AN EXPERIMENTAL INVESTIGATION OF THE IMPACT OF TEACHING ON PSYCHOMOTOR TASK PERFORMANCE

by

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ABSTRACT

Training psychomotor procedural skills in organizations is an important task that typically includes lectures, demonstrations, discussion, and on-the-job training. Trainees might also benefit from teaching others what is learned during training. Research on learning by teaching is typically limited to academic settings; however, teaching about material may enhance the effectiveness of the controlled processing phase of skill acquisition. Enhanced effectiveness might come from increases in effort, social interaction, and expectancy effects. Experimental methods with a repeated measures design were used to compare time spent practicing an assembly task to time spent teaching about an assembly task. Results from this study indicated that there were no measurable differences in performance between those who spent time practicing the task and those who taught confederates about the task. Further studies are suggested to explore the lack of evidence for or against the research question.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I: INTRODUCTION

Psychomotor skills are physical skills and abilities that are utilized in a variety of work settings and fields (e.g. factory work, sports, military, aviation, driving, law enforcement, and surgical centers; Fadde, 2007; U.S. Department of Labor, 2014). Positions requiring psychomotor abilities often call for accuracy and speed with clear procedural skills in handling equipment, assembling products, and performing simple and complex tasks both alone and as part of a team. The application of training in these fields varies widely on issues of safety, expense, and time proficiency (Alessi & Trollip, 2001). The present study examines research as it might apply to skills common to factory line employees of assembly and fabricator type jobs. Such skills have typically been acquired through on-the-job training in which employees observe and learn from experienced job incumbents (U.S. Department of Labor, 2014).

This type of training in large organizations is often accompanied by formal orientation programs which may feature lectures, demonstrations, discussions, and practice (Goldstein, 2002). This training would traditionally be recorded with a checklist for completion and company records. A training checklist might include common features of the job such as the general safety protocols and the duties of several jobs in a job rotation (U.S. Department of Labor, 2014). For example, the first day of on-the-job training in a car factory might begin with how to place bolts on a car part within a certain time frame and secure them with an industrial bolt driver. On next day of training, the employee would move on to a different work station and learn a new task according to the training checklist. Extended periods of time may pass between when employees train on certain skills and when they use them;

nevertheless, employees need to recall the training details to perform the job well (Hodgson, Al Shehhi, & Al-Marzouqi, 2014). These types of simple psychomotor tasks may not require sophisticated skills, but accuracy and speed are still highly valued. For example, the average cost per minute of down-time on a production line in the auto industry was reported as more than $22,000, so a smooth training transition can contribute to line efficiency (LaFond, 2006). Consequently, quick mastery and long-term retention of skills is highly sought after to maintain competition in the market (Miller, 2014).

Determining what training is the best use of time is an important task in a time sensitive environment like business. To improve future training, results may be studied and improved by connecting hands-on training to developing theories of learning. Unfortunately, trainers and instructional designers may not always seek out scientific research and theories regarding learning and human performance. One of the most popular and understudied notions regarding learning is that teaching is the best form of learning (Letrud, 2012). Teaching as a form of learning has long been considered effective in the field of education and is now gaining traction on popular business websites like www.Businessinsider.com (Chase, Chin, Oppezzo, & Schwartz, 2009; Paul, 2013). Despite this popularity, it is unclear whether preparing to teach and teaching is the best use of the limited time in a training setting.

If teaching is considered such a valuable experience to learning then it is important to extend the current research on teaching and compare it to other forms of learning. By controlling for time spent and other confounds during training, this study addresses teaching as a form of learning for a psychomotor task (Chase et al., 2009).

The retention of psychomotor skills trained through conventional corporate methods may be improved with the inclusion of having an individual teach about what they have learned or practiced.

Such improvements may be possible through teaching's effect on the cognitive processing of psychomotor tasks. To be more specific, in a psychomotor task of assembling parts, teaching may produce several effects for the cognitive aspects of the assembly process. The question is whether these effects lead to better retention for an immediate or delayed use of the assembly skills and procedural knowledge involved in the task. Additionally, if teaching as a form of training is found to have an effect on psychomotor skill acquisition and retention, then it should also be determined whether teaching is a better use of time then more traditional methods of training.

The present study empirically examines the application of teaching as a form of learning to a basic psychomotor assembly task. Using experimental methods, this study will demonstrate whether teaching about a specific task assembly has a positive or negative effect on performing that specific assembly task in immediate and delayed retention testing of the task. In a task training that includes several forms of learning (video demonstration, walk through, practice time, instructions), a dedicated time for teaching another person will be substituted for a portion of the training practice to compare the effectiveness of time spent practicing and time spent teaching. To provide support for applying teaching methods to psychomotor training, this paper will address psychomotor research through a review on the two modes of psychomotor processing and the training of psychomotor skills. Additionally, the discussion will continue with a review of the research on teaching as a form of learning, social learning, and expectancy effects.

CHAPTER II: LITERATURE REVIEW

Psychomotor Research

Two modes of processing. If teaching could have an impact on learning psychomotor skills, then understanding what drives and controls psychomotor behavior is important. The empirical research on motor functions and the theory that describes it, dual processing theory, is well researched and documented by Shiffrin (1988) and several others (Bargh, 1992; Naatanen, 1992; Schneider, Pimm-Smith, & Worden, 1994). Duel processing theory suggests that psychomotor skills are characterized as either controlled or automatic, and acquiring new skills is the process of transitioning between the two (Schneider & Chein, 2003; Shiffrin & Schneider, 1977). Understanding the role of these processes may provide insight into how teaching might impact psychomotor skill acquisition.

In acquiring and using skills, each process has operational advantages and disadvantages. For instance, controlled processing is considered limited by an individual's general mental capacity and the amount and type of processing needed for a task (Ackerman, 1988; Fisk & Schneider, 1984). Controlled processing occurs as individuals focus their attention and develop strategies for performing the task (Ackerman, 1988). The beginning of skill development relies heavily on, "memory, reasoning, or knowledge retrieval" (Voelkle, Wittmann, & Ackermann, 2006, p. 305). However, attention and learning "limitations are balanced by the benefits deriving from the ease with which such processes may be set up, altered, and applied in novel situations for which automatic sequences have never been learned" (Schneider and Shiffrin, 1977, pp. 2–3).

Moreover, researchers have indicated that the nature of “controlled processing is slow, serial, effortful and brittle . . . can rapidly alter processing, can partially counter automatic processes, and speeds the development of automatic processing” (Schneider & Chein, 2003, p. 555). From what is understood of controlled processing, it’s anticipated that teaching may at least, to a small degree, enhance controlled processing through its impact on effort, organization, explanatory questioning, and other learning techniques that often occur as a natural process of teaching or preparing to teach (Chase et al., 2009; Chi,1994; Nestojko, Bui, Kornell, & Bjork, 2014). Such benefits may offset differences in general cognitive ability. More research on the impact of teaching will be addressed later in this review.

As for automatic processing, this study is not likely to observe fully automatic processing for any participant but some participants may experience partial automaticity due to their previous experience or ability to quickly acquire psychomotor skills. Therefore, automatic processing is reviewed to distinguish it from controlled processing and partially explain why individuals who practice more, in place of other learning activities, may perform better initially. Automatic processing is described by researchers stating that “Automaticity leads to fast, parallel, robust, low effort performance, but requires extended training, is difficult to control, and shows little memory modification” (Schneider & Chein, 2003, p. 554-555).

Moreover, automatic processing is likely to benefit less from teaching because it “operates through a relatively permanent set of associative connections” (Schneider & Shiffrin, 1977, p. 2). The permanent connections are described as a “special type of automated process that directs attention automatically to a target stimulus” (Schneider

& Chein, 2003, p. 527). One study described that skilled performers tended to look at more information-rich locations during the performance of a task than novices did during performance of the same task (Magill, 1988). This attention directing mechanism allows for quicker reaction times in response to a stimulus and less attention for sufficient performance of the task (Gupta & Schneider, 1991).

Consequently, high performers who are very experienced with assembly motions similar to a new task are less likely to benefit from training on that task because less attention and thinking is needed to perform the task (Ackerman, 1988). Therefore, research that involves psychomotor skill acquisition should control for any automatic processing that participants may use based on what experience they have with the skills required for the task. For example, in a psychomotor experiment on practice methods for assembling Legos, Stallings (2012) controlled for previous Lego experience by having participants indicate whether they played with Legos as children. This covariant accounted for participants who could build more quickly with fewer errors than than others due to the partial automatic processing they developed as children.

Once a skill becomes fast and accurate through developed automatic processing, minimal learning will take place during the task, and in fact extensive relearning is required if the primary motions are altered (Fisk & Schneider, 1984). In the example above, if the shape and snapping fit of Legos were altered by the toy maker, then it could be reasonably expected that experienced Lego builders would need time to readjust to the minimal motion changes needed for snapping objects together. If relearning is needed, it may be benefited by teaching even more than the initial learning because more cognitively controlled processing is required to unlearn the previous actions and then learn new ones (Fadde, 2010). In addition to exploring how teaching might affect the basic functioning of psychomotor learning, it is beneficial to determine how teaching might also overlap and add to commonly accepted psychomotor training principles.

Training psychomotor performance skills. For teaching to be considered a meaningful training method, it should be distinguished from widely accept principles of psychomotor learning. This is necessary because teaching may include a diversity of learning principles as an instinctual function of preparation and teaching (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). While some overlap can be expected between the effects of teaching and learning principles, teaching should contribute uniquely to the enhancement of learning apart from the learning principles or encourage basic principles in such a way that is unique to teaching. To further this discussion, a summary is taken from Fadde (2009) in which widely accepted psychomotor learning theories were expressed as learning principles for psychomotor skill acquisition:

1. Blocked practice for faster initial learning; spaced practice for better retention and transfer; decision practice for highly motivated learners.
2. Explicit instruction for faster initial learning; implicit instruction for better retention and transfer.
3. Internal focus of attention for initial learning; external focus of attention for more skilled performers.
4. Knowledge-of-performance feedback early in skill development; knowledge-of-results feedback later; fade feedback as skills develop.
5. Artificial simulation feedback early in learning; natural simulation feedback later in learning.
6. Constant, augmented feedback for initial learning, delayed augmented feedback (e.g., video) with more advanced learners.
7. Questioning by trainer to help advancing learners develop self-coaching.
8. Part-task drills to train recognition skills separate from motor skills. (p. 470).

In reviewing this list, there appears to be some commonalities between these principles and the current understanding of teaching. Regarding the first item on the timing and intention of practice, researchers have suggested that teachers often make use of distributed learning through the course of review and preparation for teaching (Cepeda et al., 2006). Thereby, any retention advantages of this habit may not necessarily be attributed to teaching but rather to our understanding of the encoding and recall process of distributed practice.

The other learning principles on this list may also occur naturally for a teacher during teaching or preparing to teach. Consequently, the benefits that these basic principles contribute to learning should not be misattributed to the effect of teaching. If teaching were to have an effect, it may come from cognitive and social processes as studies in the teaching literature would suggest (Chase et al., 2009; Ames, 1975). Cognitive processes may be able to enhance the learning of a psychomotor task during the controlled and semi-controlled phases of learning.

Teaching as a Form of Learning

General research on teaching. Early studies on teaching indicated superior retention rates for students who tutored compared to students who did not tutor after a month of delay; however, these studies were confounded by students taking turns being tutors (Cohen, Kulik, & Kulik, 1982; Heller & Fantuzzo, 1993; Rekurt, 1994.) The reciprocal act of peer tutoring as a form of teaching does not demonstrate the benefit of teaching clearly. Kuhl, Tsao, and Liu (2003) indicated that the benefits of socially contextualizing information are unclear if learning is confounded by distinctions between a social and non-social interaction (e.g. leading a group discussion in which those who take part increase the information exchange by adding to the discussion information that was unknown to the teacher/leader). Following this line of thought, Chi, Roy, and Hausmann (2008) specified that social learning without the social exchange of information may be similar to the process of self-explanation (e.g. explaining information to oneself) and other strategies that promote effective learning.

McKeachie et al. (1986) noted that teachers tend to identify key concepts, seek relationships among ideas and mentally organize information. Two recent studies with young students observed these behaviors in simulating teaching preparation versus solo learning on computers (Chase et al., 2009). Chase and colleagues utilized a computerized teaching simulation to remove the contamination of social information exchange. This computer simulation allowed participants to develop lesson maps and watch their digital learner, called a teaching agent (TA), seemingly use the prepared content to progress in a game show quiz. Additionally, a control group simply filled out the lesson maps to participate in the game show themselves. Both groups experienced the same program and participated in the game show.

The effectiveness of this computer program came from the study deception of researchers telling the participants that the TA was actually an avatar of a student in another room, although it was always a computer. Therefore, if participants did not prepare the lesson content for the TA, then they thought the other participant would perform poorly on the game show. The study results indicated what the researchers named the protégé effect, that is, “students make greater effort to learn for their TAs than they do for themselves” (Chase et al., 2009, p. 335). The effect is especially true for low achieving students.

Participants teaching a TA spent more time reading, constructing, and revising their lesson maps to organize the information even when the simulation offered other fun activities like chat features and games. The non-TA participants spent more time on the chat and games so the difference in effort was noticeable on the retention scores afterward. (Chase et al., 2009). While participants may be more willing to expend more effort (i.e., motivation), this evidence falls short in demonstrating the utility of teaching for anything other than motivation. The extra time that the TA students spent on organizing and preparing information might fully account for the increase in retention they experienced. The benefits of this study on teaching may also be examined in a social connection to learning the content.

Social learning. Research using simulated teaching software with 8^{th} graders reported participants felt responsibility for their TAs success (Biswas, Leelawong, Schwartz, Vye, & TAG-V, 2005). Such attributions of failure and success mirror descriptions of actual teachers blaming student failure on their own teaching (Ames, 1975). Chase et al. (2009) reported that the TA participants “were particularly attentive and emotionally responsive when their protégés failed, and they often expressed regret that they had not taught their TAs well enough. By occupying the unique social position of part self, part other, the TA incited motivation to work harder to learn” (p. 366).

Chase and her colleagues concluded that even though the information and experiences available to the students were similar, the belief of social interaction related to better learning outcomes (Chase et al., 2009).

This is in line with research on the brain's reward systems which suggests that rewards activate under the belief that an experience is social in order to ease the learning of new associations (Davachi, Mitchell, & Wagner, 2003). Furthermore, physiological increases in arousal measured in skin conductance have been demonstrated in participants when they believed they were interacting with human agents via a computer compared to when they were told it was only a computer (Blascovich et al., 2002). It was a computer in both cases, so this does suggest that social situations may have an effect on learning. In addition to social learning, the literature on teaching is closely connected to expectancy effects.

Expectancy effects. Some studies on this effect report that expecting to teach has positive effects on learning rather than expecting a test (Coleman, Brown, & Rivkin, 1997; Ehly, Keith, & Bratton, 1987; Fiorella & Mayer, 2013). Other studies have conflicting findings for this effect (Renkl, 1995; Ross & DiVesta, 1976). It is likely that expecting to teach triggers more questions, alertness, and self-explanation (Chi, 1994; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Roediger & Pyc, 2012). Nestojko et al., (2014) reported in a study on expecting to teach versus expecting a test that expecting to teach improved the amount of material freely recalled, the ability to identify the source of information, and performance on short answer questions.

Nestojko et al., (2014) suggested “that participants processed information differently, and more effectively, when they expected to teach than when they expected to take a test” (p.1044). Therefore, the combination of increased effort to teach another individual, social activation of learning mechanisms, and expectancy effects may have an effect when applied to psychomotor skill acquisition and performance for controlled processing. With the effects of teaching clearly demonstrated in other fields, the present study will apply teaching to psychomotor learning.

Present Study

The present study will attempt to expand the current understanding and application of teaching as a form of learning to the acquisition of psychomotor skills. The transition from controlled to automatic processing should be benefited by the effects of teaching in certain contexts (Hochmitz, 2011). These benefits would be separate from the overlap of teaching habits with commonly accepted training principles. The context in which cognitive enhancement of psychomotor learning may be beneficial is likely to be in delayed retention rather than immediate retention. This is because blocked practice allows for better initial training in which individuals can be somewhat less controlled in their execution of motor skills (Fadde, 2010). In other words, the more an individual practices, the more they will transfer knowledge into automatic processing. By design, this is expected to partially occur in the performance of this study’s participants. This is done to simulate the recall of training that did not fully transfer in a work setting.

In contrast to extra practice, teaching about a psychomotor task may provide superior long term retention due to the enhanced encoding of the psychomotor task through teaching focused cognitive processing, social learning, and expectancy effects (Davachi, Mitchell, & Wagner, 2003; Nestojko et al., 2014). These effects may allow for better encoding of the knowledge required during the controlled phase of the procedural task. It is expected that in delayed recall, those who spent more time practicing will recall less of the procedural knowledge and perform worse than teachers despite their initial advantage of automatic processing. In other words, a combination of automatic and controlled processing will perform better initially, but perform worse when the more difficult steps of the cognitive knowledge have been forgotten. Therefore, after an examination of psychomotor skills and the effects of learning through teaching, some conclusions can be drawn about the results of the present study.

Hypothesis 1. A practice-only training schedule will display superior immediate retention of psychomotor task performance.

Hypothesis 2. A practice and teaching training schedule will display superior delayed retention of psychomotor task performance.

CHAPTER III: METHODS

Participants

Six graduate students from a graduate level psychology program volunteered to participate in a pilot study. For the experimental study, participants were students recruited by several means from Middle Tennessee State University (MTSU). Students could sign up for the study to earn credit in their classes via the online research management system used at MTSU, Sona. For classes that were not offering Sona credit, the professor either directed the students to a link for the study sign up or the researcher was allowed to give a two minute pitch to the class about signing up. Many time slots were available for the first session of the two part study. Participants also signed up for a follow-up session four weeks after the first session.

Participants were assigned to either a practice only condition (n = 23) or a practice and teaching condition (n = 23) based on the study session time slot they signed up for. See Table 1 for demographic information. The first session was an hour long training and assessment session with a maximum of four participants. The follow-up session was twenty minutes long and only assessed the participants' retained skills and knowledge. Compensation for the study included a drawing for one $25 gift card to a random participant as well as class credit for participation. The amount of credit earned varied between participating professors and the standard hourly rate on Sona. Reminder emails and texts were sent out during the week and day of the first and second sessions scheduled for each participant. A scheduled research room was used for both sessions, and three additional rooms were utilized as needed for the teaching condition.

Table 1.

Sample Characteristics

Variable	*n*
Age	
18-23	32
24-30	8
31+	4
Missing	2
Gender	
Male	18
Female	28
Year in School	
Freshman	7
Sophomore	9
Junior	13
Senior	13
Graduate	4
How often Participants Played with Legos as Children	
Never	10
Rarely	9
Sometimes	13
Often	10
Frequently	4

N = 46

Materials

Participants were provided with a 32 piece Lego Speed Boat in a plastic bag. The Lego boat was designed with 34 pieces; however, two wedge shaped pieces were omitted from the assembly task. Lego construction was chosen for the study task because it demonstrates psychomotor assembly skill as well as a subset of procedural skills. A seven minute video DVD made by the researcher on assembling a Lego boat with a demonstration and voice-over explanation was used to walk participants through the boat assembly. Each session took place in a scheduled room on campus where a TV and DVD player were provided. Official Lego instructions with pictures were provided to participants during the practice periods. The researcher added typed tips onto the Lego instructions for any needed assembly clarification. Stop watches were provided to participants for the use of tracking their time if they finished the assembly task before the time limit. Forms concerning participant information, study instructions, and questionnaires were provided to participants as well.

Measures

The assembly time and accuracy of assembling Lego Boats were recorded during specific assembly tasks. These assembly tasks took place during two sessions: an immediate assembly session and a delayed assembly session four weeks later. The immediate assembly session included two timed practice tasks and the delayed session included three timed practice tasks. The assembly tasks required participants to build an errorless boat as quickly as they could. No more than a minute and forty five seconds was allowed for boat assembly, at which time boats were assessed for errors. An error on the boat assembly task was defined as a misplaced or unplaced Lego piece. The number of errors and the number of seconds finished before the time limit were compared between the conditions and across the assembly tasks. Several pre and post assembly questions were administered to the participants to control for individual differences between participants as well as gain insight into the learning processes during training. See Appendices C and D for questionnaire details.

Procedures

Pilot study. A pilot study was conducted with graduate students from the Industrial and Organizational Psychology Master's Program at MTSU in order to determine the amount of task mastery that participants could be expected to achieve in order to be capable of teaching the assembly task to someone else. If participants were not adequately trained on the task then variance in participants' scores is likely to be based on general cognitive ability rather than the manipulated conditions. Additional confounding factors considered during the pilot included the amount of individual practice time, video quality, paper instruction quality, and space for boat assembly. Only an immediate assembly session with no more than six participants was used to assess these factors.

The questionnaire content and confederate interaction were also assessed for development from the pilot. Evaluating the insight provided from the pilot questionnaire allowed researchers to rephrase or replace some questions that were meant to be exploratory for the purpose of future research. Questionnaire items which provided little insight were removed from the questionnaire. The confederate training materials were also determined based on the response of the graduate participants. The materials were aimed at teaching confederates to be apathetic learners for the participants. See Appendix E for Confederate Training details.

Experimental study. Participants experienced either a practice or teaching training schedule depending on which condition their session was assigned to by the researcher. Sessions were assigned to a condition based on confederate availability. They were not informed of the alternate condition until the end of the study. The training schedule was the independent variable and the participants' ability to assemble the speed boat with speed and accuracy were the dependent variables. Participants in both training schedules experienced an immediate assembly session and a delayed assembly session. These two sessions were held four weeks apart. Data were collected on the assembly task performances from both sessions.

Immediate assembly session. When participants arrived at their scheduled session, they were greeted by the researcher and asked to fill out an informed consent form, see Appendix B. Participants were then provided with an Immediate Assembly Packet containing instructions, participant information, and a questionnaire, see Appendix C. There were two different packets provided during this session depending on which condition the participant was a part of, packet A (practice condition) or packet B (teaching condition). Participants were not informed of the training differences between packets A and packet B in order to avoid treatment contamination and demand characteristics. The instructions provided to participants outlined the training schedule and directions for the immediate assembly session. See Table 2 for the training schedule.

Table 2.

Training Schedule for the Practice (A) and Teaching (B) Conditions

A	Video Walkthrough	Practice	Assembly task 1	**Practice**	Assembly task 2	Questionnaire
B	Video Walkthrough	Practice	Assembly task 1	**Participant Teaches**	Assembly task 2	Questionnaire

After the training schedule and assembly task, instructions were explained from the packet and the researcher began a DVD which demonstrated how to assemble the Lego boat according to the criterion expected for the assembly task. After the demonstration of building the boat according to criterion, participants were provided with disassembled boat pieces in a plastic bag. They then assembled the boat along with the video and voice over in a slower five minute walkthrough. After the video walkthrough assembly, participants were given a copy of the Lego Boat instructions, see Appendix F for an example of the type of paper instructions provided to participants. With these instructions participants began their ten minute practice period. To maintain consistency no feedback regarding errors was provided during the practice condition. After this ten minute period, all participants were asked to disassemble what progress they had on their boats and get ready to start the first assembly task. Participants were then asked to start a stopwatch at the beginning of the assembly task and stop the watch if they finished the task before the one minute and forty five second mark. All those who were unable to finish within the time limit were asked to stop so that all boats could be assessed for errors. Assembly errors and times were recorded on the information pack. The number of errors was made was available to the participants but not where the errors were made.

After this assembly task, all participants in the practice condition session remained in the primary study room and practiced their boat assembly for an additional ten minutes with the printed instructions. In contrast, all participants in a teaching condition session were asked to move into a separate room where several confederates were waiting to be taught by participants for ten minutes with the printed instructions. Using several study rooms reduced possible interference among participants. The confederates were volunteers from the MTSU graduate students from the Industrial and Organizational Psychology Master's Program at MTSU as well as one undergraduate. The confederates participated in the training process by acting as apathetic learners for whom the teaching condition participants could instruct on building a Lego boat. Confederates would arrive twenty five minutes after a teaching condition session began, and they would only participate in the portion of the study that involved participants teaching them how to assemble the boat. The confederates were trained prior to the study session to interact with participants according to specific directions on how to respond to or assemble with participants if necessary. See Appendix E for Confederate Training details.

After the second study period for both conditions, participants then experienced the second assembly performance task in the primary study room. At the conclusion of this task, the participants' assembly errors and times were recorded. Participants then filled out their participant information form as well as their Immediate Assembly Questionnaire found in their packet.

Delayed assembly session. Four weeks after a participant's first session, they returned to perform three consecutive boat assembly tasks with the same guidelines and measures as the previous session. Refresher training, paper instructions, and practice time was not provided prior to the assembly tasks. Participants' boat assembly errors and times were recorded in the delayed assembly packet, see Appendix D, and the participants were given the Delayed Assembly Questionnaire.

After completing the questionnaire, participants were then asked to read and sign a debriefing document. The debriefing document explained the purpose and methods of the study that were omitted on the consent form. The researcher then answered any questions that participants had about the study.

CHAPTER IV: RESULTS

Two multivariate two-way repeated measures ANCOVAs with between and within variables were used to compare the mean error rates and assembly times for the Lego Speed Boat between two training conditions (practice, teaching) and across five assembly tasks (two tasks during the first session and three tasks in the second session). The amount of time that participants finished before the time limit is represented in seconds with higher numbers indicating that they finished faster (seconds finished before one minute and forty five seconds). The frequency of how often participants played with Legos as a child (from 1 - never to 5 - frequently) was co-varied with the dependent variables to control for an individual participant's skill with Legos. A familywise alpha of .05 was used.

The ANCOVA for errors made indicated that errors differed across the five assembly tasks, Wilks's F (4, 40) = 5.95, p = .001. However, errors were similar across the training conditions, Wilks's F (1, 43) = 0.021, MSE = 183.20, p = .89. The training conditions effect was also similar across the assembly tasks, Wilks's F (4, 40) = 0.46, p = .77. See Tables 3 and 4 for descriptive statistics on the immediate and delayed retention sessions for error rates. See Table 5 for Sidak comparisons of errors across assembly tasks.

Table 3.

Mean Errors for Training Conditions and Assembly Tasks in the Immediate Retention Session

Condition	Assembly Tasks	Mean	Standard Deviation
Practice	Assembly 1	10.65	8.61
	Assembly 2	7.00	7.56
Teaching	Assembly 1	10.83	8.07
	Assembly 2	7.04	8.47

n = 23 per Training Condition.

Table 4.

Mean Errors on Boat Assembly for Training Conditions and Assembly Tasks in the Delayed Retention Session

Condition	Assembly Tasks	Mean	Standard Deviation
Practice	Assembly 3	21.65	6.27
	Assembly 4	17.09	7.88
	Assembly 5	15.17	8.20
Teaching	Assembly 3	21.43	5.26
	Assembly 4	15.78	7.39
	Assembly 5	13.83	5.06

n = 23 per Training Condition.

Table 5.

Sidak Comparisons for Training Mean Errors across Assembly Tasks for Both Conditions

Assembly Task Number		Mean Difference	95% CI	
(I)	(J)	(I-J)	Lower Bound	Upper Bound
1	2	3.71*	1.61	5.82
	3	10.80*	-13.94	-7.67
	4	5.70*	-8.47	-2.93
	5	3.76*	-6.66	-.865
2	3	14.52*	-17.84	-11.21
	4	9.41*	-12.23	-6.59
	5	7.48*	-10.48	-4.48
3	4	5.11*	2.91	7.31
	5	7.04*	4.40	9.69
4	5	1.94	-.03	3.90

*significant based on a familywise alpha = .05

The ANCOVA for assembly times indicated that the time taken to build the boat was similar across the five assembly tasks, Wilks's F (4, 40) = 0.96, p = .44. Assembly times were also similar across the two training conditions, Wilks's F (1, 43) = 0.93, *MSE* = 41.30, p = .34. The training conditions effect was also similar across the assembly tasks, Wilks's F (4, 40) = 1.64, p = .18. See Tables 6 and 7 for descriptive statistics on the immediate and delayed retention sessions for assembly time.

Table 6.

Mean Assembly Time in Seconds Finished Before the Time Limit for Training Conditions and Assembly Tasks in the Immediate Retention Session

Condition	Assembly Tasks	Mean	Standard Deviation
Practice	Assembly 1	2.13	5.10
	Assembly 2	6.74	10.27
Teaching	Assembly 1	1.91	5.54
	Assembly 2	3.52	5.41

n = 23 per Training Condition.

Table 7.

Mean Assembly Time in Seconds Finished Before the Time Limit for Training Conditions and Assembly Tasks in the Delayed Retention Session

Condition	Assembly Tasks	Mean	Standard Deviation
Practice	Assembly 3	0.13	0.63
	Assembly 4	0.00	0.00
	Assembly 5	1.26	4.35
Teaching	Assembly 3	0.00	0.00
	Assembly 4	0.00	0.00
	Assembly 5	1.13	3.94

n = 23 per Training Condition.

CHAPTER V: DISCUSSION

General Findings

Results from this study indicated that the immediate and delayed retention of a psychomotor task performance does not differ whether time is spent teaching or practicing the task. There was no significant difference in performance between the conditions in terms of how many errors were made on building the boats or the amount time used to build the boats. There were differences in the errors made between assembly tasks 1 through 5, which demonstrated that participants did improve on the assembly task as well as perform worse in subsequent tasks thirty days later. There were no differences in the time used to build the boats across assembly times 1 through 5 due to lack of variance. A floor effect limited variance because most people could not fully complete their boat in the prescribed time limit.

Implications

Although significance did not support the research hypotheses, it is interesting to note that the practice condition participants did not have superior performance to the teaching condition. If it was the case that performance improvement was not experienced among the participants then a lack of difference between the conditions could be attributed to a floor effect in which none of the participants learned enough to compare training methods. This was not the case which means that there must be an alternative explanation for why no difference in performance was observed between the conditions. Generally speaking, variance was very high among all of the assembly tasks. This made attaining a significant result very difficult.

One possibility is that both conditions learned the task sufficiently enough so that differences could not be noticed by this methodology; however, differences might have been found between the conditions if larger sample sizes and more flexible methodological controls were used. The flexible controls will be addressed with the study limitations. Another possibility could be that although the two conditions experienced different activities, (one practicing and the other teaching a confederate how to build the boat) each method contributed to learning enough in both a psychomotor and cognitive aspect so they progressed together.

It is even more interesting that performance differences based on expectancy effects were not observed between conditions. With the same amount of practice and preparation time between conditions prior to assembly task one, the teaching condition should have outperformed the practice condition. Expectancy effects should have led to better preparation and performance because the teaching participants knew that they were going to teach the confederates after the assembly task. According to previous research, the expectancy effects should have allowed participants to process information differently and more effectively but the research is also conflicting on this point (Nestojko et al., 2014). An explanation for the similarity in performance on this task could be that expectancy effects have their limitations of application as research would suggest (Fiorella & Mayer, 2013). Perhaps the psychomotor task was not complex enough to trigger the kind of questioning needed for enhanced learning.

An additional unexpected result was that the practice condition did not outperform the teaching condition in the second assembly task. The practice condition had more time to build and rebuild the boat while the teaching condition often demonstrated and then encouraged the confederate to build the boat. According to the current understanding of psychomotor principles, the practice condition participants should have had superior performance from their additional blocked practice (Fadde, 2010). It is possible that the activity differences between the conditions was not varied enough and that the proper method of teaching should have been more explicit. It could be concluded that while teaching is not superior to only practicing, it is not an inferior use of time when used together. Perhaps teaching could indicate more positive or negative results in another type of task involving only cognitive performance.

Limitations

The first limitation in this study was the insufficient sample size of only twenty three participants in each condition. This may have contributed to the large variance in errors relative to the number of errors possible during the task. The large error variance was another limitation caused in part by the method of scoring the boat task. Initial pilot testing and previous research suggested that measuring assembly errors would be time consuming but relatively straight forward (Stallings, 2012). Previous research had used Lego building in a psychomotor task as well but the focus on the further developed transition from controlled to automatic skill processing in that study allowed for a different approach to the testing (Stallings, 2012). Once the current study began, there appeared to be many unanticipated permutations of how participants could error in assembling the boat. One misplaced piece could offset several other pieces so that two participants with very similar looking boats could have very different error scores.

Moreover, the current methodological design did not indicate to participants where errors have been made on their boats, and by not indicating error, subtle mistakes in boat assemblies persisted across a participant's assembly tasks unless the participant corrected it themselves. To improve the scoring mechanics, a more complex yet flexible error assessment guide should have been designed in advance to allow for individual blocks to be misplaced while not affecting all the other blocks around them. A flexible error accountancy method may have also increased participant learning and investment in the task because a participant is presumably more likely to try and correct two errors on a boat task rather than seven.

A final limitation was the floor effect experienced with the time variable. The time limit was imposed on the Lego task in order to encourage the partial development processing in a controlled manner to processing automatically (Ackerman, 1988). While many participants did not assembly the boat perfectly, they could have still transferred what they know into automatic processing via practice. Again, the previous research and brief pilot testing with graduate students did not apply well to current methodology of this study and the undergraduate population at Middle Tennessee State University (Stallings, 2012). Apparently, more time was needed to complete the task; however, too much time would have removed the need for the development of psychomotor skill expected to complete the task. More mastery before beginning the task would have likely addressed the floor effect.

Future Research

The current study did not yield the anticipated results; however, future studies may be more successful in addressing the unexpected findings noted in the general findings section about expectancy effects and block practice. Moreover, results may be more evident by overcoming the limitations of the current study. Finally, research on psychomotor skills is well developed but the effectiveness of learning by teaching is still limited in is application. If possible, a framework should be developed for what constitutes teaching and what might influence effective teaching. Research could address this by applying teaching tasks to different types of knowledge acquisition such as nonsense tasks or cognitive tasks outside of free recall testing. Once basic assumptions can be made, more complex ideas like the increased effort for others, known as the protégé effect, can possibly be formed into a model.

Conclusion

Teaching is widely regarded as an effective learning mechanism for the teacher; however, it is not commonly utilized in psychomotor training and skill development (Chase et al. 2009). This mismatch of common perception and common practice should be addressed. This study attempted to address the effectiveness of teaching and practice to acquire a psychomotor skill as compared to only practicing. Teaching was expected to be superior to a practice only method in delayed retention performance but not immediate retention performance. While either method did not outperform the other in this study, future research may be more compelling. The effectiveness of teaching to aid in learning psychomotor skills remains to be demonstrated or dismissed as a possibility.

REFERENCES

Ackerman, P. L. (1988). Determinants of individual differences during skill acquisition: Cognitive abilities and information processing. *Journal of Experimental Psychology: General, 117*(3), 288-318. doi:10.1037//0096-3445.117.3.288

Alessi, S., & Trollip, S. (2001). *Multimedia for learning: Methods and development.* Boston: Allyn and Bacon.

Ames, R. (1975). Teachers' attributions of responsibility: Some unexpected nondefensive effects. *Journal of Educational Psychology*, *67*(5), 668-676. doi:10.1037/0022-0663.67.5.668

Biswas, G., Leelawong, K., Schwartz, D., Vye, N., & The Teachable Agents Group at Vande. (2005). Learning by teaching: A new agent paradigm for educational software. *Applied Artificial Intelligence*, *19*(3-4), 363-392. doi:10.1080/08839510590910200

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry*, *13*(2), 103-124. doi:10.1207/s15327965pli1302_01

Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. *Psychological Bulletin*, *132*(3), 354-380. doi:10.1037/0033-2909.132.3.354

Chase, C. C., Chin, D. B., Oppezzo, M. A., & Schwartz, D. L. (2009). Teachable agents and the protégé effect: Increasing the effort towards learning. *Journal* *of Science Education and Technology, 18*(4), 334-352. doi:10.1007/s10956-009-9180-4

Chi, M. (1994). Eliciting self-explanations improves understanding. *Cognitive Science, 18*(3), 439-477. doi:10.1016/0364-0213(94)90016-7

Chi, M., Roy, M., & Hausmann, R. (2008). Observing tutorial dialogues collaboratively: Insights about human tutoring effectiveness from vicarious learning. *Cognitive Science: A Multidisciplinary Journal, 32*(2), 301-341. doi:10.1080/03640210701863396

Cohen, P. A., Kulik, J. A., & Kulik, C. C. (1982). Educational outcomes of tutoring: A meta-analysis of findings. *American Educational Research Journal, 19*(2), 237-248. doi:10.3102/00028312019002237

Coleman, E. B., Brown, A. L., & Rivkin, I. D. (1997). The effect of instructional explanations on learning from scientific texts. *Journal of the Learning Sciences, 6*(4), 347-365. doi:10.1207/s15327809jls0604_1

Davachi, L., Mitchell, J. P., & Wagner, A. D. (2003). Multiple routes to memory: Distinct medial temporal lobe processes build item and source memories. *Proceedings of the National Academy of Sciences, 100*(4), 2157-2162. doi:10.1073/pnas.0337195100

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*(1), 4-58. doi:10.1177/1529100612453266

Ehly, S., Keith, T. Z., & Bratton, B. (1987). The benefits of tutoring: An exploration of expectancy and outcomes. *Contemporary Educational Psychology*, *12*(2), 131-134. doi:10.1016/s0361-476x(87)80046-2

Fadde, P. J. (2007). Instructional design for advanced learners: Training recognition skills to hasten expertise. *Educational Technology Research and Development*, *57*(3), 359-376. doi:10.1007/s11423-007-9046-5

Fadde, P. J. (2009). Training complex psychomotor performance skills. In K. H. Silber & W. R. Foshay (Eds.), *Handbook of improving performance in the workplace* (2nd ed.). Retrieved from http://peterfadde.com/Research/Psychomotor-chapter14.pdf

Fiorella, L., & Mayer, R. E. (2013). The relative benefits of learning by teaching and teaching expectancy. *Contemporary Educational Psychology, 38*(4), 281-288. doi:10.1016/j.cedpsych.2013.06.001

Fisk, A. D., & Schneider, W. (1984). Memory as a function of attention, level of processing, and automatization. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *10*(2), 181-197. doi:10.1037//0278-7393.10.2.181

Goldstein, I. L., & Ford, J. K. (2002). *Training in organizations: Needs assessment, development, and evaluation (4th ed.)*. Belmont, CA, US: Wadsworth/Thomson Learning.

Gupta, P., & Schneider, W. (1991). Attention, automaticity, and priority learning. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society,* (pp. 534–539). Hillsdale, NJ: Lawrence Erlbaum. Retrieved from http://www2.psychology.uiowa.edu/faculty/gupta/pdf/gupta.cogsci91.attention.pdf

Heller, L. K. & Fantuzzo J. W. (1993). Reciprocal peer tutoring and parent partnership: Does parent involvement make a difference? *School Psychology Review, 22*(3), 517-534.

Hochmitz, I., & Yuviler-Gavish, N. (2011). Physical fidelity versus cognitive fidelity training in procedural skills acquisition. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 53*(5), 489-501. doi:10.1177/0018720811412777

Hodgson, S., Shehhi, M. A., & Al-Marzouqi, E. (2014). The effect of job rotation on employees in organizations in the UAE. *Middle East Journal of Business MEJB, 9*(3), 35-44. doi:10.5742/mejb.2014.92509

Kuhl, P. K., Tsao, F., & Liu, H. (2003). Foreign-language experience in infancy: Effects of short-term exposure and social interaction on phonetic learning. *Proceedings of the National Academy of Sciences, 100*(15), 9096-9101. doi:10.1073/pnas.1532872100

LaFond, A. (2006, March 29). The $22,000-per-minute manufacturing problem [Web log post]. Retrieved from http://www.manufacturing.net/articles/2006/03/the-22000-per-minute-manufacturing-problem

Letrud, K. (2012). A rebuttal of NTL Institute's Learning Pyramid. *Education, 133*(1), 117-124.

Magill, R. A. (1998). Knowledge is more than we can talk about: Implicit learning in motor skill acquisition. *Research Quarterly for Exercise and Sport, 69*(2), 104-110. doi:10.1080/02701367.1998.10607676

McKeachie, W. J., Pintrich, P. R., Lin, Y. G., & Smith, D. (1986). *Teaching and learning in the college classroom: A review of the research literature*. Ann Arbor, MI: The Regents of the University of Michigan.

Miller, L. (2014). 2014 State of the industry report: Spending on employee training remains a priority: Organizations' training and development investments are at 'a healthy level' compared with previous years. *T+D, 68*(11). 30.

Naatanen, R. (1992). *Attention and brain function*. Hillsdale, NJ: Lawrence Erlbaum.

Nestojko, J. F., Bui, D. C., Kornell, N., & Bjork, E. L. (2014). Expecting to teach enhances learning and organization of knowledge in free recall of text passages. *Memory & Cognition, 42*(7), 1038-1048. doi:10.3758/s13421-014-0416-z

Paul, A. M. (2013, July 06). The real reason you learn a lesson better when you teach it [Web log post]. Retrieved from http://www.businessinsider.com/why-teaching-helps-you-learn-2013-7

Rekrut, M, D, (1994). Teaching to learn: Strategy utilization through peer tutoring. *The High School Journal, 77*(4), 304-314.

Renkl, A. (1995). Learning for later teaching: An exploration of mediational links between teaching expectancy and learning results. *Learning and Instruction, 5*(1), 21-36. doi:10.1016/0959-4752(94)00015-h

Roediger, H. L., & Pyc, M. A. (2012). Inexpensive techniques to improve education: Applying cognitive psychology to enhance educational practice. *Journal of Applied Research in Memory and Cognition, 1*(4), 242-248. doi:10.1016/j.jarmac.2012.09.002

Ross, S. M., & Vesta, F. J. (1976). Oral summary as a review strategy for enhancing recall of textual material. *Journal of Educational Psychology, 68*(6), 689-695. doi:10.1037/0022-0663.68.6.689

Schneider, W. (1994). Neurobiology of attention and automaticity. *Current Opinion in Neurobiology*, *4*(2), 177-182. doi:10.1016/0959-4388(94)90069-8

Schneider, W., & Chein, J. M. (2003). Controlled & automatic processing: Behavior, theory, and biological mechanisms. *Cognitive Science, 27*(3), 525-559. doi:10.1207/s15516709cog2703_8

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84*(1), 1-66. doi:10.1037/0033-295x.84.1.1

Shiffrin, R. M. (1988). Attention. In R. C. Atkinson, R. J. Hernstein, G. Lindzey, & R. D. Luce (Eds.), *Steven's handbook of experimental psychology: Learning and cognition*, (Vol. 2, pp. 739–811). New York, NY: Wiley.

Stallings, S. (2012). *Overlearning versus refresher training in procedural skill acquisition.* (Unpublished master's thesis). Middle Tennessee State University, Tennessee.

U.S. Department of Labor, Bureau of Labor Statistics. (2014, January 8). *Occupational outlook handbook, 2014-15: Assemblers and fabricators.*

Retrieved from http://www.bls.gov/ooh/production/assemblers-and-fabricators.htm

Voelkle, M. C., Wittmann, W. W., & Ackerman, P. L. (2006). Abilities and skill acquisition: A latent growth curve approach. *Learning and Individual Differences, 16*(4), 303-319. doi:10.1016/j.lindif.2006.01.001

APPENDICES

APPENDIX A: IRB Approval

10/8/2014

Investigator(s): Michael Millard; Dr. Michael Hein
Department: Psychology
Investigator(s) Email: Mjm7v@mtmail.mtsu.edu; Micchael.Hein@mtsu.edu

Protocol Title: "Lego Training Pilot Study "

Protocol Number: 15-066

Dear Investigator(s),

The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above. The MTSU IRB or its representative has determined that the study poses minimal risk to participants and qualifies for an expedited review under 45 CFR 46.110 and 21 CFR 56.110, and you have satisfactorily addressed all of the points brought up during the review.

Approval is granted for one (1) year from the date of this letter for 60 participants.

Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918. Any change to the protocol must be submitted to the IRB before implementing this change.

You will need to submit an end-of-project form to the Office of Compliance upon completion of your research located on the IRB website. Complete research means that you have finished collecting and analyzing data. **Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date.** Please allow time for review and requested revisions. Failure to submit a Progress Report and request for continuation will automatically result in cancellation of your research study. Therefore, you will not be able to use any data and/or collect any data. Your study expires **10/8/2015**

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to complete the required training. **If you add researchers to an approved project, please forward an updated list of researchers to the Office of Compliance before they begin to work on the project.**

All research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion and then destroyed in a manner that maintains confidentiality and anonymity.

Sincerely,

Institutional Review Board
Middle Tennessee State University

APPENDIX B: Consent and Debrief Forms

Consent Form

Principal Investigator: Michael Millard
Study Title: Lego Training
Institution: Middle Tennessee State University

Name of participant: ____ Age: ___________

The following information is provided to inform you about the research project and your participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the MTSU Office of Compliance at (615) 494-8918.

1. **Purpose of the study:** To **b**etter understand training for assembly type tasks.
2. **Description of procedures to be followed and approximate duration of the study:** A Lego boat assembly task will be demonstrated, practiced, and tested. You will then come back in four weeks for additional boat assembly tasks. Participation in this study requires 1 hour for the first session and 20 minutes for the second. <u>Please do not discuss these procedures with other participants or potential participants.</u>
3. **Expected costs:** None
4. **Description of the discomforts, inconveniences, and/or risks that can be reasonably expected as a result of participation in this study:** Poking figures on the edges of Lego pieces and the mental pressure of assembling a Lego boat in a timed task.
5. **Compensation in case of study-related injury:** None
6. **Anticipated benefits from this study:** The potential benefits to science and humankind that may result from this study are a better understanding of training assembly type tasks. A potential benefits to you from this study is earning class credit for the time that you participated.
7. **Alternative treatments available:** None
8. **Compensation for participation:** None
9. **Circumstances under which the Principal Investigator may withdraw you from study participation:** None
10. **What happens if you choose to withdraw from study participation:** You may withdraw from this project at any time, for any reason without penalty or repercussion.
11. **Contact Information.** If you should have any questions about this research study or possible injury, please feel free to contact Michael Millard at 615-900-6477 or my Faculty Advisor, Michael Hein at (615) 898-2127.

    Confidentiality. All efforts, within reason, will be made to keep the personal information in your research record private but total privacy cannot be promised. Your information may be shared with MTSU IRB or the government, if you or someone else is in danger or if we are required to do so by law.

    <u>STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS STUDY</u> I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I freely and voluntarily choose to participate in this study.

Signature of volunteer ____ Date: _______________

Consent obtained by: ____ Date: _______________

Researcher Signature

<u>Michael Millard</u> ______________________________

Printed Name of Researcher

Delayed Assembly Packet

Lego Learning Debriefing

Thank you for participating in this study. In psychology research, it is sometimes necessary to conceal our hypotheses because when people know what is being studied they often alter their expectations and performance. However, we do not want you to leave misinformed, so we will now tell you what we were actually studying.

The purpose of this study is to determine the effects of teaching compared to practice in the training of assembly tasks.

The volunteers that were taught by participants during the first assembly session were only participating so that you could teach them. They did not actually need to learn to assemble the boat.

If you have any further questions about this study then feel free to ask the researcher at 615-900-4766 or mjm7v@mtmail.mtsu.edu or the Faculty Advisor, Michael Hein, at (615) 898-2127. Thank you for your help today.

______________________________________ ____________________

Signature of Participant or Participant # Date

APPENDIX C: Immediate Assembly Packet A and B

Immediate Assembly Packet A

Today you will be trained to assemble a Lego boat.
Your training will include the following activities.

Video Walkthrough	Practice	Assembly task 1	Practice	Assembly task 2	Questionnaire

You will have practice time before and after Assembly task 1. You will receive paper instructions for reference during your practice time.

Assembly Task Information

Your goal is to assemble the Lego Speed Boat as quickly and correctly as possible during assembly tasks 1 and 2.

You will have a 1 minute and 45 seconds to complete the boat. If you finish in under the time allotted for the task, then please use your stopwatch to stop your time.

Each misplaced or unplaced block will be counted as an error. Your errors and assembly time will be recorded in the spaces provided below.

The task only requires that you assemble the boat as quickly and correctly as possible, and you do not need to follow all of same steps that were taken in the video or the paper instructions. I will inform you of how many errors you have on your boat but not where they are located.

Assembly Task 1

Assembly Time ________________

Total Errors ________________

Assembly Task 2

Assembly Time ________________

Total Errors ________________

Immediate Assembly Packet B

Today you will be trained to assemble a Lego boat.
Your training will include the following activities.

Video Walkthrough	Practice	Assembly task 1	Participant Teaches	Assembly task 2	Questionnaire

You will have practice time before Assembly task 1. After this task, you will be asked to teach a volunteer participant how to assemble a Lego boat within the time limit for the assembly task. You will receive paper instructions for reference during your practice and teaching time.

Assembly Task Information

Your goal is to assemble the Lego Speed Boat as quickly and correctly as possible during assembly tasks 1 and 2.

You will have a 1 minute and 45 seconds to complete the boat. If you finish in under the time allotted for the task, then please use your stopwatch to stop your time.

Each misplaced or unplaced block will be counted as an error. Your errors and assembly time will be recorded in the spaces provided below.

The task only requires that you assemble the boat as quickly and correctly as possible, and you do not need to follow all of same steps that were taken in the video or the paper instructions. I will inform you of how many errors you have on your boat but not where they are located.

Assembly Task 1

Assembly Time ________________

Total Errors ________________

Assembly Task 2

Assembly Time ________________

Total Errors ________________

Participant Information

Name:
Age:
Email address:
Phone:

Please Circle the responses that applies to you
Gender:

Male Female

Year in school:

Freshman Sophomore Junior Senior Graduate

How often did you play with Legos as a child?

Never Rarely Sometimes Often Frequently

How often have you played with Legos or similar products in the last 6 months?

Never Rarely Sometimes Often Frequently

Have you ever assembled the Lego Speed Boat set before?

Yes No

Did any participants discuss with you the details of this study before you arrived?

Yes No

Please Circle the responses that applies to you

I thought the assembly task was very difficult.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I thought the amount of time to complete the assembly task was very reasonable.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I tried my best to learn how to assemble the boat during training.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I tried my best during the Lego assembly task.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
The pictures in the paper instructions were very helpful to my learning.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
The written tips in the paper instructions were very helpful to my learning.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

Describe how you used your time during the initial 10 minute practice period before assembly task 1.

Describe what you would recommend to someone who asked you how to best use their practice time.

APPENDIX D: Delayed Assembly Packet

Delayed Assembly Packet

Assembly Task Information

Your goal is to assemble the Lego Speed Boat as quickly and correctly as possible during assembly tasks 1, 2, and 3.

You will have a 1 minute and 45 seconds to complete the boat. If you finish in under the time allotted for the task, then please use your stopwatch to stop your time.

Each misplaced or unplaced block will be counted as an error. Your errors and assembly time will be recorded in the spaces provided below.

Assembly Task 1

Assembly time ________________

Total Errors ________________

Assembly Task 2

Assembly time ________________

Total Errors ________________

Assembly Task 3

Assembly time ________________

Total Errors ________________

Delayed Assembly Questionnaire

Please answer the following questions.

Name:

Have you assembled Legos since the previous session? Yes No

I thought the assembly task was very difficult.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I thought the amount of time to complete the assembly task was very reasonable.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I tried my best during the Lego assembly task.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I thought the training provided was useful to preparing me for this assembly task.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
I am confident in assembling my boat even four weeks after training.	Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

APPENDIX E: Confederate Training

Confederate Training

Participants in the research study will have 10 minutes to teach you how to assemble a Lego Boat. Participants will have Lego boat instructions and boat pieces with them. It does not matter whether you actually learn how to assemble the boat, but you should be listening to whatever the participants are teaching you.

Please follow these guidelines to ensure a similar experience across participants:

- Attempt to go into the training with a blank slate and use what you are taught during this teaching period to assemble the boat if you are directed to do so.

- If participants ask whether you know how to assemble the boat or whether you have assembled the boat before, then respond with “No.” Be slightly apathetic if possible.

- Assemble what you can at a reasonable pace so that participants have time to guide and direct you if they prefer.

- You are NOT quizzing them on the boat assembly. However, they may quiz you.

- Provide participants with short, basic answers if they try to quiz you.

APPENDIX F: Example of Assembly Instructions

Lego Instructions with Researcher Tips