Diligo 2.0: a digital assessment tool for geometric and emotional skills in preschoolers

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Abstract

Preschoolers have to face an important turning point during the introduction to primary school, which requires a set of skills to ease the transition from kindergarten. This transition has an important role on the future development of the child's personality and academic results. To cope with this challenge, there are some skills that can be assessed and trained in early childhood. Diligo 2.0 is an Agent-Based game developed for Android devices to be a monitoring tool to assess in 5-years-olds, emotional competences and geometric and spatial thinking. These two sets of skills are some of the core abilities useful for the child to successfully access primary school. Diligo 2.0 is also designed to assess the child attitude to engage in slow or fast thinking activities. The assessment of these skills can be both normative and ipsative, depending on the use of it as an inter-individual or an intra-individual comparison assessment tool.

Keywords

Assessment, geometric skills, emotional skills, preschoolers, fast thinking, slow thinking, school readiness, serious game, tutoring system

1. Introduction

The transition to primary school has been identified by research as a challenging time and a possible source of stress for children. The children are asked to adapt to many changes such as the physical environment, learning expectations, rules and routines, social status and identity, and relationships for children and families [1]. It is important to highlight that the transition to primary school is not just a single event, while it can be considered as a long procedure, which has the potential to define some possible trajectories for school and academic future results [2]. An important concept to introduce as a fundamental variable to describe the outcomes of this period is "School Readiness", which has generally, been described as the "level of development at which an individual (of any age) is ready to undertake the learning of specific materials" [3]. From an operational point of view, the concept of School Readiness can be described as a set of specific skills through which children become able to learn in school [4]. These skills include mathematical, geometrical, communication, social and emotional skills which should have reached a level of development high enough to let the child access to primary school as an approachable challenge [5, 6, 7].

The Italian Ministry of Education established in 2012 the Italian National Guidelines for Kindergarten, which include those skills and competences considered to be essential for the 6-years-olds to face their transition to primary school.

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The development of Diligo 2.0 has started right from considering these guidelines in order to design an ipsative and monitoring tool to assess in 5-years-old two of the main skills which are part of the School Readiness concept such as geometric and emotional skills and the psychological and behavioral attitude to engage in slow/fast thinking activities [8].

There are several reasons why we chose to focus on geometrical and emotional skills. Geometrical and spatial skills are highly predictive of math skills and executive functions development [9] and for children they can be the most difficult to face with when starting with primary school. Furthermore, the development of executive functions that is predicted by spatial and geometrical reasoning is also linked to better learning approaches during school years, becoming a fundamental aspect of the school readiness concept [10], and the development of mathematical skills has been shown to be the most predictive of the boost of the whole-child curricula while considering academic success [11].

Emotional skills are as well a fundamental element to help the child during the transition to a more complex environment such as primary school compared to kindergarten, since children who start primary school with good emotional and social skills can be more at ease at establishing new social relationships with peers and adults, they can better understand and solve social and emotional problems and make more friends [12], letting the transition to primary school be smoother and allowing the child to take advantage of this period to create the basics for successful relationships along the following academic years, which have a great impact on the overall wellbeing of individuals, their engagement in education and their academic success as well [13].

These are the main reasons why we focused on developing a tool for these two kind of skills, starting from the school readiness concept, giving the framework to better understand the impact of socio-emotional and geometrical-spatial skills can have on the future development of children and their future academic successes.

This tool enables teachers, parents and researchers to access different levels of information and statistical data to better understand, monitor and train children's skills. We can synthetize the components of the emotional skills as it follows: awareness of the emotions, use and comprehension of emotion-related vocabulary, recognition of facial expressions and their link to the emotions, comprehension of the situations that elicit emotions, knowledge of the cultural rules for displaying emotion and regulation and management of one's own and others emotions [14, 15, 16, 17]. We can list as well the specific competences included as geometric skills: knowledge of the geometrical figures, acquisition of big and small concepts, recognition of number representation, spatial concepts of in-out and up-down, temporal order in terms of before and after, spatial directions left and right and recognition of visual differences [18, 19].

Furthermore, Diligo 2.0 allows to detect the behavioral attitude to use Kahneman's [8] thinking systems: "System 1" which is fast, automatic, unconscious, emotional and "System 2" which is slow, logical, conscious, effortful. The two systems interact with each other and the development of System 2, if trained, can lead to more effective thinking process by enhancing metacognitive monitoring over fast cognitive processes. This additional feature to monitor slow and fast thinking has been included since the idea that children are exposed since the very first years of their life to technology and interactive devices, and later in their life they grow up in a society which is increasingly pushing individuals to use fast thinking instead than slow processes, so it seemed to be useful to assess this behavioral and psychological attitude toward slow/fast thinking systems [20].

2. The development of the app

Diligo 2.0 is a serious game developed for Android devices and it is based on the STELT platform, Smart Technologies to Enhance Learning and Teaching [21]. Diligo 2.0 for geometric skills is now currently fully developed and it is about to be tested with kindergarten children at "Scuola dell'Infanzia B. Gigli" in Loreto, Italy.

The Diligo 2.0 version focused on emotional skills is currently in development and it is based on the same architecture.

The game has been designed to be a monitoring tool to assess the geometric and emotional competences in 5-years-olds, and as already said, the tool has been designed also keeping in mind the ability to assess the psychological and behavioral attitude to engage in slow/fast thinking activities.

The underlying hypothesis about fast/slow thinking preference is then that children tend to choose the kind of activity that better matches with the ones they experience the most during their average days, and because of this, during the first phases of experimentation of the app with children, which will approximately take place from January 2021, teachers and parents will be given a short questionnaire about the activities their children are involved the most.

The assessment can be both normative and ipsative: by normative, it means that the use of the data collected can be used for inter-individual comparisons; when ipsative, it becomes an intra-individual assessment, useful to highlight strengths and weakness of the single child, allowing the teacher to keep track of his/her dynamic developmental profile.

Diligo 2.0 has been designed and developed adopting an Agent-Based Model approach [22], this means that there are two main interactive agents: the first one is the user, who plays all the tests trying to help the main character of the game; the second Agent is "Leo the Explorer", an artificial agent which guides the user in the several sections of the app and during the game giving tips, instructions, feedbacks and narrative introductions to every level of the game.

This modelling approach has been chosen to better involve the child into the game, in order to motivate him/her by giving constant feedback, reinforcements and to set the whole game as an adventure, giving a challenging frame to the tests.

Exactly for this reason, Diligo 2.0 uses a narrative approach, and that's one of its strengths. A narrative approach allows to use learning structures that are naturally present as human behavior to introduce complex content to children. We can think about stories, dialogues during the playing of children, all of these are part of the early experiences for children to develop concepts and to learn and to understand reality [23, 24, 25, 26].

The game has been firstly given to a group of teachers at "Scuola dell'Infanzia B. Gigli" in Loreto, to test it by their own during July 2020, in order to highlight possible adjustments and to have a practical feedback from the people who actually works with children. We gave teachers the opportunity to test Diligo 2.0 for geometric skills and later we gave them an evaluation checklist to complete in order to better understand and collect their feedbacks.

The checklist included the following points:

- Easiness of use
- Ergonomics
- Graphics
- Balance of difficulty
- Duration
- Efficacy
- Overall quality

Each of those points included more specific sub-points, and the overall feedbacks were positive in each of these areas and included useful tips for usability improvements we made the most of.

The prototype currently developed is also able to communicate with a server, linking the data of the children's test to a GUID (an acronym for 'Globally Unique Identifier'), which is a number used to identify the children in a safe way, in order to preserve the privacy of his/her data, and displaying all the aggregated data into an analytics app for teachers and researcher. The analytics app is still under development and will allow to anonymously monitor classes and groups of children, allowing teachers to .

3. Structure and workflow of the software

The home page of the app, as shown in Figure 1, features the possibility for the teacher to login the child through the GUID which has already been sent to the teacher. This passage allows the app to communicate with the server and to save data from the session linked to that specific GUID. There are three main sections of the app. The first one from the left is the "Play" button, the second one allows the user to see a "Profile" page where, after the session has been concluded, it is possible to see a short feedback about the behavioral preference for slow or fast thinking, and the last button is used to see the "Credits" section.

Figure 1: *Diligo 2.0 Geometric Skills* Home screen

When the child access into the game section, he/she is introduced to the game environment by the Tutor of the game, "Leo the Explorer", who explains the basic functioning of the game, such as the meaning of the on screen buttons, the way to interact with the different games, and also a short narrative introduction for the child, who is involved into a treasure hunt among eight different islands as the Explorer's Assistant, who has to help him face all the challenges to retrieve the different treasures placed each one on a different island.

The game is then structured in eight different levels, one for each competence, and every level has four alternative forms that differ in terms of setting, background story and requests for the child, but preserving the focus on the same competence and the same gameplay. Each level is then divided in four different questions or requests for the child. For every level, the child has the opportunity to select a fast or slow mode. The main difference between the fast and the slow mode is about the structure of the level. In the fast mode, the child has to face a "point-and-click" task, so the tutor makes a request that to be answered requires the child to touch a specific element on screen. In the slow mode, each evaluative item is followed by a narrative interval where the child is asked to make choices that does not impact the score of the game, but add instead a narrative background to the activities he/she is involved with, as shown for example in Figure 2, making the slow mode quite longer in terms of time and more challenging to follow from an attentional point of view.

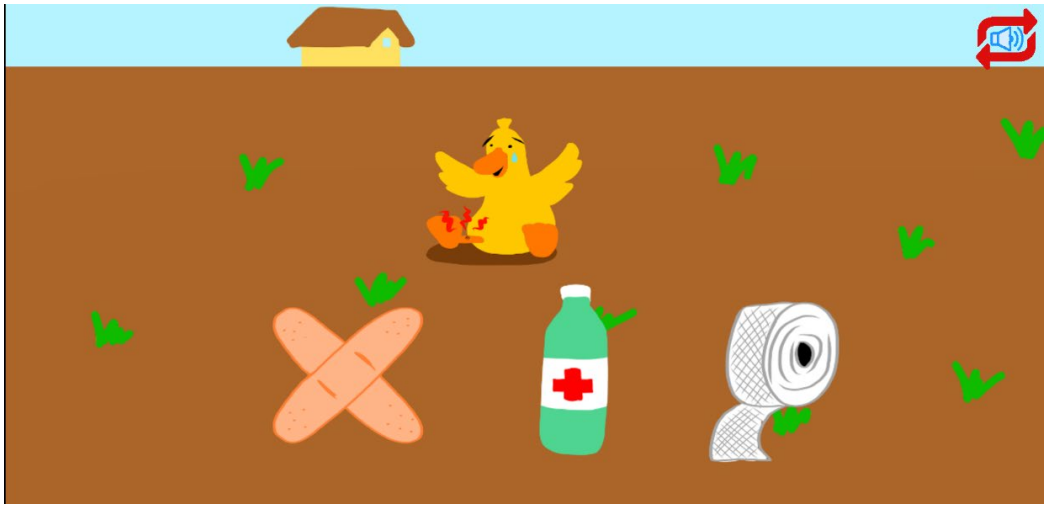

Figure 2: A screen capture from *Diligo 2.0 Geometric Skills* in slow mode, showing a moment of choice during the narrative of a specific level located in a farm, where the child is asked to help a little duck which has a small injury.

The game path is predetermined, so the child can't choose the order to face the levels, and this design choice has been made to ensure the test validity and not affect the assessment, so that every child follows the same path. At the end of the game, the game sends all the scores data to a server, and makes available a brief report inside the "Profile" section of the app with an overall feedback about the preference for fast or slow activities, while to show data and statistics about the geometric or emotional skills it is required to use the separate analytics app, accessible for teachers and researchers. The scoring is not influenced by the slow or fast mode: 1 point is assigned for every correct answer and 0 point for every wrong one.

In order to use Diligo 2.0 as an ipsative tool for the child, when he/she is logged in and starts a new game session, the game recognizes the player and when the session is completed, it saves a new session of data, in order to make comparisons between the same child's results.

3.1. Geometric skills

In terms of gameplay, every level in Diligo 2.0 is designed to be completed by touching a specific element on screen that matches with the request of Leo the Explorer, as shown for example in Figure 3. The requests are all given by voice from Leo the Explorer, who has been dubbed in Italian language.

Following in Table 1 the eight different competences are described in terms of their respective tasks.

Table 1
Geometric competences and tasks

Competence	Task
Knowledge of the geometrical figures	Select a specific geometric figure from a picture
Acquisition of big and small concepts	Select a small/big object
Recognition of number representation	Tell if two representation show the same number or not
Acquisition of spatial concepts of in-out	Select an item which is inside/outside of a specific area

Acquisition of spatial concepts of up-down	Select an item which is above/below a specific object
Acquisition of temporal order in terms of before and after	Select an item which is before/after another object in terms of arrival order
Acquisition of spatial directions of left and right	Select an item which direction is right/left
Recognition of visual differences	Tell if two representation of the same object are the same or differ

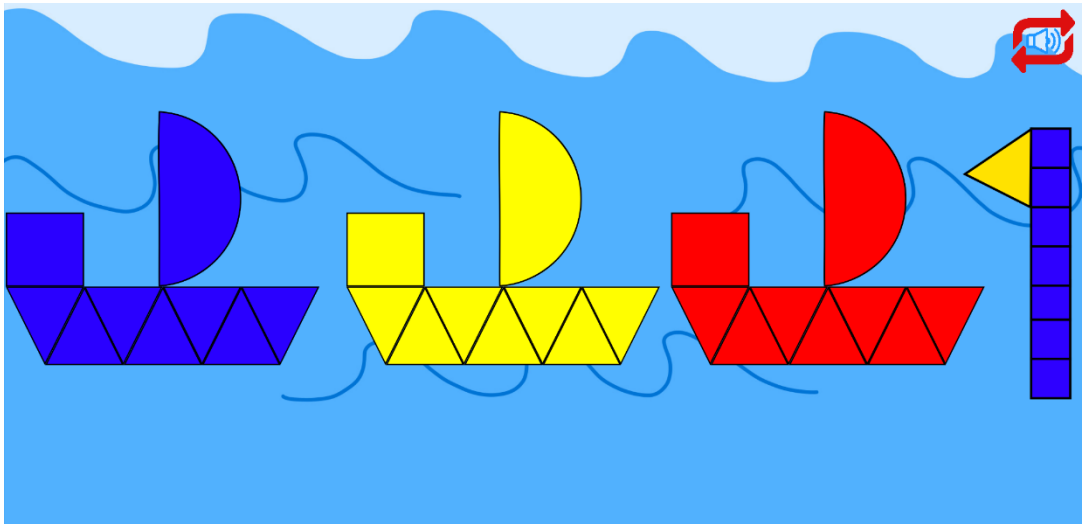

Figure 3: An example from the "Acquisition of temporal order in terms of before and after" level in *Diligo 2.0 Geometric Skills*, where the child has to chose which boat arrived before the yellow one. On the upper right corner, it is visible the button to repeat all the instructions of the task requested to the child.

3.2. Emotional skills

While the Geometric Skills version of Diligo 2.0 is now fully developed, the Emotional Skills version is not completed yet. However, the app is at an advanced development stage, so it is possible to describe the competence included in this version as well. The gameplay logic is the same of the Geometric Skills version, but in this case the focus is on emotions and basic social skills. For example, as shown in Figure 4, the child is asked to recognize which couple of children shows the same emotion.

Following in Table 2 the eight different competences are described in terms of their respective tasks.

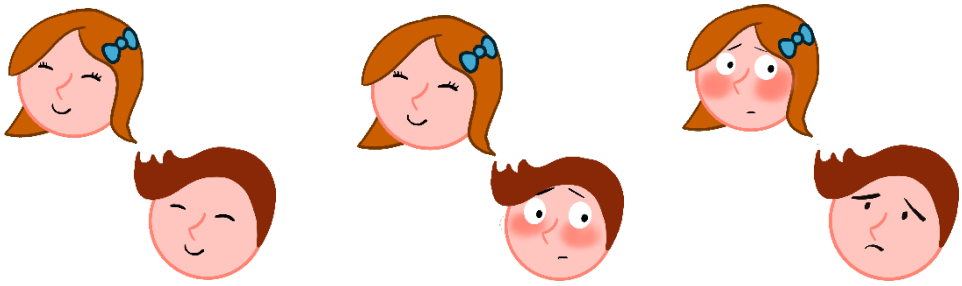

Figure 4: An example from the level "Recognition of facial expressions and their link to emotions" in Diligo 2.0 Emotional Skills, where the child has to choose which couple of faces shares the same emotion.

Table 2
Emotional competences and tasks

Competence	Task
Recognition of facial expressions and their link to emotions	Recognize which couple of child expresses the same emotion
Use and comprehension of emotion-related vocabulary	Select the correct face that matches with the name of the emotion
Comprehension of the situations that elicit emotions	Select the correct face that matches with the emotion coherent with a specific situation
Awareness of the emotions (in terms of intensity)	Select the correct face that matches with the description of the intensity of a specific emotion
Knowledge of the cultural rules for displaying emotion	Select which illustration shows the best solution for a specific situation
Recognition of bodily expressions and their link to emotions	Select the correct illustration that matches with the name of the emotion
Awareness of the emotions (and basic link with specific kind of thoughts)	Select the correct illustration of thoughts that matches with the emotion requested
Regulation and management of one's own and others emotions	Select which illustration shows the best solution for a specific situation

4. Conclusions

Diligo 2.0 in both versions tries to promote a more sensitive awareness about each child specific educational needs and to support the teacher monitoring the group class to adjust its educational path along the way. Furthermore, Diligo can give powerful insights in data from a normative and ipsative point of view, allowing teachers and researcher to monitor children and classes for a better understanding of their specific development. In the future the app could be used also as a training tool to help the children improve their skills, providing them an entertaining learning experience through the serious game modelling and the agent-based approach, which can be an innovative way to involve and easily access through digital devices a great amount of data to better understand and support the specific needs of children in such a crucial point in their life as the transition from kindergarten to primary school is.

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6. References

[1] Hirst, M., Jervis, N., Visagie, K., Sojo, V. Cavanagh, S., Transition to primary school: a review of the literature. Canberra: Commonwealth of Australia (2011).
[2] Shore, R., Ready Schools: A report of the Goal 1 Ready Schools Resource Group, The National Education Goals Panel, Washington, DC, (1998).
[3] Lewit, E., Baker, L., School Readiness. The Future of Children, 5(2) (1995) 128-139. doi:10.2307/1602361
[4] Kienig, A., The importance of social adjustment for future. In: Transitions in the early years: Debating continuity and progression for young children in early education, 2002 pp. 23-37.
[5] Doherty, G., Conception to age six: The foundation of school-readiness, Toronto, Learning Partnership, 2007.
[6] Janus, Magdalena, Offord, D., Readiness to learn at school. ISUMA: Canadian Journal of Policy Research 1 (2000) pp. 71-75.
[7] Kagan, S. L., Readiness past, present, and future: Shaping the agenda. Young Children, 48(1) 1992 pp. 48-53.
[8] Kahneman, D., Thinking, Fast & Slow, F. Straus and Giroux, New York, 2011.
[9] Verdine, B. N., Irwin, C. M., Golinkoff, R. M., Hirsh-Pasek, K. Contributions of executive function and spatial skills to preschool mathematics achievement. Journal of experimental child psychology, 126 2014 pp.37-51. doi:10.1016/j.jecp.2014.02.012.
[10] Vitiello, V. E., Greenfield, D. B. Executive functions and approaches to learning in predicting school readiness. Journal of Applied Developmental Psychology 53 2017 pp. 1-9. doi.org/10.1016/j.appdev.2017.08.004
[11] Jenkins, J. M., Duncan, G. J., Auger, A., Bitler, M., Domina, T., Burchinal, M. Boosting school readiness: Should preschool teachers target skills or the whole child?. Economics of education review 65 2018 pp.107-125.
[12] Cavioni, V., Zanetti, M. A. (2019). Social-emotional learning and students' transition from kindergarten to primary school in Italy. In: Early Childhood Development: Concepts, Methodologies, Tools, and Applications. IGI Global, 2019 pp. 528-547.
[13] Kienig, A. (2013). Children's transition from kindergarten to primary school. In: International Perspectives on Transition to School. Reconceptualising beliefs, policy and practice. Routledge, London, 2013 pp. 22-32.
[14] Cole, P. M., Martin, S. E., Dennis, T. A., Emotion regulation as a scientific construct: Methodological challenges and directions for child development research, Child development, 75(2) 2004 pp.317-333.
[15] Eisenberg, N., Spinrad, T., Emotion-related regulation: Sharpening the definition, Child Development, 75 2004 pp. 334–339.
[16] Saarni, C., The development of emotional competence, New York, Guilford, 1999.
[17] Thompson, R. A., Emotional regulation and emotional development. Educational Psychology Review, 3 1991 pp. 269–307.
[18] Newcombe, N. S., Huttenlocher, J., Making space: The development of spatial representation and reasoning, MIT Press, 2003.
[19] Dehaene S., Varieties of numerical abilities. Cognition. 1992 Aug 44(1-2) pp.1-42. doi: 10.1016/0010-0277(92)90049-n.

[20] Miglino O., Festina lente. Apprendere ad armonizzare i processi di pensiero lento e veloce come precursore dell'imparare a ragionare [Learning to harmonize slow and fast thinking as a precursor of learning how to reason]. Giornale italiano di psicologia [Italian Journal of Psychology] 4 2019 pp. 859-864.
[21] Miglino, O., Di Ferdinando, A., Schembri, M., Caretti, M., Rega, A., Ricci, C., STELT (Smart Technologies to Enhance Learning and Teaching): una piattaforma per realizzare ambienti di realtà aumentata per apprendere, insegnare e giocare [A platform to develop augmented reality environments to learn, teach and play], Sistemi intelligenti [Intelligent Systems] 25(2) 2013 pp. 397–404.
[22] Helbing D., Agent-Based Modeling. In: Helbing D. (eds) Social Self-Organization. Understanding Complex Systems. Springer, Berlin, Heidelberg 2012. doi:10.1007/978-3-642-24004-1_2.
[23] Barthes, R., Introduction to the structural analysis of narratives, London, 1977.
[24] Smorti, A., Il pensiero narrativo: costruzione di storie e sviluppo della conoscenza sociale [The narrative thinking: building stories and social cognition developemnt], Giunti, Firenze, 1994.
[25] Bruner, J., Play, thought and language. Prospects, 16(1) 1986 pp. 77-83.
[26] Casey, B., Erkut, S., Ceder, I., Young, J. M. Use of a storytelling context to improve girls' and boys' geometry skills in kindergarten. Journal of Applied Developmental Psychology 29(1) 2008 pp.29-48.