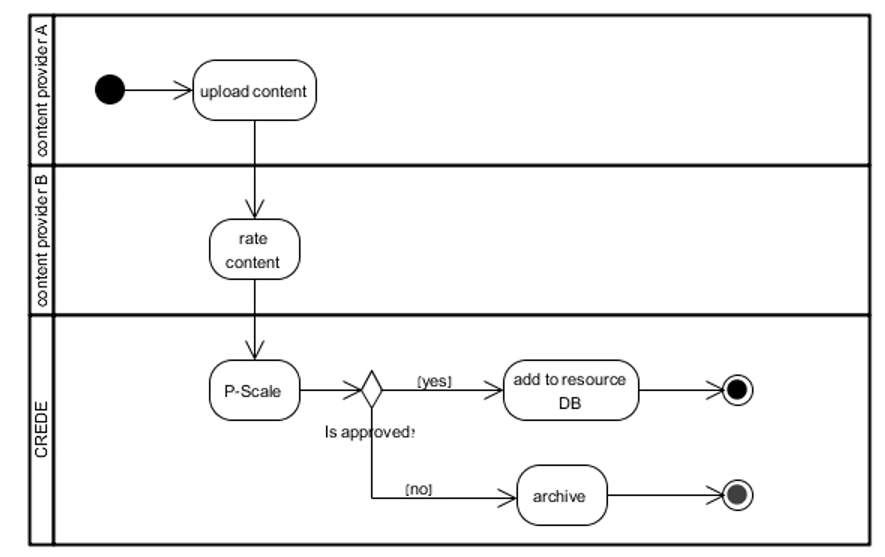
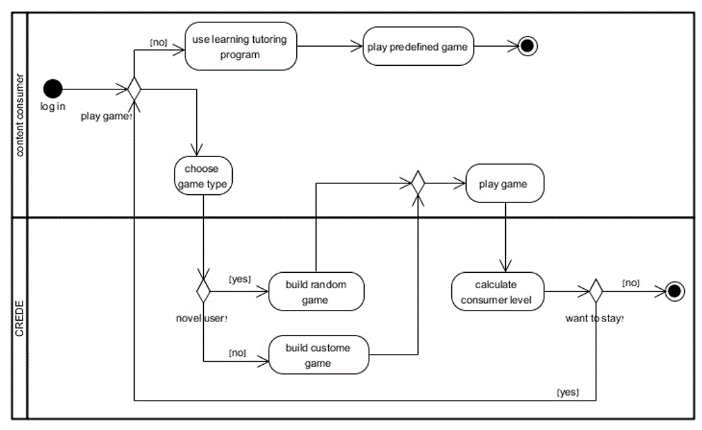


Figure X. Diagram explaining content provider and content consumer actions.

## Features of the CREDE paradigm

The most important features of an educational ICT system for CREDE are:

* edutainment, gamification, and individualization for motivation;
* infrastructure to allow cooperation of all stakeholders for inclusivity;
* a fully autonomous operation mode;
* crowdsourcing and knowledge base for variety; and
* monitoring and feedback mechanisms.

The proposed solution can take the form of design and implementation of CS that diverges from the traditional model by being a proximity-centered, individualized, managed, evolving process with all-directional interactions and feedback (vs. a one-time say-and-leave approach). For each learner, the system will hold up-to-date personal data on progress and achievements, which it will use to try to find the best personalized learning path. It will distinguish common patterns of learning behavior from those which are anomalous (i.e., it will identify learners who are experiencing progress that is exceptionally good or exceptionally poor). It will note which tasks are more difficult for a learner to complete, suggesting which skills and knowledge they should enhance to achieve a more effective learning outcome, as well as which gamification elements should be added for particular users to keep them engaged with the system. The system will use learning analytics to influence each participant’s motivation, improve each learner’s behavior, and keep each learner active. It will use additional CS analytics to keep crowd-creators engaged and willing to contribute, while using macroscopic granulation to suggest which tasks are more likely to be completed with ease (or difficulty) by specific groups of learners or content creators.

Crowdsourcers who are interested, involved, close, and immediately knowledgeable can be a solution for many problems, such as willingness to contribute and quality of the resources. Crowdsourcers can be classified in terms of concentric circles around a learner at different degrees of proximity. The more intimate the circle and a crowdsourcer’s knowledge and contact, the more important the efforts of that crowdsourcer and the greater the weight they should be given. This not only leads to better quality; the proximity and personal interest also give great motivation and feedback to the crowdsourcer.

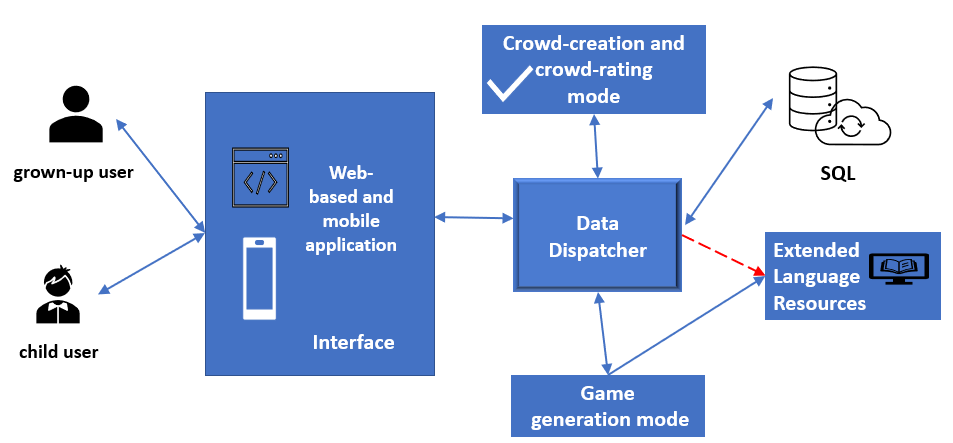
The four major roles of all actors (including, importantly, the learner) are:

* creating;
* rating or evaluating;
* monitoring; and
* managing.

# The CREDE system and its requirements

A special system was devised and tested to prove the feasibility of the CREDE paradigm. Existing content, even if valid and appropriate for some contexts, is not always appropriate for small or under-resourced languages such as Hebrew. Therefore, new approaches, techniques, and methodologies should be designed and tested for these small languages. One such approach is the use of CS for content creation and approval.

The architecture of the CREDE system reported here has several core modules, and a detailed description of the system requirements and implementation is given below. An overview of the proposed CREDE architecture, showing the core modules of the system, data interchange, and user interaction, is given in Figure 1.



*Figure 1. An overview of the proposed architecture, showing the core modules of the system, data interchange, and user interaction. The red dashed arrow represents the updating of the Extended Language Resources storage with crowd-contributed data items.*

## Basic system description

This educational software for learning to read Hebrew (at the kindergarten or grade A reading level) was built as an autonomous system that uses gamification and CS elements and implements the CREDE paradigm. Educational aspects of the system and game designs were implemented according to the Israeli Ministry of Education kindergarten and school program for reading, “Infrastructure for reading and writing” (Tashtit likrat kriya ve ktuva). As young children begin to learn to read, they first develop knowledge of print conventions (e.g., the correct reading direction, which in Hebrew is right to left), knowledge of the names and printing of letters of the alphabet, and graphophonemic awareness or an understanding of language sounds (Grant et al., 2012). Children’s ability to provide the sound associated with each letter allows them to move on to the more complex skills of phonics (the ability to map letters and sounds) and spelling (Foulin, 2005). Therefore, the process of learning to read can be divided into several parts, moving from a basic understanding of the alphabet (in terms of sounds and letters) to a more complicated level of reading (from reading a single letter to reading and later spelling small words). From the linguistic point of view, CREDE contains the following elements:

* graphophonemic awareness;
* alphabetic understanding;
* phonics (letter–sound correspondence); and
* phonological recording (use of spelling–sound rules and/or word-specific associations).

The main system requirements for CREDE are CS, gamification, and autonomy. The theories and implementation methods for those principles are defined in the following subsections.

The CREDE system uses CS for content-controlled resource gathering. The main goal of the system is to help preschool children to acquire basic reading skills using a GBL environment. The interface of the system is in line with the principles of KISS (keep it simple) and a responsive ATAWAD (anytime, anywhere, any device) design approach.

The system has three types of users:

* unknown user (guest anonymous learner);
* identified user (registered learner); and
* crowd grown-up user (registered parent/teacher).

The software has three major modes:

* training and tutoring (see Figure 2);
* playing and testing (see Figure 3); and
* reports and crowd contribution.

A picture containing diagram

Description automatically generated

Figure 2. The landing page for the CREDE training mode.

In the training and tutoring mode (also called presentation mode), each letter, its sound, and its syllable are presented and explained using multimedia content. The Hebrew alphabet consists of 22 letters. For each letter, an item of content is presented according to increasing level of difficulty, from a single letter to a word consisting of 4–7 letters. A 4–letter word is considered to be a difficult word since, in Hebrew orthography, only consonants are written and a vowel appears as a niqqud (part of a system of diacritical signs used to represent vowels or distinguish between alternative pronunciations of letters of the Hebrew alphabet). Therefore, in a majority of cases, a 4–letter word is a 4–consonant word. The tutoring section for each letter ends with a letter-recognition game.

For identified users (registered learners), the game content is built and adapted according to data on their progress that is collected and tracked. Information about a learner’s errors and mistakes, the time a learner spends on solving tasks, and the learner’s progress, engagement, and use of the program is stored in the system. The content is adapted to the learner’s academic level, providing personalized learning paths and a variety of reading strategies. For each successful game, the user receives points. For each game, data about the user’s actions are added to the database (including number of games played, number of correct/incorrect answers, incorrect letters or words, and average time to play). A specially designed graphical leader board is visible to keep learners active and to encourage them to play more games, which means learning and training more letters and words.

In playing and testing mode, a learner (a child) can play any game that he/she chooses. All games are customized for this learner using information about his/her errors and mistakes, successes and achievements, time spent on solving previous tasks, and individual progress. The CREDE system uses learning analytics to suggest which of a great variety of games and activities should be made available to a learner. It analyses which tasks are more difficult for a learner to complete, suggesting the skills and knowledge that they should enhance to achieve a better learning outcome, and the gamification elements that should be added for this user to maintain engagement with the system. The system thus encourages children to learn and experiment through play. Constant and very precise feedback makes it possible to put the optimal next-stage activity in front of the child, thereby allowing the games to evolve naturally into learning and forming a very sophisticated environment that keeps the learner active.

An unknown user (a guest anonymous learner) can access and use the training mode freely, including all the learning and game elements. In such cases, the system does not remember the user’s behavior, choices, successes, or mistakes. The unknown user therefore gets only a partial default functionality of the playing and testing mode.

Graphical user interface

Description automatically generated with medium confidence

Figure 3. The playground page from which different games for playing and testing can be chosen.

In the third, grown-up mode, after registration and a child–parent matching phase, an adult becomes a registered grown-up user (i.e., a parent or teacher). For each registered grown-up user, different kinds of reports are generated in relation to the progress, activities, and system use of the relevant child/children. Each grown-up user also receives a request to perform some CS-related activities, thereby contributing to the CREDE system in the form of data gathering (crowd-creation) and data evaluation (crowd-rating).

## Crowdsourcing activities

The CREDE paradigm is characterized by its use of CS. In the categorization of CS approaches, “implicit crowdsourcing” means that the purpose of the task is secondary to or even partially hidden from the participants; in “explicit crowdsourcing,” the task is the primary purpose of participation (Lyding et al., 2018).

CS in education has been defined as “a type of an (online) activity in which an educator or an educational organization proposes to a group of individuals via a flexible open call to directly help learning or teaching” (Jiang, Benatallah, & Schlagwein, 2018). CS activities may achieve the following objectives:

* benefit education through provision of suitable content;
* provide practical experience for the participants;
* contribute to the exchange of complementary knowledge; and
* augment abundant feedback (evaluations) for learners.

In CREDE, the crowd creates the educational content, in a process known as crowd-creation. This is an explicit CS approach in which new content, such as a new word, its picture, its pronunciation, its sound, some metadata (e.g., the initial and final letters of the word), and its Hebrew orthography (niqqud), is uploaded to the system by a specific user. This new content is later approved by a group of other users assigned at random, in a process called crowd-rating. Only verified content (in our case, content with 100% approval) is added to the CREDE database of language resource items for use in future training and game-based testing.

An informed consent form (including the conditions of use) is administered to provide all users with the information they need to make a decision about participation in CS activities. In line with the General Data Protection Regulation, the CREDE system website uses cookies that allow a user to agree to or reject the processing of personal data by the website. In addition, all users receive warnings about:

* uploading only free pictures (i.e., no uploads of copyrighted material, although the system does not check this); and
* use of uploaded audio and photo files in other projects or games.

## Game-based learning and gamification

GBL and gamification are buzzwords in the fields of learning and education. GBL is training that uses game elements to teach specific skills or achieve specific learning outcomes. The basic idea is to take some content and objectives and to make them fun. Gamification is the application or integration of game-design elements and game principles into non-game contexts. Gamification is not GBL, nor does it require students to play games.

The gamification of learning is an educational approach that aims to motivate students to learn by using games and game elements in learning environments. The goal is to maximize enjoyment and engagement by capturing the interest of learners and inspiring them to continue learning (Kim et al., 2018). The CREDE system uses a combination of GBL and gamification, in that most of the learning is done via playing games (in the playing and testing modes of the system) and all of the content creation and evaluation is done via a gamified interface.

A playground page (Figure 3) provides a training and testing interface through which child users choose which game to play. The game is an “invisible” test for a specific letter or letters of the Hebrew alphabet. Each child, playing as an identified user, receives a specially tailored set of letters and words. All the child’s successes and mistakes are gathered and added to the database for future games and reports. All the letters and words with which a user struggled in the past, together with previous mistakes and information about their progress, are taken into account in the creation of data items for the next game.

In the grown-up mode, a parent user who contributes to the system receives points, badges, and encouragement phrases. For crowd-creating (collaborative creation), points are given for each item submitted to the system, with more points added later after the item is approved. Different types of badges are given to users according to their contributions. During the crowd-rating stage (content evaluation), different encouragement phrases are given to users in line with their agreement with other’s judgments or comparisons with other content contributors: for example, “90% of the parents think like you” or “3 more parents found this content to be inappropriate.”

## Autonomy of the system

One of the requirements for the designed software is autonomy. The basic idea of an autonomous system is that it continues to grow and evolve without the involvement of the original creators, and that the software does not require management a=or maintenance. The initial system is designed by developers, but it subsequently grows and evolves using knowledge and resources supplied and approved by the crowd or other sources, without any interaction with the original developers.

In CREDE, a new item of content is created and uploaded by the crowd (i.e., parent/teacher users). A new data item includes a new word, its picture, its pronunciation, its sound, some metadata (such as the initial and final letters of the word), and its Hebrew orthography (niqqud). This new data item is later rated by a group of other users selected at random. Only verified content enters the CREDE database of language resource items for use in future training and game-based testing. The same word can be used with a different picture or sound file. Thus, for some word X, sometimes image A is used and sometimes image B is used; conversely, image Y can be associated with several words. However, this multiple content option is not available to the crowd-creator, who instead has to upload the word and its data for each image separately.

The CREDE software does not require persistent management or maintenance and is not a heavily used computer system. The expected time-frame for use is only several months (a reasonable period for a child to learn the Hebrew alphabet). Therefore, certain types of thresholds are predefined, along with a set of actions to be carried out once the threshold is reached. For example, if the system reaches a certain capacity threshold value, the oldest and/or unactive items will be removed or archived, with some functions of the system becoming unavailable for a specific user.

# Experiment and results

## Experiment

The educational software was tested for a short period of time (January to March 2020) in three kindergartens. Official permission to conduct the research was received from the Scientific Officer of the Israel Ministry of Education. This approval allowed the researchers to perform various assessments and evaluations, gather data, and conduct interviews and activities related to CREDE. The short duration of the test was due to the lockdown of kindergartens in response to COVID-19.

During our experiment, the parents of 110 kindergarten children were contacted by email, message, poster, and flyer. All formats included a brief explanation of the CREDE system and the experiment and provided a link to more detailed information. Kindergarten teachers helped the research team to distribute these materials and to create user accounts for some of the children.

During the experiment, one of the researchers entered the system weekly as a parent and provided 10 incorrect or inappropriate data items.

## Results

The researchers made a detailed analysis of the data collected in order to evaluate the success of the proposed approach. They monitored each child’s involvement (number of games played, number of correct/incorrect answers, content of correct/incorrect answers, time spent on tasks, average time to play, and game choices) and system usage (average time to play and daily/weekly entrances to the system), and each parent’s willingness to contribute and approve new content. In this article, only findings related to CS activities are presented and discussed. The quantitative analysis of participants’ data was carried out by analyzing the user log files.

At the end of March 2020, 67 child users had been created (some with the help of kindergarten teachers), but only 37 parent/teacher users had been created. Some of the grown-up users were related to the same child, and nine users were related to more than one child. In terms of parent system usage, we found that:

* four parents entered the system only once;
* 13 parents entered the system once a week;
* eight parents entered every 2–3 days; and
* the remaining 12 parents did not have any entering pattern (some entered daily at first and later not at all; some entered every 2 weeks; some entered several times a day).

In total, 91 new items were uploaded to the system by only 17 parents. The number of submitted items per user and number of approved items can be found in Table 1. Of the users, 23% submitted 52% of the uploaded content. Of the 91 items, 88 were approved by at least three parents and were therefore added to the CREDE extended language resource database.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Number of users per uploaded item | Total number of uploaded items | Total number of approved items |
|  | 2 uploaded 1 | 2 | 1 |
| 4 uploaded 2 | 8 | 8 |
| 3 uploaded 4 | 12 | 12 |
| 3 uploaded 5 | 15 | 15 |
| 1 uploaded 7 | 7 | 7 |
| 2 uploaded 10 | 20 | 18 |
| 1 uploaded 12 | 12 | 12 |
| 1 uploaded 15 | 15 | 15 |
| Summary | 17 uploaded 91 | 91 | 88 |

Table 1. Numbers of items submitted and approved.

All 10 inappropriate items uploaded by the research team member were disapproved by users, although three of the inappropriate items each received several approvals.

Of the 34 parents who entered the system more than once, 30 agreed to do some crowd-rating. Only six data items had some rating disagreements (three of the inappropriate items provided by the research team and three other items provided by parents). Statistics for willingness to rate item content are difficult to provide, since sometimes a parent entered the system when there were no items to rate (i.e., when there were no new items submitted by other users waiting in a temporary item’s table).

# Discussion

As a result of COVID-19, we have witnessed an unprecedented field test involving hundreds of millions of educators and students worldwide using EdTech, ICT, remote education, and distance learning. One of the main barriers to adoption of these technologies has been a lack of technical knowledge and skills. However, in addition to technical difficulties, educators in many countries have faced a shortage (or even a total lack) of good, free educational resources.

Although substantial numbers of games and GBL environments and platforms already exist in the world of edutainment and e-learning, the majority of these are for English-speaking audiences. The creation of educational content-controlled resources and games is time-consuming and often requires help from an entire team of experts. Thus, the creation of valid and appropriate educational content for small or under-resourced languages demands creativity and the application of novel techniques and approaches.

We believe that this lack of educational content-controlled resources can be addressed with the help of the crowd. In this paper, we described the CREDE paradigm, reported its implementation in a specially designed system for the early stages of learning to read, and analyzed the willingness of the crowd to contribute. We showed that the individualized CS of involved crowdsourcers (parents) improved the quality of the resources gathered; the proximity and personal interest also provided excellent motivation and feedback to the crowdsourcers.

Our experiment shows that parents were willing to carry out CS activities to create valid and appropriate content. However, they preferred data-evaluation activities to data-creation activities. The majority of users (30 of 34) agreed to do some crowd-rating, but only half (17 of 34) provided new data items. Of all the content uploaded, 52% was provided by 23% of the users, which is a good result according to the CS literature; for example, 95% of Khan Academy crowd translators withdraw from translation activities in less than 3 years, and in 2012 Duolingo’s contributor retention rate was only 13%.

In light of the theories and activities discussed above, we can conclude that CS in education and language learning, if used correctly, can bring great benefits, enriching educational content, stimulating the creation of data and knowledge (metadata), and encouraging the creation of valid content. User-generated content creation is an effective way to use the crowd to generate educational and language learning resources for under-resourced or small languages. Our experiment shows that parents (a so-called motivated crowd) are willing to contribute as crowd-creators and/or crowd-raters. Individualized CS by involved crowdsourcers ensures that the gathered resources are of good quality. We therefore believe that CS in education has great potential and will be widely used.

The system reported here is currently a supplementary environment for the early stages of learning to read. However, it can be added to different platforms as a learning tool. Studies have shown that games can accelerate learning, especially when they are scheduled to fit the course syllabus and combined with teacher-led instruction. Adding games to a carefully planned program can improve a child’s learning, reinforce the child’s ability to master a specific skill or topic, and serve as a valid supplement to the course syllabus. Accordingly, we anticipate that in future versions of CREDE a “syllabus support” agent will be added to create an optimal path for learning via play.

# Conclusions and further research

The next stage is to develop a learning mechanism that adapts the pedagogy to learners who are at a distance, such that each individual’s effort can serve all learners wherever they are. Thus, a truly universal network of extremely vital educational knowledge bases will be created, leading to dramatic improvements in EdTech outcomes and educational success for even the most disadvantaged and under-resourced learners.

In recent years, the authors have been involved in multinational efforts involving many dozens of researchers from each European country, and these have already proved highly successful. The enetCollect COST action funded by the EU Commission has been in operation since 2016, and has already proved the feasibility of the concept many times over.

This study has two main limitations. First, because of the limited number of participants and research methods, t. Given our aim of exploring theoretical and practical research concepts, we ; future research that also usesscana s Second, this study does not focus on security, which remains a concern in real-life applications. For example, a group of malicious users can create a coalition and approve incorrect or inappropriate content; similarly, users can create grown-up accounts and use them to rate their own data items. Future research should seek to address these issues.

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