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A Framework for the Creation of Leap Motion Gestural Interfaces for Handwriting Education to Children with Development Coordination Disorder

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Abstract. Gestural interfaced-based computational tools can be more suitable than other kinds of interfaces during calligraphy education to children with Developmental Coordination Disorder. The touchless tools reduce difficulties with handwriting of these pupils because they do not require physical contact and they dispense efforts of fine motor skills needed to perform calligraphy. They also serve as a motivational tool and they are more intuitive than touchscreen and graphical user interfaces. This paper deals with concepts of Development Coordination Disorder and human-computer interaction principles and it proposes a framework with a set of specific guidelines for software for the development of gestural interfaces for calligraphy education to children with DCD. Containing 25 guidelines in 3 stages – Prototyping, Development and Evaluation, this model takes into account the characteristics of DCD and recognizes fine motor skills technologies, relating all proposed guidelines to each other and supports the creation of appropriate gestural interfaces to assist these children at this school stage.

Keywords: Gestural Interfaces; Framework; Guidelines; Developmental Coordination Disorder; Handwriting.

First Considerations

As gestural interfaces for children calligraphy learning are often inappropriate or poorly designed (Saffer, 2008), it is recommended that the development of these interfaces starts with its framework which contains a number of guidelines to be followed and can be adapted to the reality of the process of teaching handwriting to children with DCD, taking into account those devices that have the characteristic of recognizing fine movements without tactile response, for example, Leap motion (Nunes & Silveira, 2015b), (Nunes & Silveira, 2015c).

A framework, therefore, is a type of system or model to formalize a conceptual process, capturing a common feature among different concepts (Ferguson, Jelsma, Versfeld & Smits-Engelsman, 2014) and allow the reuse of these definitions for analysis, design, implementation and testing, being commonly used in the software programming area in computers (Landin, Niklasson, Bosson & Regnell, 1995) and helping in the development of interfaces (Johnson & Deutsch, 1993).

The advantage of using a framework is that it acts as a paradigm for the development of something in accordance with an established standard, saving additional time and research work, as the whole process is regulated, besides productivity benefits in creating new tools, with reliability and quality, as well as updating and constant maintenance of the model. A disadvantage has to be the time spent in the creation of formulations and settings.

Therefore to use a framework, there is need of an analysis for a complete understanding and handling during implementation in accordance with their recommendations.

I. Developmental Coordination Disorder

Developmental Coordination Disorder (DCD) is a disorder linked to fine and gross motor coordination with children and adults who commit to academic achievement, physical education and everyday activities such as dressing, personal hygiene, nutrition, social interaction/relationships and health, without any clinically evident brain injury/damage. It is mainly characterized by spatial, motor, postural and verbal difficulties, compromising movements, perceptions, thought and language (Polatajko & Cantin, 2005), (Magalhães, Cardoso & Missiuna, 2011), (Portwood, 2013).

People with DCD have an intellectual capacity in accordance with the general population, but the presentation and difficulties of the disorder can vary between individuals and may change in accordance with environmental demands and life expectancy. For some, however, its impact is persistent and significant up to adulthood, affecting daily life and creating problems with time management, organization and planning (Kirby, Edwards & Sugden, 2011), (Kirby, Sugden & Purcell, 2014).

It is estimated that there are 5% to 6% up to 22% of school-age children with DCD, with 2% severely affected. In the general population, the number of DCD prevalence is between 5% and 7%, most frequently with males (Martin, Piek & Hay, 2006), (Cardoso & Magalhães, 2009), (Ferguson et al., 2014).

Discussing the difficulties that DCD presents before, the problem of space is many times confusing for subjects, concerning concepts like high, low, near or far, as well as the shapes and sizes of figures used in writing (Wilson & Mckenzie, 1998), (Vaivre-Douret et al., 2011).

With neurological motor dysfunction, DCD prevents the brain from performing all its functions, compromising balance, generating imprecision and slowness (Geuze, 2003). The areas that suffer most are changes in body posture and temporal-spatial orientation (Ferguson et al., 2014). The stance is reflected in movements lacking rhythm and little control (Fong, Ng & Yiu, 2013). In some cases, language is not affected, but there is a phonological and phonetic deficit in speech (Gaines & Missiuna, 2007). The main features of this disorder can be seen in Figure 1.

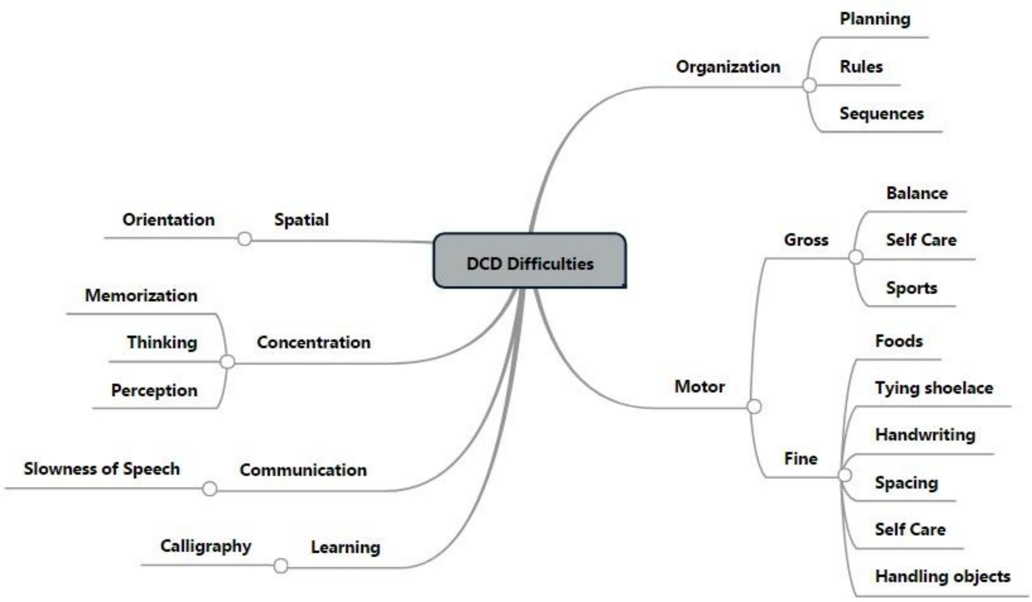

Figure 1: DCD and its characteristics. Source: Prepared by the author.

Children with DCD experience school failure, with challenges in calligraphy, as handwriting is the most affected area due to the difficulty in controlling and holding a pencil, little tactile sensation and limited concept of space, characterized by the absence of spacing between letters and the impediment to position the pencil at a specific point of the paper, along with the lack of three-dimensional perception when copying or drawing geometric figures and disorganization in presented works on paper (Miyahara & Möbs, 1995), (Zwicker, Missiuna, Harris & Boyd, 2011), (Jolly & Gentaz, 2013), (Scordella et al., 2015). By using digital technology, however, school problems can be overcome, since the cognitive part of the brain is unaffected and children with DCD can use them with dexterity and rapidity (Thorvaldsen, Egeberg, Pettersen & Vavik, 2011), (Czyżewski, Dalka, Kunka & Odya, 2014), (Ferguson et al., 2014).

Educating children with DCD during literacy should focus on calligraphy and literacy with techniques and tools that improve physical and psychological aspects of the child at this stage (Othman & Keay-Bright, 2010), (Prunty, Barnett, Wilmut & Plumb, 2013), such as dotted exercises, using non-toxic modeling clay, boards and paintings, chalk or brush, chairs and adapted tables, different types of pencils, pens (that light up when pressed), erasers, rulers, lined paper which is always aligned with the child's arm, giving more autonomy and confidence for these pupils and those who are in special needs education (Kirby, 2011), (Hsu et al., 2013), (Huau, Velay & Jover, 2015).

You can also allow the child to write with pre-shaped letters, requiring a certain amount of work or exercises, making use of other moments of interaction with colleagues, such as intervals, in addition to giving extra time, not scoring all errors, encouraging oral responses or use of digital technologies that benefit from kinesthetic movements (those performed in the air), as well as technologies which use gestural interfaces, helping in the education of children with DCD as they have problems in finalizing and reverse letters (handedness and orientation) (Chen & Cohn, 2003), (Summers, Larkin & Dewey, 2008), (Magalhães et al., 2011), (Missiuna, Rivard & Pollock, 2011).

II. Leap Motion

Leap motion Technology is a compact-size device with infrared sensors and cameras that have the capability to track and recognize only the movements of the fingers and hands of a user, as can be seen in Figure 2. The tool requirement is the need to calibrate prior to use so that a new user gets used to using it (Nho, Seo, Seol & Kwon, 2014), (Seixas, Cardoso & Dias, 2015).

Figure 2: Leap Motion. Source: www.leapmotion.com

This tool has a split control in 02 (two) areas: Hover Zone and Touch Zone. The first captures movements shallow as a general navigation cursor on the screen, being located between the user and the sensor. The second zone is closer to the monitor, activates buttons and other controls equivalent to for example the clicks of a mouse. It is located between the sensor and the computer monitor if it is used (Sutton, 2013).

Leap Motion is a device example that uses gestural interfaces and has drawn attention because of precision in recognizing movements. Financially, the cost of acquisition is more affordable than other devices, such as ASUS Xtion Motion Sensor, Microsoft Kinect (Xbox 360) - Win and I, MYO Armband (Thalmic Labs), Interactive Projections - GestureTek (wall, floor), Nintendo Wii (U), PlayStation Move-Eye (Sony) and Wisee: WiFi signals (Potter, Araullo & Carter, 2013), (Weichert, Bachmann, Rudak & Fisseler, 2013).

In addition, its physical dimensions are more comfortable to changing environments and transport for people with disabilities, also having a detection capability of your sensor more accurately than others in the market, focusing its motion capture system only on the hands (Shen, Luo, Wang, Wu & Zhou, 2014).

This device also has a set of applications that can be free or paid and are available in (Leapmotion, 2017), with the example of software to be recommended for use with children with DCD the Skywriting Alphabets, Floatmotion, BT Handwriting Free and Herbi Write About (Leapmotion, 2017).

When developing applications for Leap motion, you need to use SDK (Software Development Kit) of this tool and choose a framework with a programming language for development as e.g. C ++, C \ #, Unity (V2), Objective- C, Java, Python, JavaScript, and Unreal Motor Unit (Orion). The SDK offers two (02) options for data collection on the interface - the native and websocket. This creates web applications that contain a dynamic library for creating new applications (Bassily, Georgoulas, Guettler, Linner & Bock, 2014), (Seixas et al., 2015).

With these features, for example, the Leap motion can be interesting for children with DCD in literacy to enhance learning calligraphy training hand movements, also at work in the communication process, expression, interaction and storing digital actions through movements and kinesthetic movements performed in the air (Bachmann, Weichert & Rinkenauer, 2014), (Liu, Zhang, Rau, Choe & Gulrez, 2015).

The application being developed will contain e.g. calligraphy activities divided into modules that reinforce the learning of uppercase and lowercase letters, numbers, geometric shapes and symbols. It will be used during the process of literacy and literacy of children with DCD for later use similar procedures to (Becker, Mauer, Emer, Behar & Assumpção, 2014), also characterized as exploratory qualitative research.

III. Work / Method Proposal

To help teach and motivate calligraphy to children with DCD using gestural interfaces through devices without tactile contact, we propose a framework containing a set of guidelines for developing applications that potentially intervene in literacy steps and calligraphy of this target audience.

The guidelines in this framework propose a guide on how interfaces of applications should be implemented, facilitating the accessibility and systemized usability for people with DCD and allowing gestural interface technologies being used more safely.

As an example of technology that works with the recognition of fine hand movements, we recommend that software can be developed for Leap motion by virtue of its advantages listed in Section 3, taking into account the context of the subjects with this disorder, their needs and constraints, as well as being an inclusive solution for people with disabilities in general.

One can create applications for handwriting activities that reinforce learning uppercase and lowercase letters, numbers, geometric shapes and symbols in order to expedite learning for individuals with DCD. They will be used during the process of literacy and calligraphy of children with DCD, before teaching traditional methods for calligraphy, thus creating, for this classic methodology, training benefits and memorization as shapes, letters and numbers should be created through the practice of kinesthetic movement, making it intuitive.

For this, however, a good methodology and addressing ethical issues should be involved in the development of one or more applications that effectively promote calligraphy learning in children with DCD through appropriate gestural interfaces, facilitating educational calligraphy opportunities by way of such tools, in addition to being diverse and inclusive when considering the individuals involved.

This framework is therefore the starting point of the development of gestural interfaces for people with DCD on devices that consider fine motor hand movements, in addition to highlighting the need for further and new approaches to content analysis for this audience, its characteristics and meanings, using the concepts of accessibility and effectiveness of applications created, also launching other looks to promote calligraphy learning that gestural technologies offer and are thus challenging and thought-provoking.

Description of Framework

The proposed framework consists of 25 (twenty five) based guidelines in the Participatory Design Principles and User-Centered Design, highlighting the characteristics of children with DCD and being divided into 03 (three) main parts: Prototyping, Development and Evaluation, as in Figure 3.

Figure 3: Proposed Framework with the parts of Prototyping, Development and Evaluation. Source: Prepared by the author.

Prototyping aims to advance understanding of the needs of children with DCD in relation to calligraphy learning, acting as a set of guidelines that will guide the development of gestural interfaces effectively targeted at these subjects and being supported by the work of (Othman & Keay-Bright, 2010), (Placitelli & Gallo, 2012), (Othman & Keay-Bright, 2011), (Caro, Martínez-García, Tentori & Zavala-Ibarra, 2014) and (Caro, 2014) with regard to the understanding of user requirements for better system development, and therefore having a greater number of guidelines, fourteen (14), like the other steps of the framework, taking into account the part of planning with schematics of the product before it is generated (Dey, Abowd & Salber, 2001) and usability (Hall, 2001), (Still & Morris, 2010), reducing the chances of a bad design (Wiethoff, Schneider, Rohs, Butz & Greenberg, 2012).

The second stage, Development, has 07 (seven) guidelines related to the peculiar characteristics of the devices with recognition of fine movements, therefore, particularly for Leap motion, there are some hand formats to your SDK that need to be chosen. This step concentrates the guidelines that need to unite the demands of devices (Hand Size and Position, Hand Immersion, space between objects, Highlight Selected) with the needs of children with DCD for proper use (Realism, Encouragement and Ergonomics).

The evaluation phase has 4 (four) guidelines (Technologies Used, A Device for Children, Punctuation and General Checking) directed to carry out the assessment of the previous steps and guidelines by identifying the characteristics of children with DCD, the focused technology, interface obstacles/interaction between subjects and tools, also suitable alternatives of how adversity can affect the desired results, and finally the compliance check of the recommendations with the set (Prates & Barbosa, 2003).

Thus, the proposed guidelines are:

Prototyping:

P1. Fine Movement Applications: Consider relevant devices having feature recognition of fine motor movements centered on hands without tactile response, for example, Leap motion. These devices are relevant in a context where there are children with additional motor difficulties to normal, as with DCD, to help in the process of autonomy and security in calligraphy learning during school literacy (Nunes & Silveira, 2015a). These technological devices can be recommended for people with DCD before the traditional calligraphy learning process as it would help in the visual memory of the formation of letters by performing kinesthetic movements in the air (Sugden & Chambers, 1998), causing the child to stay focused on coordination, accuracy and dexterity needed for speedy writing motion and precision needed for calligraphy (Polatajko & Cantin, 2005), (Snapp-Childs, Casserly , Mon-Williams & Bingham, 2013);

P2. For Calligraphy: The application task should be directed to exercise the difficulties in learning calligraphy. For children with DCD, these difficulties are different and more pronounced. The child has difficulty in fine motor skills in writing letters, numbers, words and the difficulty of planning the route to get there (Kaiser, Albaret & Doudin, 2009), (Sudirman, Tabatabaey-Mashadi & Ariffin, 2011);

P3. Highlight Objectives: The objectives of each part of the software should be well explained and highlighted, focusing on a purpose to be achieved through the task of compliance (cognitive part) and the movements to be performed (motor part) because children with DCD have difficulty learning how to move the body and members (in this case: shoulder, elbow, wrist, hand and fingers) to perform writing and have to pay more attention to complete motor activities (Caro et al., 2014), (Caro, 2014), (Bo & Lee, 2013);

P4. Interaction: Provides the communication processes and application interaction for children with DCD by providing possibly real and interactive situations as they may be disinterested in some activities and avoid interactive processes with their peers or situations closer to their reality (Othman & Keay-Bright, 2011), (Zwicker, Missiuna, Harris & Boyd, 2012), (Gonsalves, Campbell, Jensen & Straker, 2015);

P5. Motivation: Promoting stimuli and encouragement by using animations, videos and sounds. The engagement and involvement of children in the task of compliance can increase their ability to exercise the cognitive and motor parts, making them more enjoyable and decreasing frustration. Animations, videos and sounds should be used with caution to avoid being interpreted as noise and stress. They should be fun and useful, providing opinions on actions, being used in times of transition or when nothing happens on the screen, because the fatigue and repeated failure to shares not carried out can cause them to not participate in the activities and present secondary emotional problems, such as low self-esteem, intolerance to frustration and demotivation (Magalhães, et al., 2011), (Tresser, 2012), (Mandich, Polatajko & Rodger, 2003);

P6. Levels and Transitions: Create very clear and defined transitions through easy levels without much difficulty from one level to another, showing a progress of tasks in cognitive and motor parts. Generally, children will perform the same number of tasks or task times and change, the next steps should be similar to previous so they are also executed many times and that children do not lose concentration, as children with DCD may experience problems with abrupt change, with much effort to plan and execute a task, showing in the lack of performance (Caro et al., 2014), (Missiuna, Moll, King, King & Law, 2007);

P7. Movements and Repetition: Focus on repetitiveness of movements in sequence. Help in learning new moves and consolidation of motor exercises, acting significantly with intervention therapists, and empower the subjects for future action, as children with DCD may have trouble learning a new motor skill and with repetition, some of these qualifications will be performed well and others poorly (Smits-Engelsman, Wilson, Westenberg & Duysens, 2003), (Jelsma, Geuze, Mombarg & Smits-Engelsman, 2014);

P8. Spatial, Visual and Body Motor Understanding: Promoting control of movements, posture, balance and hand-eye coordination (fine visual-motor), the child may feel the effects that each movement provides for the completion of a task, in addition to providing a space and visual understanding as a result of each body and motor movement, as children with DCD may have difficulty with activities with changes in body position and the custom to use vision as a feedback guide of their movements (Zwicker, Missiuna & Boyd, 2009), (Wilson, Ruddock, Smits-Engelsman, Polatajko & Blank, 2013), (Ferguson et al., 2014);

P9. Tasks: Create simple, short, easy to remember and intuitive tasks. This will help in achieving objectives, will serve as a stimulus for other steps and reduce frustration. For children with DCD, the maximum cognitive load they support is a little less than a child with a typical development, it is important to map out the shortest and most realistic term goals, leaving the most predictable environment possible (Caro, 2014), (Sugden & Chambers, 1998), (Sugden & Chambers, 2003);

P10. Accessible Navigability: Offer accessibility tools, promoting autonomy by offering buttons on the application interfaces, such as: go / back, left, pause / resume, internal search, location map, access the main menu, increase / source reduction , text size (if any), alignment, spacing, color manipulation, contrast, background. It is important to introduce and encourage the use of digital technologies with accessibility and usability features, so that children with DCD can be proficient and self-sufficient, and promote motivation for the implementation of activities (Othman & Keay-Bright, 2011), (Jacoby et al., 2006);

P11. Writing and Language: Be concise, clear and use plain words, avoiding problems of interpretation and giving time to understand the instructions to users, since according to its characteristics, children with DCD often spend more time to understand, complete an action and run the instructions. Emphasizing that they have to pay more attention to the implementation of activities than a typical child, requiring usually a longer response time and slower execution of tasks (Mandich et al., 2003), (Dewey, Kaplan, Crawford & Wilson, 2002), (Snapp-Childs, Mon-Williams & Bingham, 2013);

P12. Instructions and Help: Provide accurate and useful instructions in order to help avoid a lot of information. Create an emergency button/icon in case of questions. This type of resource can be a support for a better understanding of the task and benefits users with more severe levels of disorder or multiple disorders (comorbidity, or co-occurrence), for the child with DCD requires the description of each step to run the required gesture by activity, assisting in the planning of the movement (Wilson et al., 2013), (Smyth & Mason, 1997);

P13. Errors and Answers: Promote corrections by giving answers/tips throughout conversation, for example, about the possible misunderstanding of the user and how he can correct it by performing the right action, as children with DCD need appreciation throughout most of the activity, enforcing that effort is more important than ability (Poulsen & Ziviani, 2004), (Katartzi & Vlachopoulos, 2011);

P14. Design: Use simple and strictly functional designs for the general objective of the application, preventing anxiety and nervousness before the execution of a task so the subject is not distracted by visual elements without relevance to the context of the moment, as a child with DCD needs to focus on the objective of the activity and has no opportunity to be distracted (Mon-Williams, Wann & Pascal, 1999), (Visser, 2003), (Chen, Tsai, Biltz, Stoffregen & Wade, 2015).

Development:

D1. Hand Size and Position: Choose a hand model that is child friendly and in a position to provide a deep understanding of space with the use of 3D lighting and texture, in addition to position control and appropriate rotation (Garber, 2013), (Potter et al., 2013), (Adhikarla, Sodnik, Szolgay & Jakus, 2015). Choose the best hand and position format as hand movements may be limited, and as handwriting of children with DCD requires greater coordination of joints and limbs for the execution of the writing movements and, consequently, significantly more effort than with children with normal development ((Prunty, Barnett, Wilmut & Plumb, 2014);

D2. Immersion of Hands: Focus on the immersion of hands only while teaching calligraphy to children with DCD in literacy. It is recommended to not create an avatar of the whole body, which creates difficulties with gross motor skills, and can confuse the child and leave it devolved to keep the focus in the field of fine motor movements as writing involves constant understanding of feedback from the movement of the hands and children with DCD tend to disperse and become discouraged with other points of distraction (Kaiser et al., 2009), (Forsyth, Maciver, Howden, Owen & Shepherd, 2008), (Cantin, Ryan & Polatajko, 2014);

D3. Realism: Use the 1:1 Virtual Reality (VR) scale so that objects and virtual hands are most realistic and as natural as possible. Be as realistic as possible, it will help the child with DCD to work better in the environment of the activities, as they may have linked emotional problems and also frustration of the tasks or half of tasks are not close to the reality and discourage the use of digital technologies VR (Tresser, 2012), (Tarnanas et al., 2013), (Silva & Rodrigues, 2015);

D4. Space between Objects: Set a distance between objects (buttons, avatars) in the application, as well as providing a large comfortable click area, avoiding unwanted and accidental actions, as children with DCD tend to be more clumsy, resulting in difficulties in learning, behavior, emotional character and performance in new motor tasks (Celletti et al., 2015), (Smits-Engelsman, Jelsma, Ferguson & Geuze, 2015);

D5. Highlight of Selected / Selection: Enhancement through the selection of different lights or colours. Thus, users can differentiate what is being manipulated more prominently, as a child with DCD sometimes need tools that draw attention and arouse interest in activities, avoiding fatigue and dispersion (Weichert et al., 2013), (Robert et al., 2014);

D6. Encouragement: Use a layout with appropriate accessibility and usability features to encourage the tasks. A layout which promotes usage by children with varying degrees of impairment of DCD, because they need to properly exercise writing movements with speed and precision for calligraphy, along with feelings of fun, development of these skills, achieving success in the tasks, participation and interaction with the application (Silva & Rodrigues, 2015), (Ferguson, Jelsma, Jelsma & Smits-Engelsman, 2013), (Jarus et al., 2015);

D7. Ergonomics: Offer a comfortable hand positioning, being suitable for constant and repetitive use of fine motor movements, avoiding stress and discomfort, as for the child with DCD task performance is linked to comfort factors and fatigue, leading to demotivation for participate in motor activities, like calligraphy, which occur the early stages of transition and maturity in their implementation (Hsu et al., 2013), (Pauchot et al., 2015).

Evaluation:

E1. Technologies Used: Assess whether the application explains which technologies are used. It is important to inform the child with DCD on what is required with the use of fine movements technologies such as Leap motion and gestural interfaces in handwriting activities. That is, the child will know within reason which fine motor movements will be required to perform, helping the child to be aware of movement (Sudirman et al., 2011), (Souza, Prates & Barbosa, 1999), (Prates, Souza & Barbosa, 2000), (Thorvaldsen et al., 2011);

E2. An Application for Children: Check if an application for children is provided, as the disorder manifests itself differently in each child, and may also be accompanied by other disorders (comorbidity) (Visser, 2003), (Flapper & Schoemaker, 2013), (Kirby et al., 2014). Every application task should be focused on children with DCD, their needs, preferences and circumstances, and therefore customized (Caro et al., 2014), (Caro, 2014);

E3. Pointing: Find out whether a pointing process was used in all phases of the tasks in a way which encourages children with DCD to attain the objective, as they are accustomed to performing the same motor skills in achieving success or anticipate movements (Jelsma et al., 2014), (Ferguson et al., 2013), (Chang & Yu, 2010). If a mission is not fulfilled, redistribute the point spread or create a subscore to motivate constant repetitions, such as colour changes of score numbers.

E4. General Check: Pay attention to the proposed software for the child with DCD. Prove that all guidelines have been implemented, for example, if the application was able to keep the user's attention, if principles of ergonomics and usability were followed, it boosts motivation, if it observes the characteristics of applications which recognizes fine motor movements and directs activities for calligraphy learning (Weichert et al., 2013), (Jeffries, Miller, Wharton & Uyeda, 1991), (Nielsen, 1994), (Curtis, Ruijs, de Vries, Winters & Martens, 2009).

Moreover, according to Figure 3, we can verify there are connections between all phases of the framework, having the designer of gestural interfaces freely navigate through all stages, but with the observation that not all guidelines will necessarily be interrelated.

Prototyping is directly linked to development where a primary guideline may be reviewed when considering a second, being interconnected. This also presents itself in the stages of development and evaluation. In the first and last phase, prototyping and evaluation, this interconnection appears again because, after verification of the guidelines in the third stage, with the need for change in the prototype stage, this action can be performed directly, without the need to include the middle part.

In general, the framework with guidelines can be reviewed in Table 1.

Interconnections of the Guidelines between the Parties to the Framework:
As previously mentioned, there may be connections between the guidelines for each of the parts of the framework because of similarity of themes or because of implications of configuration and implementation. Thus, the appropriate descriptions and explanations are necessary.

For the stage of prototyping Table 2 was configured, showing the intra- and interconnections of each guideline presented. One can see that in the first line, the guideline P1 is directly linked to the theme of this work, that is, to work with devices that map the fine motor movements of a child with DCD, taking into account the guidelines related to the task target, calligraphy (P2), making it always with usability and accessibility features (P10), while also taking into consideration the type of hand (D1) to be chosen by the designer from the SDK, in this case, Leap motion. In addition to these guidelines, linked to the immersion of hands (D2), with the need for space between objects (D4) of the application to the correct handling of these children, due prominence to the selected items (D5) and appliance to the ergonomic criteria (D7) for this audience should also be taken into account. Regarding the evaluation guidelines to determine which technologies are used (E1) and a general verification process (E4) are related to the guideline that recommends the use in devices with tracking fine movements (P1).

Table 1: Summary framework proposed with its guidelines. Source: Prepared by the author.

	Prototyping
P1	Fine Movement Applications
P2	For Calligraphy
P3	Highlight Objectives
P4	Interaction
P5	Motivation
P6	Levels and Transitions
P7	Movements and Repetition
P8	Spatial, Visual and Body Motor Understanding
P9	Tasks
P10	Accessible Navigability
P11	Writing and Language
P12	Instructions and Help
P13	Errors and Answers
P14	Design
	Development
D1	Hand Size and Position
D2	Immersion of Hands
D3	Realism
D4	Space between Objects
D5	Highlight of Selected / Selection
D6	Encouragement
D7	Ergonomics
	Evaluation
E1	Technologies Used
E2	An Application for Children
E3	Pointing
E4	General Check

Related to the theme of calligraphy (P2) in the prototyping phase, we have the previous (P1) for manipulating fine movements tools and recommending the necessary emphasis of objectives (P3) application. In the second stage, one needs to check if the hands are handled properly (D2) and provide proper ergonomic positions (D7) for children with DCD.

Related to the theme of calligraphy (P2) in the prototyping phase, we have the previous (P1) for manipulating fine movements tools and recommending the necessary emphasis of objectives (P3) application. In the

second stage, one needs to check if the hands are handled properly (D2) and provide proper ergonomic positions (D7) for children with DCD.

Table 2: Connections of guidelines with prototyping. Source: Prepared by the author.

	Prototyping	Development	Evaluation
P1	P2, P10	D1, D2, D4, D5, D7	E1, E4
P2	P1, P3	D2, D7	E1, E4
P3	P2, P6, P8, P9, P11, P12, P14	-	E1, E3, E4
P4	P5	D3	E2, E4
P5	P4, P6, P7, P10	D2, D6	E1, E2, E3, E4
P6	P3, P5, P7	-	E3, E4
P7	P5, P6	D3, D6	E3, E4
P8	P3	D3, D7	E2, E4
P9	P3	D3, D6	E4
P10	P1, P5	D4, D6	E1, E4
P11	P3, P12	-	E4
P12	P3, P11, P13	-	E4
P13	P12	-	E4
P14	P3	D7	E4

In the case of the directive regarding the highlighting of the objectives (P3), it is directly related to the criteria of the type of task that directs the application created, in this case calligraphy (P2), if these tasks are divided into difficulty levels and if there are transitions (P6) if they promote activities that incorporate notions of space, visual and fine motor motion (P8), if the tasks help to meet the proposed objectives (P9) if the information is placed in an understandable way in writing and language (P11) to the subject of this investigation, if there are appropriate instructions and help tools (P12) for any user's needs and the design (P14) designed for application interface was appropriate for the context. On the part of Development, P3 is not directly related to any of their guidelines, as these seven (07) are not strictly connected to the fulfillment of tasks and due prominence of their goals. Finally in relation to the assessment, P3 checks whether the targeted objective receives the explanation of the technologies used (E1), have dealt scoring criteria (E3) and happened to proof of guidelines (E4).

The P4 relates to the promotion of interaction criteria for children with DCD and if there were incentives to motivate them (P5), taking into account environments closer to reality (D3), if there was only a tool for the child (E2) and if there is a check of recommendations (E4).

For the guideline that emphasizes the importance of motivation (P5) for the child with DCD, checking interactivity (P4) of the application and its interface should be essential, along with the need of levels and appropriate transitions (P6), the repetitiveness of actions and movements (P7), and the provision of usability benefits and accessibility for handling (P10). On the part of Development, one needs to check if the hands were included correctly (D2) and promote encouragement (D6) so that these children achieve the application objectives with its gestural interface. As evaluative process, the P5 connects with all (E1, E2, E3, E4) the criteria of that stage, since motivation is required in all of them.

The P6 guideline (Levels and Transitions) is linked to the objective (P3) of the application, motivational process (P5) and the need to promote repeated activities and hand motor movements (P7), not relating to any development criteria because these are more targeted to Leap motion and P6 is not. And recommendations to establish punctuation/pointing (E3) and its verification by the E4 are the items of evaluation of connected P6.

The recommendation on movements and repetition (P7) interconnects with the motivational (P5) and the need of levels and transitions (P6), it should focus on children with DCD and promoting their skills, for consolidation and learning new movements. Development, P7 highlights the convenience of close-to-realistic environments (D3) and situations for encouragement (D6) of these users in the calligraphy learning process. Regarding the assessment, the criteria relating to P7 are the same as the previous paragraph (E3, E4), therefore it is necessary to check whether there was accountability of punctuation to promote repetitiveness for children with DCD.

The promotion of controlled movements, posture, balance and fine visual-motor coordination (P8) is directly linked to the desired objective (P3) in addition to the availability of situations close to the daily life of children (D3) and provide repetitive movements (D7) for learning consolidation. Like the evaluative process, P8 interconnects the need to have an application for children (E2) and general verification (E4).

The guideline that emphasizes the creation of simple, short, easy to remember and intuitive tasks (P9) connects with the clarity of objectives (P3) that proposes the application and gestural interface development, at the level closest to the real environment (D3) and encouraging (D6) of children with DCD to perform the tasks proposed and is interconnected with a general assessment (E4) of the framework's recommendations.

The guideline P10 (Accessible Navigability) connects those that promote usability and accessibility criteria in applications like Leap motion (P1), with motivational characteristics (P5) to these users and act on the development with well-located objects (D4) in interfaces for selection without errors, along with the promotion of encouragement (D6) its proper use. P10 is also linked to the technology used (A1) and the general check (E4) during the evaluation.

Writing and Language (P11) is a guideline on the part of prototyping of the framework that relates to the manner in which the objectives (P3) are placed to reach the users, as well as being important for the provision of the terms of instructions and help (P12), without being directly linked to the development of recommendations, which refer to devices that implement fine motor movements, but which are evaluated in a general way (E4).

Instructions and Help (P12) connect to guidelines in highlighting of goals (P3), the way they communicate (P11) and providing tools for correction of errors and appropriate responses (P13) to children with DCD while using applications with gestural interfaces and does not bind to the development and only the general check (E4) in the evaluation phase.

The guideline dealing with the correction of errors through answers/tips (P13) interconnects to the one that adequately provides instructions and help

(P12) as they are antecedents and consequences to the prototyping understanding process, or to correct and need instructions, as users are new to the use of gestural interface application creation. Regarding the development phase, there are no interconnections because these recommendations are specifically directed to devices like Leap motion and are only linked to general verification (E4) of the Evaluation.

And finally, P14 (Design) relates to the display mode of the target (P3) to be achieved and the promotion of ergonomic criteria (D7), and a link with the general check (E4) in the evaluation phase, not having connections with Development for these are very specific to certain device types.

For the part of Development, was configured Table 3 describing the interconnections with other guidelines.

Table 3: Connections with development. Source: Prepared by the author.

	Prototyping	Development	Evaluation
D1	P1	D5	E4
D2	P1, P2, P5	D5	E1, E4
D3	P4, P7, P8, P9	D6	E4
D4	P1, P10	D5	E4
D5	P1	D1, D2, D4	E4
D6	P5, P7, P9, P10	D3, D7	E3, E4
D7	P1, P2, P8, P14	D6	E4

Initially, it had been the relationship between the directive that standardizes hand shape and position (D1) from SDK Leap Motion, specifically. It is also connected with the first of the Prototyping phase (P1), which recommends the development of applications with gestural interfaces for fine movement devices, taking into account the part of development which provides the highlight for the selected object (D5) at the interface with in order not to happen unwanted selections, plus there is a general check (E4) Evaluation.

The guideline D2 is the concentration of hands as a member to be recognized by the fine movement device (P1) for teaching handwriting (P2), so that children with DCD in the literacy process are constantly driven (P5), without the occurrence of unwanted Actions (D5) and being evaluated by the technologies used (E1) and a general analysis (E4).

The system to be developed and handled by the gestural interface must be the closest to everyday life (D3) of children targeted, having an interaction process (P4) through the promotion of repetitive movements (P7) for learning, giving spatial / visual notions and body / motor (P8) and creating simple and intuitive tasks (P9) to help in encouraging activities (D6) and having a broad investigation (E4) in the evaluation phase.

When setting up an appropriate distance between objects (D4), you need to check what the device recognition of fine motor movements is (P1) and their usability and accessibility requirements (P10) to properly highlight the selected objects (D5) to use, need to be extensively (E4) evaluated.

For the highlight of the selected objects (D5), this guideline connects to the type of fine motor movements device (P1) to be used, according to the type of hand (D1), how it will be placed (D2) and whether there will be adequate spacing of objects (D4) so that no errors occur and there is a general check (E4).

In D6 (encouragement), there is a systematic connection with the motivational part (P5) and promotion of movements that can be repetitive (P7) in fulfillment of intuitive tasks (P9) in appropriate accessibility and usability features (P10), through the need to take everyday situations (D3) and obedience to ergonomic criteria (D7), trying to check if scores have been placed (E3) and having a thorough investigation (E4).

And as the final specification, the need for a comfortable position of the hands (D7) for continuous and repetitive use, relates to the type of device (P1) to be used, the application function to be performed (P2) - Learning calligraphy, by promoting movements that give spatial sense / visual and body / motor (P8) and having a design (P14) functional for children with DCD, promoting an encouragement (D6) to participate in activities and being evaluated completely (E4).

In the third phase of the framework, evaluation, we have Table 4, in which the guideline that ascertains which technologies are handled (E1) relates to the part of Prototyping, which emphasizes the importance of using fine motor movements devices (P1) with appropriate gestural interfaces for calligraphy learning (P2) and clearly identifying the objectives (P3) to be achieved, accompanied by motivational processes (P5) for the use of common form/shape and accessible (P10) for children with DCD. Also, it interconnects with the recognition of hands (D2) in the development step and with a general examination (E4) of all recommendations.

The guideline that emphasizes the availability of a device per child (E2) connects, in the prototyping phase, the recommendations that preach the need for interactive processes (P4), those that promote motivation (P5) for children with DCD and provide movements that give spatial notions / visual and body /motor (P8) and show no connection with the development stage because of its specificity with technology and having connection with the general assessment (E4) of the guidelines.

Table 4: Connections with assessment. Source: Prepared by the author.

	Prototyping	Development	Evaluation
E1	P1, P2, P3, P5, P10	D2	E4
E2	P4, P5, P8	-	E4
E3	P3, P5, P6, P7	D6	E4
E4	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14	D2, D3, D4, D5, D6, D7	E1, E2, E3

Then the E3 recommends using a scoring process at each stage of the application tasks so happens the encouragement of children with DCD to achieve a goal to be highlighted (P3) being interconnected with motivational factors (P5) through the use of levels and transitions (P6) suitable for these children, in addition to promoting repeatability (P7) to learn new movements with encouragement processes (D6) and checkout (E4) if all were observed.

Finally, realize that the E4 guideline relates directly to all other guidelines, as it makes an overall assessment check, making sure that all recommendations have been met, ensuring a very detailed view of the entire framework.

Final Considerations

The literacy of children with the Developmental Coordination Disorder by the use of digital technologies in calligraphy education can be interesting with the development of applications that comply with the guiding guidelines for devices without tactile contact through appropriate gestural interfaces, so that they are mediating in the process and not a final, somewhat flexible and that presents itself as only a new look but also promote a new perspective of discovery, being interesting and dynamic, enriching education and with a multidisciplinary approach in its design.

This study therefore addresses concepts of Development Disorder Coordination and Human-Computer Interaction Principles and proposes a framework with a set of specific guidelines of software for the development of gestural interfaces aimed at calligraphy education to children with DCD. 25 guidelines and divided into 3 stages – prototyping, development and evaluation, this model takes into account the characteristics of this disorder and technologies that recognize fine movements – here Leap motion, making all the proposed guidelines respect each other and can support the creation of appropriate gestural interfaces to assist these children in this school phase.

For future works, we need the development of an application that meets the recommended guidelines using a Leap motion device and the evaluation of other handwriting recognition software and fine motor movements devices, verifying how the adhere to the guidelines proposed here from a set of validation points.

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