Computers in Human Behavior 27 (2011) 1129–1142

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

The effect of nonhuman's versus human's external regulation on children's speech use, manifested self-regulation, and satisfaction during learning tasks

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ARTICLE INFO

Article history:
Available online 22 January 2011

Keywords:
Zone of proximal development (ZPD)
Zone of children's motivation (ZCM)
Self-regulation learning (SRL)
Private speech (PS)
Thinking aloud (TA)
Isolated computer-based learning environment

ABSTRACT

Because of several analytical and methodological critiques on the findings and contexts of children's private speech (PS), self-regulation learning (SRL), and thinking aloud (TA), the present study was conducted to shed new light on the effect of the nonhuman's/computer's versus human's/teacher's intervention (C-Condition versus T-Condition) on young children's speech use, SRL, and satisfaction during learning tasks. Four developmental measurements with novel criteria were used to measure: (1) speech analysis, (3) SRL as a function of task level selection, (3) SRL as a function of task precision, and (4) a friendly-chat questionnaire to measure children's satisfaction. Two types of intervention (enacted versus verbal encouragement) were applied through computer-based learning environment and investigated by forty preschool children divided by their teachers between the two conditions equivalently. It was hypothesized that children who acted alone (C-Condition) were more PS productive, manifested higher SRL, task performance, and satisfaction. The results confirmed the hypothesis with no significant differential effect of the gender on performance, showed that the injudicious use of encouragement hindered the children's regulation behavior, and proved that PS and TA elicitation were fully different. However, the results were not confirmed Vygotsky's view and simultaneously not fully inline with Piaget's view of self-regulation development.

1. Introduction

The seminal research regarding the contemporary children's private speech (PS) began in 1920s with the early work of Vygotsky and Jean Piaget 1950s. Vygotsky viewed that PS is a function that directly connected to thought, problem solving, increases linearly with task difficulty and success, and represents a stage in the gradual internalisation of interpersonal linguistic exchanges whose final ontogenetic destination is inner speech or verbal thought. Vygotsky also believed that self-regulation learning (SRL) is *behavioral* appearing after and as a result of regulation by others in a specific task and promoted by external regulators.

Paradoxically, Piaget viewed PS as egocentric or immature and believed that SRL is promoted by giving children extensive opportunities to make choices and decisions, to make rules by which they will regulate themselves. Piaget also believed that SRL is *psychological* presented from early infancy in the child's equilibration of actions, regulation by others does not have to come before self-regulation in a specific task and argued that regulation by others hinders the development of self-regulation (Piaget, 1932).

Accordingly, the present study, which is a companion of our recent work (*citations removed for blind review and from the list of the References too*), was conducted to shed new light on the effect of the computer's external regulation, as a nonhuman external regulator, versus teacher's external regulation, as a human external regulator, on children's speech use, self-regulation as a function of task level selection and as a function in task precision, and children's satisfaction *during* learning tasks. This study has risen because of several analytical and methodological critiques in the literature still remain without remedy or even attempts that could lead to that remedy.

1.1. Analytical critiques on the current findings (Vygotskyian's versus Piagetian's research)

Vygotsky (1986) originally, introduced the term *inner speech* and Piaget (1932) used *egocentric speech* to refer to the concept of PS. The subsequent research, up to date and with no exception, are fully guided either by Vygotsky (e.g., Daugherty, White, & Manning, 1994; Deniz, 2004; Ericsson & Simon, 1993; Schunk, 1986; Stright, Neitzel, Sears, & Hoke-Sinex, 2001) or Piaget (e.g., Boekaerts & Corno, 2005; DeVries & Zan, 1992) with a major difference

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doi:10.1016/j.chb.2010.12.014

(if it can be seen as a difference) is that they used other alternatives to describe the concept of PS such as *self-verbalization* (Duncana & Cheyne, 2002), *self-directed speech* (Winsler, Fernyhough, McClaren, & Way, 2005), and, most recently, *self-talk* (Winsler, Manfra, & Diaz, 2007) without explaining why those alternatives. Ironically, all those alternatives refer, simply, to the children's overt speech to themselves during learning tasks as Vygotsky and Piaget already defined. In this context, it is expected to see new terms to describe the concept of PS but without any valuable or major changes that may lead, or at least inspire, the researchers to seriously think about a revolution in studying PS and SRL. In more specific language, *what valuable will be added with new terms of the same phenomenon more than confusing the readers and the researcher as well especially during searching the literature?*

Vygotsky's original prediction (Vygotsky, 1986, 1987) was that PS increases linearly with task difficulty that confirmed by the subsequent studies (e.g., Beaudichon, 1973; Behrend, Rosengren, & Perlmutter, 1992; Duncana & Pratt, 1997; Kohlberg, Yaeger, & Hjertholm, 1968) where other studies (e.g., Behrend, Rosengren, & Perlmutter, 1989; Fernyhough & Fradley, 2005) have bolstered the Vygotskyan principle (Vygotsky, 1987) of the so-called zone of proximal development (ZPD), that children's PS *only* occurs when the task is located within the range of their ability and will be less frequent or absent when the task is too difficult. One on hand, if all the given tasks are already located within the range of the child's ability, then, naturally, he does not need any kind of motivation to deal with those tasks individually because there will be no challenges the child faces that may increase/decrease his behavioral regulation during learning tasks. On the other hand, if all or some of the given tasks are higher than the child's ability, then he will be most probably, if not definitely, frustrated to continue.

Many studies have examined PS during reading/listening (Balamore & Wozniak, 1984; Goodman, 1981; Sokolov, 1972; Tinsley & Waters, 1982; Wozniak, 1975), and examined the effect of the verbal instructions (e.g., Frauenglass & Diaz, 1985; Lee, 1999; Müller, Zelazo, Hood, Leone, & Rohrer, 2004; Wozniak, 1972) on performance and found that when things have been given to children to verbalize to themselves, they were delayed longer when they have been given cues as in which time to speak compared with those children who have been given less and specific instructions and, therefore, the use of PS should have a positive effect on task performance. However, this conclusion was reached because empirical studies have not consistently uncovered a positive effect of PS on task performance (Frawley & Lantolf, 1986). Other studies (e.g., Berk & Spuhl, 1995; Fernyhough & Fradley, 2005; Lee, 1999; Winsler, Diaz, & Montero, 1997) have concluded that PS leads to task success and increased behavioural regulation while others (e.g., Bjorklund & Douglas, 1997; Gaskill & Diaz, 1991; Siegler & Stern, 1998; Winsler, Carlton, & Barry, 2000; Winsler, De Léon, Wallace, Carlton, & Willson-Quayle, 2003; Winsler, Diaz, Atencio, McCarthy, & Chabay, 2000; Winsler & Naglieri, 2003) have found that the relationship between PS and task success is indirect and have suggested that PS is not always linked with immediate gains in task performance and that children may use internalised forms of speech such as whispers and inaudible muttering.

1.2. Theoretical critiques on SRL and self-regulation's measurements

SRL has also been defined in several and different directions that differ from one study to another and from one area of knowledge to another based on the researchers background and perspective and has emerged not only as a multidisciplinary, but also as an interdisciplinary research (Agina, 2008). In philosophy the definition was based on self-control (e.g., Piaget, 1932), in psychology the definition was based on self-management (e.g., Schraw, 1994), in cognitive the definition was based on self-generated (e.g., Vygotsky, 1978), in motivational learning the definition was based on self-motivation (e.g., Berk & Winsler, 1995), and recently, a new definition of SRL in terms of computer-gaming has raised as the "learners' ability to direct their verbalization process and, simultaneously, monitoring their learning process's goals" (Agina & Kommers, 2008).

Some researches (e.g., Azevedo & Cromley, 2004; Butler & Cartier, 2005; Kramarski & Mevarech, 2003; Palincsar & Brown, 1984; Veenman, 2005) indicated that learners still have difficulties in behavioral regulation; students often do not realize that they should regulate their ideas, they do not know how to regulate productively, forge ahead without considering alternatives of their decisions, get bogged down in logistical details of their work, and focus on superficial measures of progress. Thus, students need support to identify effective ways to reflect on and regulate their ideas. Other researches (e.g., Palincsar & Brown, 1984; Pressley, 1986) indicated that, knowledge of SRL strategies is usually insufficient in promoting student achievement; students must be motivated to use the strategies, regulate their cognition and effort, understand what of cognitive strategies, and how and when to use strategies appropriately. Some researches (e.g., Patrick & Middleton, 2002; Puustinen & Pulkkinen, 2001) noticed that the empirical research has often been conducted using questionnaires and inventories designed to evaluate the central concepts of the models and that survey methods have produced significant advances in the understanding of SRL.

However, it has been demonstrated that self-report measures do not necessarily give a reliable picture of the SRL tactics students actually engage in Winsler, Abar, Feder, Schunn, and Rubio (2007). More naturalistic and empirically valid methods will certainly result in a more dynamic and diversified appreciation of the nature of the SRL phenomenon. Accordingly, it is a question that, *how can the survey methods, questionnaires, self-reports, or any other technique be used with young children?!* Although, some of the recent researches (e.g., Agina, 2008; Butler, 2002; Puustinen & Pulkkinen, 2001) have briefly formulated what the previous work of SRL concluded as an empirical research question "how learners become strategic decision makers rather than strategic planner", the answer remains challenged up to date.

1.3. Methodological critiques on the current self-regulation's contexts and settings

Many studies (e.g., Pintrich & De Groot, 1990; Pintrich et al., 1994; Schunk, 2005) have clarified the main complexities of SRL in the school contexts as the effects of which had to be determined to know how self-regulation occurred and, therefore, schools with children are complex places and much different from controlled laboratory settings with adults. A clear example of this complexity is seen in research on help seeking, which is an important self-regulation strategy whereas all students require assistance at times, to understand material, and when confused about what to do (Newman & Schwager, 1992). Seeking help from others (e.g., teachers, peers, and parents) seems like a natural response; yet wide individual differences occur in students' frequency, amount, and type of help seeking. These differences suggest a complex interplay between social and motivational factors.

Importantly, at both educational and controlled laboratory settings the researchers (e.g., Fernyhough & Fradley, 2005; Girbau, 2002; Muraven, 2010; Tang, Bartsch, & Nunez, 2007; Winsler et al., 2007), up to date, are still continuing to support their participants with explicit instructions before/during/after learning tasks to regulate themselves and prompt them to talk/act when they are silent for long periods. This external intervention was typically in the form of prior training on how to use the material, encourage-

ment through the external regulators to keep talking during the performance, or a questionnaire after the session. These practices are not recommended as they place artificial constraints on the situation, changes the cognitive processes and task activities required, and distort the natural spontaneous emergence of self-regulatory behavior (Daugherty et al., 1994). To be sure that the subjects actually report their mental states without distorting them (Bernardini, 1999), it is important that the subjects do not feel that they are taking part in a social interaction.

Remarkably, all the affordable studies (e.g., Fernyhough & Fradley, 2005; Tang et al., 2007; Winsler et al., 2007) still involve the external regulators to instruct and guide the participants before/during/after the experiment in which all of them still followed either Vygotsky's views or Piaget's views. On one hand, such external intervention, which is a form of social interaction, may influence children to verbalize their actual regulation behavior and direct their cognitive process towards undesirable verbalization. Precisely, this external regulation may cause children to divide their cognitive capacity between the present task and understating the external instructions, thereby forcing their cognitive process to work in different directions (i.e., towards a task focus process versus an external focus process), which is so-called extraneous cognitive load of learners that should be minimised during the learning process (Sweller, 1998).

On the other hand, the children's silence during task performance is also a cause for concern, especially for long time where the verbalization becomes invaluable and could lead to undesirable speech either. However, some researchers (e.g., Branch, 2000; Hoppmann, 2009; Stratman & Hamp-Lyons, 1994) have criticized the thinking aloud (TA) technique for the fact that TA and the limited capacity of memory hinder the participant's cognitive processes, thus affecting performance if the tasks involve a high cognitive load especially that the presence of the external regulator (Duncana & Cheyne, 2002), to a great extent, creates the problem of separating PS and TA verbalization from the undesirable speech.

When the external regulators, on one hand, interfere insufficiently to guide the participants, their verbal/nonverbal cues during the performance might result in an inappropriate level of verbalization in which their verbalization is, mostly, a feedback to the environment rather than to those instructions. On the other hand, when the external regulators interfere sufficiently the participants who were asked to think aloud, as part of a research method, will not talk to themselves *spontaneously* but, instead, because they have been instructed to do so. However, despite, many types of task feedback have been investigated (e.g., John Hattie & Timperley, 2007); too many theoretical critiques on the task feedback with young children still challenged (e.g., Gottfried, Fleming, & Gottfried, 1994; Kluger & DeNisi, 1996).

2. The present study

Unlike all the previous work, the present study was conducted to examine the effect of the teacher, as a human external regulator (T-Condition) versus computer's, as a nonhuman external regulator (C-Condition), on young children's speech use (task-related versus task-unrelated), manifest self-regulation (SRL as a function of task level selection versus SRL as a function of task precision), and children's satisfaction during learning tasks. Stated differently, the problem of the present study is to investigate the different effect of the nonhuman's versus human's external regulation on young children's behavioral regulation during learning tasks. The proposed methodology used two sequences of encouragement cues (enacted versus verbal), which were applied through special isolated, computer-based learning system that acts as a standalone learning environment (to our knowledge, this subject has not explored yet). Thus, the present study defined self-regulation as "the learners' ability to direct their verbalization process and, simultaneously, monitoring their learning process's goals" (cf. Agina & Kommers, 2008). The two proposed conditions (T-Condition versus C-condition) were investigated through the following research question and hypothesis:

- *Do children do better, worst or the same with their real teacher's, as a human external regulator (T-Condition), compared when they act alone with the computer, as a nonhuman external regulator (C-Condition), during learning tasks through the same computer-based learning system?*

Hypothesis:

- *During learning tasks through the computer-based learning system, children who act alone with computer, as a nonhuman external regulator (C-Condition), will outperform children who act with their real teacher, as a human external regulator (T-Condition) in the following: (A) producing more task-related than task-unrelated speech, (B) manifesting a higher degree of self-regulation during task performance, and (D) gaining a higher degree of satisfaction.*

3. Material and methods

3.1. Participants

The participants were 40 children (M_{age} = 5.6 years) from Al-Mustakbel preschool, which is one of the public preschools at the centre of Tripoli. The teachers distributed the children into two equivalent groups (C-Condition versus T-Condition) were each group involved 20 children (10 boys and 10 girls). All children spoke Libyan as their native language, which is a hybrid of Arabic and Italian and was also the language used by the stimulus material. The school medical records were revised for all the participants to mainly ensure that there is no sign for attention deficit hyperactivity disorder (ADHD) or similar challenges such as the autism spectrum disorders (ASD) or problems with hearing or vision.

3.2. The learning environment

The stimulus material was a computer-based edutainment program presented as an isolated, computer-based learning environment that does not require the child to have previous training and simultaneously prevents the intervention of human external regulators before/during (*only in the C-Condition*)/after learning tasks). It was specifically implemented for the present study, which is a part of an empirical and 'lengthily' research, to enable young children to talk and think while acting during learning tasks. In total, 20 tasks were selected among the developed tasks in close cooperation with various preschool teachers and based upon the children's daily classroom activities. The tasks were also evaluated by a number of children through a pilot investigation that involved 103 children and eventually revised by experts in teaching. The tasks were a collection of puzzles, numbers matching, social activates and picture-arrangement (Fig. 1) *exactly* as the children experienced in their classroom (as an effort to *avoid* children to seek help from the external regulators to understand the structure of the tasks during the actual experiment and to enable the game to act as a standalone learning environment).

3.2.1. The game progression

The progression of the game was based on two conceptual perspectives. The teachers first selected the tasks based on

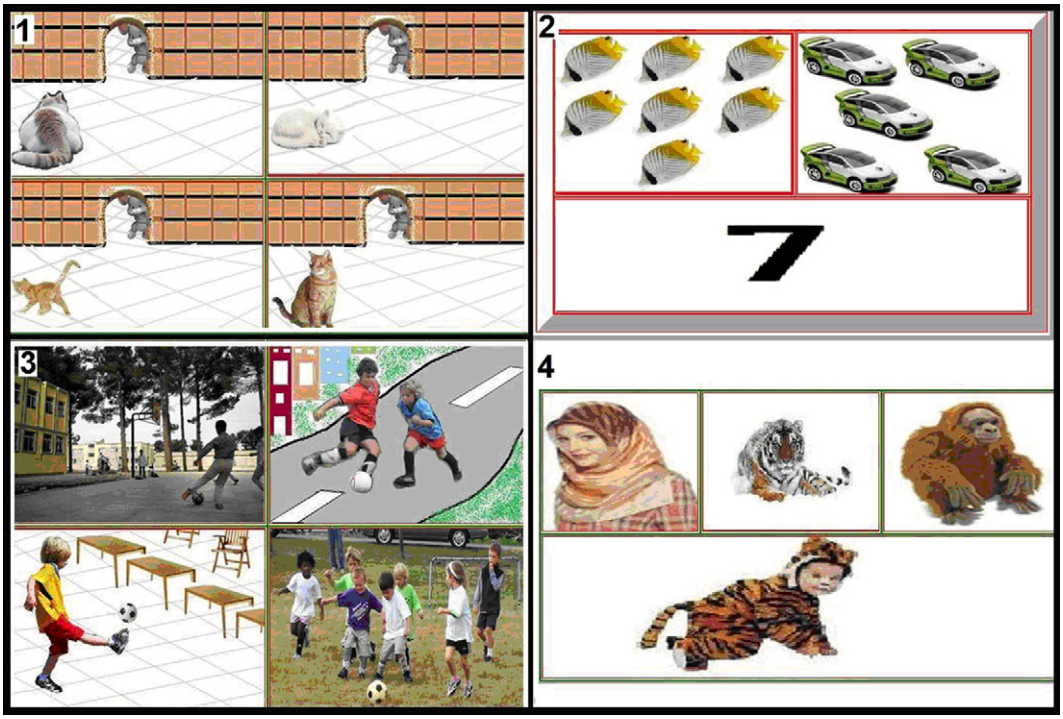

Fig. 1. Examples of motivated and unmotivated tasks.

Vygotsky's theory of the "zone of proximal development (ZPD)", which is "the difference between what children can achieve without help and what they can achieve with help" (Vygotsky, 1978) to classify each task as a simple/difficult. Second, they ordered the tasks based on the "zone of children's motivation (ZCM)", which is a new concept in the literature introduced only in our previous published work (*citations removed for blind review and from the list of the References too*) and defined as "the gap between self-motivated learning and the need to be motivated to learn". The ZCM was applied to classify each task as motivated/unmotivated for the child to interact. Accordingly, some tasks were identified as requiring little self-motivation despite the fact that they were classified as complex tasks (see pictures 1 and 3 in Fig. 1), and other tasks, despite being classified as simple (see pictures 2 and 4 at Fig. 1), required the child to be more self-motivated to interact. Thus, the ZCM had had to be applied because the game, per se, had have to be implemented to *exactly* fit the children's classroom learning process as an effort to avoid children to seek help from the external regulator or to produce undesirable cognitive processes.

Because no previous training was offered, as an effort to avoid any external interaction before the experiment, the game began with the instruction "*Touch the correct sign with your finger to start the game*" spoken first by the animated Princess and repeated by the animated Superman on a continual loop for 5 min or until the child reacted (Fig. 2). If the child did not react within 5 min, he ended the experiment.

An animated and musical introduction then prepared the child to engage and introduced the main stimuli of the game (Princess, Superman, time-line allotment and the bell, which was used by Superman to tell the child that the time allotted for the task had ended). After the child entered, the game introduced two additional simple tasks related to the child's gender (*"If you are a boy, touch the boy's picture, and if you are a girl, touch the girl's picture"*.) and child's favourite colour (*"touch your favourite colour"*) without mentioning the statement "*with your finger*" to ensure that

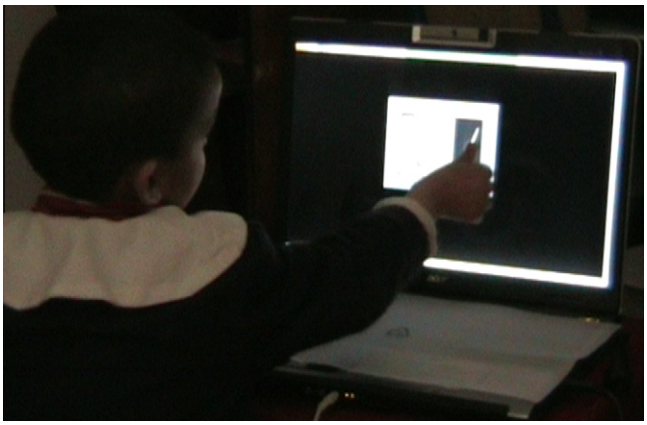

Fig. 2. Children start the game directly without previous training.

the child was perfectly able to point to the correct item using his finger and to warn the child to pay attention to the task allotment time. The child had had to react to each task within a minute; otherwise, he ended the experiment.

Specifically, the game allowed the children 60 s to choose the task level (more simple/difficult) and another 60 s to answer the task itself. This is the regular time given by the teachers at the school to the children to act/react and the game followed the same behavior to avoid children to bother because of the time. Before each task, the Princess asked the child to select (i.e., make a decision) about the next task level (more simple/difficult). Technically, the game introduced two boards at the middle of the screen (Fig. 3) while the Princess verbalized: "*Touch the green board for the easier task or the yellow board for the more difficult task*". After the child's reacted and answered the task, the game displayed the correct answer while the Princess verbalized it for 10 s and immediately the game introduced the screen of the next task level.

Fig. 3. Children select the next task level by one touch.

3.3. The experimental design

3.3.1. The verbal versus enacted encouragement cues (AMA-CUES)

For the sake of the clarity and simplicity, the name "AMA-CUES" used in the present research in which the external regulators (the teacher and computer) used it as the system to encourage children to make a decision about the task answer if they did not make it within the first 30 s of the task allotment time (see Appendix A). The teachers, who closely cooperated with the authors, developed the system "AMA-CUES" based on their experience. Technically, the first 30 s of the allotment task time (i.e., the enacted stage) was intentionally left without verbal encouragement cues because children usually need a time to regulate themselves to respond and, therefore, offering encouragement instantly may distort them to actually report their exact regulation behavior (as an effort to *exactly* follow what the teachers follow in the classroom that the encouragement cues should be *judiciously* used during learning tasks given the fact that 'silence' is the natural situation for children during learning tasks. However, despite this is a silent stage, the term 'enacted' appears more meaningful because the external regulator (teacher/computer) may or may not interfere '*silently*' and without verbal instructions to direct the children's attention to the computer screen. The teacher interfered by using her finger whenever the child tried to communicate (Fig. 4) while the computer only interfered once after 20 s and 10 s before the verbal stage begins by flashing the border of the task only once. The game expected that the child needs at least one enacted encouragement in case he did not answer the task within the first 20 s).

During the second part of the task allotment time (i.e., the verbal stage), the external regulator in both conditions (teacher/computer) was systemically interfered by verbalizing specific encouragement each 10 s to motivate children's self-regulation during task precision. However, as an effort to offer the freedom children need to select what they want with full free-will as they already experienced in their classroom, there were no verbal encouragement cues offered during the task level selection.

3.3.2. Scoring self-regulation as a function of task level selection (AMA-GUIDE)

For the sake of the clarity and simplicity, the name "AMA-GUIDE" used in the present research in which the computer used it as the system to find out how often did children apply the principles of the adequate SRL during the task level selection *in points*, that is; how much did children collect *points* during selecting the task level (see Appendix B). However, whatever the child decided to choose (simple/complex level), the game introduced the tasks in a sequence of simple, complex, simple, complex and so on and applied the "AMA-GUIDE" before introducing the actual task (Fig. 5) to measure children's self-regulation during the task level selection. However, if the child did not make any decision within allotment time of the task level selection (60 s), the game presented *the same task* and labelled it as a mid-level (*exactly* as the teachers followed in the classroom). Stated differently, in the actual experiment children were received the same task regardless of their preference (simple/difficult), although they were kept unaware of this fact and accordingly, the game applied the "AMA-GUIDE", which was essentially developed through a pilot investigation prior and updated through the trajectory of our empirical research and publications.

3.3.3. Scoring self-regulation as a function of task precision (AMA-SCORE)

For the sake of the clarity and simplicity, the name "AMA-SCORE" used in the present research in which the game used it as the system to find out how often did children regulate themselves to answer the task, that is; how much did children collect *points* during answering the current task (see Appendix C). Specifically, the game automatically applied "AMA-SCORE" to score the task performance as correct/incorrect for each task and related the final judgment of the task precision to the choice of task complexity level that the child already made before presenting the actual task and whether the childe received an encouragement or not (Fig. 6). If the child did not answer during the task allotment time (60 s), the game considered that as incorrect answer (*exactly* as the teachers followed in the classroom).

Fig. 4. The teacher's enacted encouragement during learning tasks.

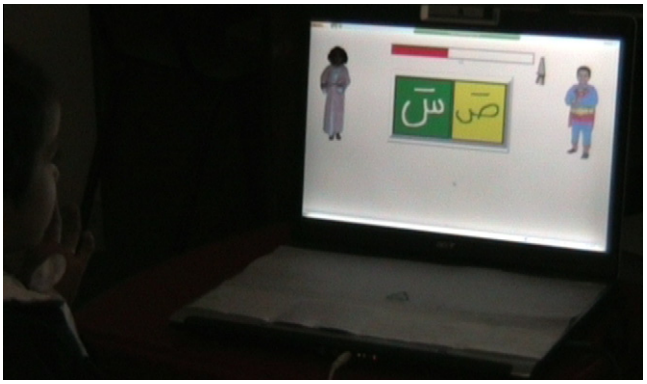

Fig. 5. Self-regulation learning as a function of task level selection.

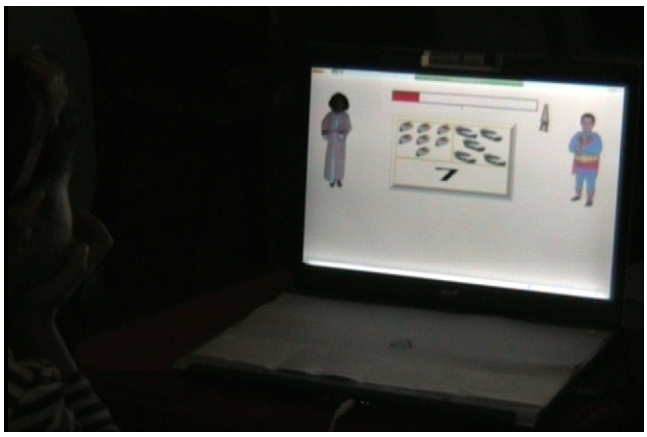

Fig. 6. Self-regulation learning as a function of task precision.

3.3.4. Measuring children's speech utterances

The children's task-related speech was differentiated and defined as any speech about the task, explanation/comments about the answer/question, or ongoing process (Winsler et al., 2005). However, only the short sentences (i.e., murmuring such as "*offfff*", "*aha*", "*wow*", '*Omm*' and so on, whispers, and inaudible lip movements) were also categorized as task-related speech utterances too. The children's task-unrelated speech was simply differentiated as any speech that was not classified as task-related (i.e., the speech about the computer, game, environment, classroom, teachers, or any other speech was not classified as task-related). The utterances of both speech types were counted and tabulated (see examples in Appendix D).

3.3.5. Scoring the children's satisfaction (AMA-CHAT)

For the sake of the clarity and simplicity, the name "AMA-CHAT" used in the present research in which the game used it as the friendly-chat questionnaire system to find out the extent the children were comfortable/satisfied during learning task. Stated differently, the game 'wanted' the children to evaluated it as a standalone learning environment through expressing their satisfaction during learning task by the computer with/without their teacher. Technically, to avoid the external intervention after the session, the game was attached with a friendly-chat questionnaire with the Princess and Superman that involved eight simple questions, which were developed with closely cooperation with the teachers, for the participants to describe their feelings (*satisfaction*). Superman opening the conversation by informing the child that he and the Princess would like to chat with him about the game because he (the participant) showed a high degree of intelligence and could help to improve the game (regardless of his actual achievement and as a motivation for the children to respond *exactly* as the teachers followed in the classroom). First, Superman asked the child whether he would like to chat with them by touching the correct/incorrect (agree/disagree) sign in the middle of the screen (Fig. 7).

If the child agreed, the Princess first told the child that whenever he did not understand the point, he should touch her or Superman once again to repeat the explanation. For the next question, Superman asked the child to touch the correct sign once again to chat with him about the game and when the child agreed, Superman explained *but not directly asked* the question (*exactly* as the teachers follow in the classroom) and warn the child to confirm his answer (agree/disagree) by touching the sign of agree/disagree represented by the common sign among children, as the teachers ensured, for the agreement and non-agreement (Fig. 8).

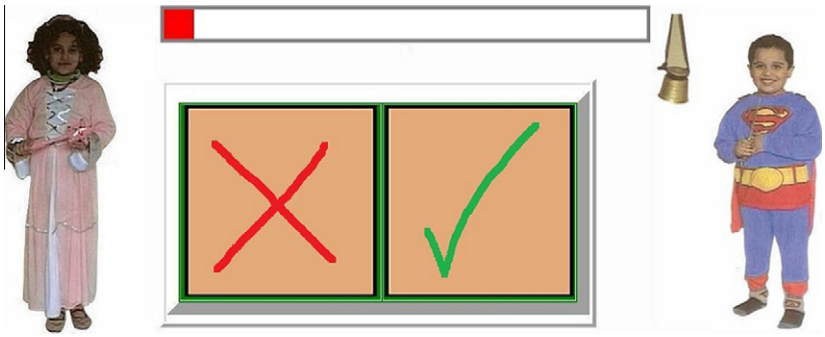

Fig. 7. The start of the friendly-chat questionnaire.

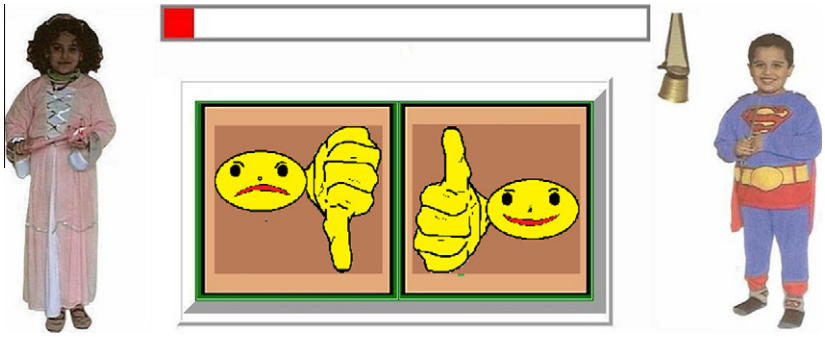

Fig. 8. The children's confirmation of the questionnaire's answers.

Fig. 9. The game's reward session.

When the child either declined to chat, finished the questionnaire, or the time reached 16 min, which was the allotment time to finish the questionnaire, the Princess moved the game to the reward session, which was the last session. Each child was rewarded with a piece of chocolate (Sinkers/Kinder-Surprise), which were the favourites among the participants as their teachers mentioned (Fig. 9). Finally, the Princess and Superman thanked the participant and informed him that he did a very nice job with high performance and told him that when the room light comes on, he will find the chosen chocolate with the teacher in the meeting room.

3.3.6. Data gathering

The game gathered data on factors such as the exact time the child started the game in milliseconds, the chosen task level, the actual task level, the level response-time in milliseconds, the task precision response-time in milliseconds, the degree of the manifested self-regulation during the task level selection generated by AMA-GUIDE, the degree of the manifested self-regulation during the task answer generated by AMA-SCORE, and the answers of the questionnaire generated by AMA-CHAT. For the sake of the accuracy, the video recording for all children was reviewed to ensure that children were acting perfectly till the end of the experiment.

3.4. Procedures

As any other preschool in Tripoli, there is a special experimental room ready for any experiment, which is usually located in a quiet corner, mostly, with the same equipments: a child-sized chair, an external touch-screen (17 in.)—used to avoid any possible coordination problems for the children—connected to a laptop computer with two hidden portable video cameras, and, therefore, it was easy to ask the school administration to order any other equipment. The first camera captured the entire environment, and the second offered a clear view of the task on the screen and the child's face. An extra small microphone was connected to the second camera for better audio recording.

Children, however, were kept unaware of the cameras and the microphone to avoid a problem of splitting attention that could lead to undesirable cognitive processes. Each child attended a 5 min welcome session in the meeting room but did not receive training on how to use the game. Instead, children were made aware that the game requires a smart player to complete the tasks and that the experimenter was only presented to watch their performance in order to reward them. Children were also made aware that neither their teacher nor the experimenter would know the answers. All sessions were held in the morning at 9:00 AM to avoid differences due to fatigue as the teachers recommended. The actual experiment ran with two children of each group per day (first two T-Condition children and then two C-Condition children) and the entire experiment required 10 days to accomplish.

4. Results

The initial research goal was to examine the effect of the nonhuman versus human external intervention on young children's use of speech (task-related versus task-unrelated), manifested self-regulation (SRL as a function of task level selection versus SRL as a function of task precision), and satisfaction during learning tasks through the computer-based learning environment. This was done by exploring the differential effect between the two types of instructional conditions, C-Condition (computer as a nonhuman external regulator) versus T-Condition (teacher as a human external regulator) in a laboratory condition.

4.1. The overall performance (the research question)

The research question addressed had to do with the difference in overall performance between the two conditions in terms of better, worst or the same on the C-Condition compared to the T-Condition. The effect of the C-Condition versus T-Condition on the scores for task performance related to task level (simple/complex/mid-level) and task precision (correct/incorrect) was performed by ANOVA. Despite the children under the T-Condition were faster in all responses than children under the C-Condition (Table 1), the ANOVA result revealed a significant condition effect, $F(3, 57) = 17.51$, $p < .01$, $\eta^2 = .06$, indicating—as expected—that children under C-Condition were outperforming children under T-Condition in overall performance (Tables 2 and 3).

4.2. The C-Condition produced more task-related than task-unrelated speech (Hypothesis A)

Table 2 showed that the most significant differences between the two conditions was the high contribution of children in C-Condition to increase the task-relevant speech and the high contribution of children in T-Condition to increase the task-unrelated speech that confirmed the hypothesis. However, the Kappa scores indicated fairly agreement between the two conditions ($\kappa > .30$) in speech productivity during the verbal unit and also fairly agreement between the two conditions ($\kappa > .30$) during the enacted unit.

Table 1
The children's responses in milliseconds as generated by the game, by condition.

Time needed to	C-Condition [*computer as a nonhuman's external regulator*] (*n* = 20)					T-Condition [*teacher as a human's external regulator*] (*n* = 20)				
	M	SD	Sum	Max	Min	*M*	SD	Sum	Max	Min
Start the game	*9832*	8697	3,932,836	57,981	551	*6227*	5954	2,484,719	35,641	870
Select the next task level	*12,125*	9953	4,850,206	70,345	389	*6329*	6006	2,525,431	35,641	672
Answer the current task	*11,791*	9586	4,716,720	57,666	413	*7448*	7517	2,971,826	65,798	773
Finish the questionnaire	*789,663*	422,029	315,865,371	8,864,643	456,543	*752,671*	118,237	301,068,502	957,660	395,789

Table 2
The effect of the external regulation on children's speech productivity, by condition.

Intensity of the speech utterances	C-Condition [*computer as a nonhuman's external regulator*] (*n* = 20)		T-Condition [*teacher as a human's external regulator*] (*n* = 20)	
	During enacted unit	During verbal unit	During enacted unit	During verbal unit
Task-related (*192 utterances: 58%*)	37 (*11%*)	79 (*24%*)	19 (*.06%*)	57 (*17%*)
Task-unrelated (*140 utterances: 42%*)	16 (*.05%*)	27 (*.08%*)	29 (*.08%*)	68 (*21%*)
Total (*332 utterances*)	53 (*16%*) 159 *utterances* (*48%*)	106 (*32%*)	48 (*14%*) 173 *utterances* (*52%*)	125 (*38%*)

Table 3
The effect of C-Condition versus T-Condition on children's self-regulation, by condition.

The manifested SRL during	C-Condition [*computer as a nonhuman's external regulator*] (*n* = 20)		T-Condition [*teacher as a human's external regulator*] (*n* = 20)	
	During enacted unit	During verbal unit	During enacted unit	During verbal unit
Task-related speech (*354 times – 60%*)	137 (*23%*)	41 (*.07%*)	81 (*14%*)	95 (*16%*)
Task-unrelated speech (*234 times – 40%*)	78 (*13%*)	57 (*10%*)	64 (*11%*)	35 (*.06%*)
Total (*588 times 100%*)	215 (*36%*) 313 (*53%*)	98 (*17%*)	145 (*25%*) 275 (*47%*)	130 (*22%*)

Table 4
The extent the children applied AMA-GUIDE as generated by the game, by group.

Principles	Occurrences [How often did children apply AMA-GUIDE?]		Amount of SRL [occurrence × principle-mark]	
	C-Condition (*n* = 20)	T-Condition (*n* = 20)	C-Condition (*n* = 20)	T-Condition (*n* = 20)
AMA-GUIDE [self-regulation as a function of task level selection]				
Principle-*4*	77 (*10%*)	41 (*.05%*)	308 (*23%*)	(*12%*)
Principle-*3*	96 (*12%*)	63 (*.08%*)	288 (*21%*)	189 (*14%*)
Principle-*2*	88 (*11%*)	53 (*.07%*)	176 (*13%*)	106 (*.08%*)
Principle-*1*	47 (*.06%*)	81 (*10%*)	47 (*.03%*)	81 (*.06%*)
Principle-*0*[a]	92 (*11%*)	162 (*20%*)	0	0
Total	400 (*50%*) 800 (*100%*)	400 (*50%*)	819 (*60%*) 1359 (*100%*)	540 (*40%*)

[a] The "Principle-0" indicates that the game was unable to understand all the occurrences of the children's behavioral regulation during the task level selection.

Table 5
The extent the children applied AMA-SCORE as generated by the game, by group.

Score	C-Condition [*computer as a nonhuman's external regulator*] (*n* = 20)				T-Condition [*teacher as a human's external regulator*] (*n* = 20)			
	Score's occurrences during		Amount of SRL during		Score's occurrences during		Amount of SRL during	
	Enacted	Verbal	Enacted	Verbal	Enacted	Verbal	Enacted	Verbal
AMA-SCORE (*self-regulation as a function of task precision*)								
Score-6	69 (*17%*)	14 (*.04%*)	414 (*22%*)	84 (*.04%*)	–	–	0	0
Score-5	36 (*.09%*)	29 (*.07%*)	180 (*10%*)	145 (*.08%*)	26 (*.06%*)	47 (*12%*)	130 (*.07%*)	235 (*13%*)
Score-4	13 (*.03%*)	10 (*.02%*)	52 (*.03%*)	40 (*.02%*)	–	–	0	0
Score-3	18 (*.04%*)	27 (*.07%*)	54 (*.03%*)	81 (*.04%*)	23 (*.06%*)	28 (*.07%*)	69 (*.04%*)	84 (*.05%*)
Score-2	31 (*.08%*)	0	62 (*.03%*)	0	46 (*11%*)	17 (*.04%*)	92 (*.05%*)	34 (*.02%*)
Score-1	37 (*10%*)	0	37 (*.02%*)	0	39 (*10%*)	29 (*.07%*)	39 (*.02%*)	29 (*.01%*)
Score-0	11 (*.03%*)	18 (*.04%*)	0	0	11 (*.03%*)	9 (*.02%*)	0	0
Total	215 (*54%*) 313 (*78%*)[a]	98 (*24%*)	799 (*43%*) 1149 (*61%*)	350 (*18%*)	145 (*36%*) 275 (*69%*)[a]	130 (*33%*)	330 (*18%*) 712 (*38%*)	382 (*21%*)

[a] The total of the occurrences indicates that the game was unable to understand all the occurrences of the children's behavioral regulation during task precision.

Table 6
The effect of the external regulators' intervention on children's satisfaction, by group.

The friendly-chat questionnaire during learning tasks with Princess and Superman (*to what extent did children feel comfortable during learning tasks with/without the external regulators* (*teacher* versus *computer*)*?*)	Children's reactions			
	C-Condition (n = 20)		T-Condition (n = 20)	
	Agree	Disagree	Agree	Disagree
(1) The game is easy to use	20 (*100%*)	–	14 (*70%*)	6 (*30%*)
(2) It is easy to select the task level	20 (*100%*)	–	17 (*85%*)	3 (*15%*)
(3) All tasks are difficult	1 (*5%*)	19 (*95%*)	5 (*25%*)	15 (*75%*)
(4) The task time is enough	17 (*85%*)	3 (*15%*)	11 (*55%*)	9 (*45%*)
(5) You will play this game once again	18 (*90%*)	2 (*10%*)	19 (*95%*)	1 (*5%*)
(6) You will recommend this game	20 (*100%*)	–	16 (*80%*)	4 (*20%*)
(7) You like this game	20 (*100%*)	–	19 (*95%*)	1 (*5%*)
(8) You want the teacher [*teacher's name*] to be with you to finish the tasks	2 (*10%*)	18 (*90%*)	7 (*35%*)	13 (*65%*)

4.3. The C-Condition manifested a higher degree of self-regulation (Hypothesis B)

4.3.1. Self-regulation as a function of task level selection

First, the game generated the result in frequency, proportion, and the *difference in points* that showed the extent the children in both condition applied the AMA-GUIDE during the task level selection. The result showed that children in the C-Condition were outperforming in manifesting self-regulation during the task level selection than children in the T-Condition (Table 4).

To statistically ensure this result, an ANOVA was performed, and after controlling the task level selection, the result revealed significant effect, $F(4, 75) = 9.55$, $p > .05$, $\eta^2 = .05$, indicating—*as expected and as the game generated*—that children in C-Condition were outperforming children in T-Condition in manifesting self-regulation as a function of the task level selection. Therefore, an ANCOVA was performed with the condition (boys versus girls) to determine the effect of the gender (as a covariant variable) on children manifested self-regulation as a function of the task level selection whereas the quantitative explanatory variables were the children's task level selection and children's age. The result revealed no significant condition effect for children in the C-Condition, $F(3, 13) = 1.60$, $p > .05$, as no significant condition effect for children in T-Condition, $F(5, 17) = 2.08$, $p > .05$ indicating that gender had no effect on the manifested self-regulation as a function of the task level selection. The correlation between the children's task level selection and applying AMA-GUIDE was ($r = .04$, *ns.*) among children in C-Condition and ($r = .02$, *ns.*) among children in the T-Condition. The Kappa scores indicated poor agreement ($\kappa < .20$) between children in C-Condition and T-Condition in applying each principle of AMA-GUIDE.

4.3.2. Self-regulation as a function of task precision

The game generated the result in frequency, proportion, and the *difference in points* that showed the extent the children in both condition applied the AMA-SCORE during the task precision. The results showed that children in C-Condition were also outperforming in manifesting self-regulation as a function of task precision than children in T-Condition (Table 5).

To statistically ensure this result, an ANOVA was performed, and after controlling the task precision, the result revealed a significant effect, $F(2, 31) = 8.47$, $p < .01$, $\eta^2 = .60$, indicating—*as expected and as the game generated*—that children in C-Condition were outperforming children in T-Condition in manifesting self-regulation as a function of task precision. The correlation between the children's task precision and applying AMA-SCORE was ($r = .02$, *ns.*) among children in C-Condition and ($r = .01$, *ns.*) in T-Condition. The Kappa scores indicated poor agreement ($\kappa < .20$) between children in C-Condition and T-Condition in applying each principles of AMA-SCORE. Because gender had no significant condition effect on the manifested self-regulation during the task level selection, there was no need to run it once again with the task precision because the result will be the same even if the numerical result is different.

4.4. The C-Condition showed a higher degree of satisfaction (Hypothesis C)

The game generated the result only in frequency and proportion for each question of the questionnaire (Table 6). Despite, the results showed that children in both condition showed different reactions, children in the C-Condition showed no complain (100%) to use the game, the selection of the task was definitely not complicated (100%), they liked the game (100%, and they recommended it (100%) indicating—as expected—that children in the C-Condition gained a higher degree of satisfaction than children in the T-Condition.

5. Discussion

The present study investigated the effect of the nonhuman's (computer) versus human's (teacher) external intervention on young children's speech use, manifested self-regulation, and satisfaction during learning tasks through an isolated, computer-based learning environment. Two different sequences of encouragement cues (enacted versus verbal) were proposed during learning tasks for the two different conditions, computer's intervention (C-Condition) versus teacher's intervention (T-Condition). In what follows, the aim is not to state the extent the results are consistent with the previous work as it reflects the extent the proposed measurements are consistent (reliability) and the strength of the results (validity).

5.1. The relation among ZPD, ZCM, and AMA-CUES

According to the fact that a child may be self-motivated already to act and react and the tasks are already implemented and ordered in the game based on the ZPD and ZCM respectively, the aim was to use the enacted and verbal encouragement cues *judiciously* through applying the AMA-CUES when it is thought to be necessary to motivate the child's cognitive process based on the fact that the use of the encouragement may also distort the child cognitive process to report his actual behavioral regulation and the fact that silent is the natural situation during learning tasks. This application is very obvious when comparing the

effect of the enacted versus verbal encouragement on children's speech use (Table 2) and self-regulation (Table 3), the manifested self-regulation as a function of task level selection (Table 4), and self-regulation as a function of task precision (Table 5). Accordingly, it is a question that why some children finished some tasks correctly, talked to themselves spontaneously, increase their behavioral regulation, and without receiving any encouragement? That is because embedding ZCM with ZPD through applying the enacted versus verbal stages helps children to control their behavioral regulation to distinguish their *spontaneous-talk* (i.e., task-related speech during the *enacting* stage, which is clearly pure thinking aloud verbalization because children talk to themselves spontaneously and without receiving any encouragement) from their private speech (i.e., task-related speech during the *verbal* stage, which is clearly pure private speech because children direct their speech despite they receiving encouragement) and the undesirable speech (i.e., task-unrelated) in which this conclusion is currently under deeply investigation.

However, the most significant obstacle in applying AMA-CUES with children in T-Condition is that when the teacher verbalized one of the encouragement cues, most of the children reacted to the teacher, mostly as a question, before answering the task itself and without consider the task allotment time (i.e., children do not consider the task allotment time when they talked to their teacher). This obstacle forced children in T-Condition to 'less-gained' the correct answers, which is a hard condition for the AMA-SCORE to apply the scores with the high marks, increase the selection of the mid-level, and produce more task-unrelated speech than children in C-Condition.

5.2. The relation among AMA-SCORE, AMA-GUIDE and AMA-CUES

Despite, children in C-Condition applied the "Principle-0" 92-times and children in T-Condition applied it 162-times respectively, the AMA-SCORE applied "Score-1" 37-times for children in C-Condition *only* at the enacted stage and 39-times and 29-times for children in the T-Condition at the enacted and verbal stages respectively. This result indicated that some children in both conditions do not make a choice about the task level, which is considered as a degree of self-regulation by AMA-SCORE through "Score-1". Although, this result implies the relationship between the AMA-GUIDE and AMA-SCORE as a measurement of self-regulation, it is also indicating that the game has to be upgraded to precisely determining which children did *intentionally* select the mid-level from which children did *unintentionally* did.

Therefore, neither "Score-6" nor "Score-4" the children in T-Condition apply where children in C-Condition apply both scores despite the low application of "Score-4" (13-times). The reason behind this result is that children in T-Condition either do not answer the task correctly or receive encouragement cues, which is a hard condition in both "Score-6" and "Score-4" to be applied by AMA-SCORE, that hinders their regulation behavior (be notified that the Scores 3, 4, 5, and 6 are only applied if the task's answer is correct). In contrast, some of children in C-Condition were fully able to act before receiving any encouragement cue in which the AMA-SCORE allowed the application of both "Score-6" and "Score-4" that allowed children in C-Condition to outperform children in the T-Condition. Furthermore, the relation between AMA-GUIDE, through "Principle-4" and "Principle-2", and AMA-SCORE, through "Score-6" and "Score-4" respectively, and the extent the children in T-Condition apply those principles (Table 4) and scores (Table 5) implies that those children in T-Condition already make a decision to accept the challenge to face the complex/simple level for all tasks, which is a hard condition to gain both "Score-6" and "Score-4" respectively, but they failed to do so because they already received encouragement cues in which the AMA-SCORE do not allow the application of both scores (i.e., the teacher's external regulation through the verbal encouragement hinders the children's self-regulation development, which is an injudicious intervention).

However, the application of both "Score-5" and "Score-3" by the AMA-SCORE for children in both conditions indicates that the judicious use of the encouragement during learning tasks increases, but never hinders, the children's behavioral regulation. While these results, on one hand, does not confirm Vygotsky's view that self-regulation is a result of external regulation, it is, on the other hand, not inline with Piaget's view that external intervention hinders the self-regulation development.

5.3. Implications of the results

Technically, the methodology used in the present study solves many problems/questions concerning the contexts and settings of self-regulation. First, the question how self-regulation occurs (e.g., Pintrich & De Groot, 1990; Pintrich et al., 1994; Schunk, 2005) during learning tasks and, therefore, how can self-regulation be calculated in points, which is a new concern raised by the present study, are now having clear answers and that is a result that has never seen before. Therefore, the complexity of students' seeking help (e.g., Newman & Schwager, 1992), which considers as an important self-regulation strategy in the previous work whereas all students require assistance at times, to understand material, and when confused about what to do, are also having clear answer and that is because of embedding the ZCM with ZPD in which children become able to control their behavioral regulation during learning tasks and this is very clear when comparing children in both conditions in terms of seeking help from the external regulators (computer versus teacher).

Practically, the results of the present study provide evidences that the nonhuman's external regulation has clearly different effect on children's behavioral regulation than the effect of the real human's external regulation (HOW?). This is very clear because children are more speech productive when they engage with a real human external regulator (i.e., their real teacher) while they are more actors during the task level selection and task precision when they engage with a nonhuman external regulator (i.e., computer). While this is very natural result because children already expected a feedback from their teacher during learning tasks in which their speech intensity becomes higher, it is really surprising, however, that the previous work still relates the children's speech productivity, self-regulation, and task performance to the task success/failure without realising the fact that the *context*, itself, of the external regulation and the *content* of the encouragement cues play the critical role for children's behavioral regulation during learning tasks.

Precisely, if children's speech productivity relates to the task success/failure as the previous work (e.g., 8, 22, 34, 63, 11, 25, 48, 60, 61, 62, 66) concluded that private speech increases linearly with task success, then how could we interpret the outperforming of children in T-Condition in speech productivity despite they already gain less successful tasks? Stated differently, despite, children in T-Condition are more speech productive, they do not outperform children in C-Condition in applying AMA-SCORE, which is already a computer agent that *basically* constructed on the task success (i.e., applying AMA-SCORE during the task precision indicates that the child gains more successful results). While this result, in turn, indicates that thinking increases self-regulation and talking decreases self-regulation during learning tasks, which is a result that has never seen before (see again Table 3), it is also does not confirm Vygotsky's view that

private speech increases linearly with task success as it does not confirm Piaget's view that the external regulation hinders SRL development.

From a technical and practical point of view, our investigation found that the mechanism of the proposed methodology, per se, does not allow Vygotsky's view, that self-regulation is a result of external regulation, to be confirmed as it does not allow Piaget's view, that external intervention hinders the self-regulation development, to be fully confirmed too. This, in turn, makes the results of the present study or any other AMA-based study to be mostly, if not totally, inconsistent with the previous work without the need to state that. Another very sensitive implication is that during reviewing the video recording we found that some children start talking before receiving any verbal cue either during the task level selection or during task precision, which is an actual and *pure* thinking aloud verbalization given the fact that thinking aloud occurs *spontaneously* and without any previous guidance for the participants to do so.

While this is a limitation of the present study because it does not precisely count that, it also leads to reinvestigate the use of the thinking aloud protocols with young children through the isolated, computer-based learning environment, which is currently under investigation through the question: how can young children be able to talk to themselves *spontaneously* without previous instruction to do so? Inline with that, although AMA-CUES, AMA-GUIDE and AMA-SCORES show higher performance than their original versions in our previous work (*citations removed for blind review and from the list of the References too*), some of the occurrences of the children's behavioral regulation are still fully ambiguous and unknown in which the game marks them as "*Otherwise, the game scored zero point*" (i.e., in terms of technical results, the game was not able to determine many occurrences of the children's behavioral regulation during task precision. See again the last row in Table 5). Therefore, the game still uses the "Principle-0" as an alternative behavior to avoid the computer, as a nonhuman external regulator, to hanging up during the task level selection (See again the occurrences of the "Principle-0" in Table 4). An obvious limitation is concerning the game ability to calculate the total of each child's regulation behavioral in each tasks given the fact that the game is currently able to generate the amount of self-regulation in points. In simple words, the game already holds all the data for each single child in each single tasks from task level selection until task precision, then, mathematically, the 'quantity' of self-regulation for each child in each task can be calculated in which the computer is still unable to make it. This clearly leads to call the power of the mathematical calculus to be used to solve this problem as it calls the power of embedding the technology of the computer artificial intelligent (AI) in order to enable the game not only to be fully conscious with all the occurrences of each child's behavioral regulation but also to exactly determining and *analysing* all the occurrences in a fashion way. This subject is currently our major topic under investigation through the question: how can the computer be conscious with all the child's behavioral regulation during learning tasks?

5.4. Conclusion

First, the future research should take into consideration that young children are able to monitor, control and increase their behavioral regulation during learning tasks even without the external intervention based on the stimulus material and methodology used. Inline with this conclusion, the present study is highly recommending the use of the learning environments that act as a standalone learning systems in studying children's speech use and manifested behavioral regulation. Second, based on *'the when'* and on *'the how'*, there are two types of the external intervention the researcher should take into consideration, judicious and injudicious, in which the first increases the development of children's behavioral regulation and the second hinders it. Third, self-regulation, per se, is different from one situation to another based on the given task the child is going to achieve (SRL as a function of task level selection versus SRL as a function of task precision). Forth, the present study invites the researchers in this area to seriously think about new methodological aspects and measurements that may lead to new ways of investigating children's speech use and self-regulation and to avoid introducing new terms of the same phenomenon (e.g., should we introduce the term *spontaneous-talk*, *self-speak* or they already introduced?!!!). The present study also invites the specialist in the area of AI to embed this technology in studying children's speech use and self-regulation that, in turn, may lead to a new revolution in this area.

Acknowledgments

We would like to thank the Libyan embassy in Belgium for funding this research. We also thank the preschool administration for all of their support, with very special thanks to the young heroes—the children—and their parents and teachers, whose cooperation and advice were invaluable.

Appendix A. "AMA-CUES" for verbal encouragement during task precision

The original utterance (*exactly as verbalized by Superman during the performance. The language is a hybrid of Libyan and Italian and written by Arabic letters*)	English translation (*the translation is based on the exact meaning but not on the word-to-word translation. So it can be presented in other words and context. However, the most important thing is the meaning of the original encouragement cues that should be clear in English*)	Verbalized at (*the external regulator was verbalized one of the three encouragement cues each 10 s*)
كانك مافهمتش السؤال مس الاميرة تو تعاودلك السؤال مرة ثانية	If you do not understand the question, touch the Princess and she will repeats the question once again	30 s
احني عارفين هذا السؤال صعب ولكن نعرفوا انك ذكي جداوبتجاوب السؤال	We know this is not easy question, but also we know you are very smart to answer it	40 s
احني مازال اررراجو في اجابتك	Still, we are waiting for your answer	50 s

Appendix B. "AMA-GUIDE" for scoring SRL as a function of task level selection

Principle-4
A child decides to continue with the complex task after he completed the previous task correctly. Thus the game scored four points
Principle-3
A child chooses a complex task after he completed the previous task correctly. Thus the game scored three points
Principle-2
A child decides to continue with the simple tasks after he completed the previous task incorrectly. Thus the game scored two points
Principle-1
A child chooses a simple task after he could not complete the previous task because of time. Thus the game scored one point
PRINCIPLE-0
Any other decision, including the mid-level selection, the child made is classified as inadequate self-regulation. Thus the game scored zero points

Appendix C. "AMA-SCORE" for scoring SRL as a function of task precision

Score 6: For the correct answer of the given task [simple/complex] *IF AND ONLY IF* the level choice of all the previous tasks was complex *AND* the child responded *WITHOUT* receiving any encouragement cue

Why? *Because the child already regulated himself to always give the correct answer through selecting the complex levels AND simultaneously accepted the challenge to face the complex tasks always and, therefore, without receiving any encouragement during learning task, which is naturally a high degree of SRL. Thus, the system scores six points.* ***Otherwise, the game scored zero point***

Score 5: For the correct answer of the given task [simple/complex] *IF AND ONLY IF* the level choice of all the previous tasks was complex *AND* the child responded *WITH* receiving encouragement cue(s)

Why? *Because the child already regulated himself to always give the correct answer through selecting the complex levels AND simultaneously accepted the challenge to face the complex tasks always but the child received encouragement cue(s) during learning task, which is naturally a degree of SRL. Thus, the system scores five points.* ***Otherwise, the game scored zero point***

Score 4: For the correct answer of the given task [simple/complex] *IF AND ONLY IF* the level choice of all the previous tasks was simple *AND* the child responded *WITHOUT* receiving any encouragement cue

Why? *Because the child already regulated himself to* always *give the correct answer through selecting the simple level intentionally AND simultaneously the child did not accept the challenge to face any complex task and child received encouragement cue(s) during learning tasks, which is naturally a high degree of SRL. Thus, the system scores four points.* ***Otherwise, the game scored zero point***

Score 3: For the correct answer of the given task [simple/complex] *IF AND ONLY IF* the level choice of all the previous tasks was simple *AND* the child responded *WITH* receiving encouragement cue(s)

Why? *Because the child already regulated himself to always give the correct answer through selecting the simple level intentionally AND simultaneously the child did not accept the challenge to face any complex task but with no encouragement during learning tasks, which is naturally a high degree of SRL. Thus, the system scores three points.* ***Otherwise, the game scored zero point****.*

Score 2: For the correct answer at the complex level and incorrect answer at the simple level *IF AND ONLY IF* the task level choice was a complex *AND* the previous answer was correct *AND* regardless receiving the encouragement cue(s)

Why? *Because the child already regulated himself to face a complex task based on the correct answer of the previous task, which is naturally requiring a high degree of self-regulation to make this decision, the incorrect answer of the simple task is ineffective on the child's manifested SRL. Thus, the game scored two points even if the current task is simple and the child's answer is incorrect.* ***Otherwise, the game scored zero point***

Score 1: For the mid-level *IF AND ONLY IF* the child answers the current task correctly *AND* regardless receiving the encouragement cue(s)

Why? *Because of the probability that a child may intentionally deselect the task level to examine what the game is going to present if he did not make a choice, which is a degree of SRL that hardly to be known during the performance (i.e., it is impossible to know whether the child was really followed that behavior or not). Thus, the game scored one point if the child's answer is correct regardless the task actual level (simple/complex).* ***Otherwise, the game scored zero point***

Reminder: The mid-level means that a child did not make a choice about the task level (more simple/difficult)

Score 0: For the correct answer at the simple level and incorrect answer at the complex level *IF AND ONLY IF* the task level choice was simple *AND* regardless the previous task precision AND regardless receiving the encouragement cue(s)

Why? *Because the simple task can be easily answered even with a low degree of SRL as it is a natural response to answer the complex task incorrectly even with a high degree of SRL. Thus, the game scored zero point*

Appendix D. Examples of task-related/unrelated utterances

The original utterance (*exactly as verbalized by children during the performance. The language is a hybrid of Libyan and Italian but not pure Arabic and written by Arabic letters*)	English translation (*the translation is based on the exact meaning but not on the word-to-word translation. During the stage of Data Gathering, the original utterances were used but not the translation*)
Task-related speech	
C-Condition	
لا. السؤال واضح	No. The question is clear
حتى اوككاني مش ذكي, الاجابة ساهلة	Even if I am not smart, the answer is easy.
و..وو...ووو	Wow... wow–wow... wow–wow–wow (*this utterance was verbalized as a song)*
T-Condition	
مافهمتش السؤال ومن غير مانمس الاميرة نعرف الاجابة	I do not understand the question and without touching the Princess, I know the answer
الاسئلة الصعبة بدت	The difficult questions begin
Task-unrelated speech	
C-Condition	
الاميرة صوتها حلو	The Princess's voice is sweet
تقدر اطير يا سوبرمان	Can you fly Superman?
لعبة حلوة هلبة	Very sweet game
T-Condition *(children were mostly directed their speech to the teachers and, mostly, as questions)*	
خيره الابلة ماترددش عليا؟	Why the teacher does not respond to me?
يالبلة هذا نفس الواجب وللا؟	Teacher: is this the same homework-task?
كانا ماتبيش ترددي عليا، خلليني بروحي	If you do not want to respond to me, then leave me alone
يالبلة، اجابتي هذه صح وللا غلط؟	Teacher: is my answer correct or incorrect?
هذا مش زي اللعبة اللي جابهالي بابا.	This is no the same game my dad brought to me
يالبلة. الاجابة هذي وللا هذي	Teacher: is this the answer or this one?

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