Task-based EFL language teaching with procedural information design in a technical writing context

Abstract: Task-based language learning (TBLL) has heavily influenced syllabus design, classroom teaching, and learner assessment in a foreign or second language teaching context. In this English as foreign language (EFL) learning environment, the paper discussed an innovative language learning pedagogy based on design education and technical writing. In this TBLL course, the language learning based assignments centered on designing and analyzing objects using various computer-aided design software and physical LEGO toolkit. The design software was used collaboratively and the design analysis was done mostly as group activities. The language production activities centered on technical document authoring, using collaborative online authoring tools for website hosting and note-taking for design projects, besides oral in-class presentations, and online posting in English. Language reception activities such as readings related to the course lectures, videos, assignment, and assessment instructions were hosted and linked from Moodle—the learning management system. This paper critically analyzed student performance with physical LEGO design and CAD software, including how student groups authored websites detailing the structural and functional specifications related to the product assembly procedure. This paper outlined how design pedagogy could be included in the curriculum while teaching English as a foreign language. In the process, students not only learnt about design fundamentals, but how to author complex technical documents in English. Findings based on course data and class interactions have adequately demonstrated that students were capable of handling the task-based language projects with reasonable efficiency and confidence.

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PUBLIC INTEREST STATEMENT

This research examines the extent to which project-based language learning could be successfully integrated in a foreign language teaching context where target language proficiency is moderate, at best. This article takes a unique approach to teaching language with physical and hands-on product design in a blended learning and flipped classroom model. The article provides many examples of how foreign language teaching could be more engaging, productive and goal-driven, and how students can see their documentation and communication projects being a true reflection of the real-world situations. The article provides very clear guidelines on the pedagogical structures that may explain how such a language course could be taught successfully.
1. Introduction

Majority of middle and high school students in Japan was of the opinion that they had difficulty studying English, and the problems with English language proficiency accumulated as they graduated from middle school to high school and onwards to the university. Research has traditionally argued that a large part of this ongoing problem and impact on students’ academic futures is a result of the lack of a positive experience with English when it was introduced, the learning pace of different students in large classes, lack of enough language instructors with necessary English skills, and the lack of English in the society and Confucianism as an identity that hinders language acquisition (Chia, 2003). Teaching styles may effect English education as well. For example, lack of awareness about Kolb’s categorization of the learning styles as Diverger (learn from concrete experience), Assimilator (learn from reflective observation), Converger (learn from abstract conceptualization), or Accommodators (learn from active experimentation) besides other learning and instructional design models, might hinder a balanced pedagogical structure, approach and growth in the language classroom. Some researchers label Japanese learners as Analytic learners (Call, 1998; Rao, 2002) while some others report that Japanese students are visual learners (Rao, 2002).

The recent focus in Japan towards globalization and teaching communicative English instead of the traditional translation and grammar-based language instruction could potentially gain further momentum with the advent of project-based learning (PBL) as a pedagogical approach. The PBL method and action-based teaching aims to foster autonomous and exploratory learning by organizing the learning as sequenced tasks such as identifying questions, collecting and analyzing data, and reporting the results (Beckett & Miller, 2006; Lier, 2007). PBL has been widely accommodated and researched in both general and science education (Krajcik & Blumenfeld, 2006). Interestingly, PBL has been widely incorporated in L2 education as a method for student-centered and collaborative learning (Hedge, 1993), researched extensively as a method offering valuable insights about discourse practices through interactions in project-based L2 classes (Kobayashi, 2006; Vargas, 2012), and resulted in increased motivation, enhanced linguistic proficiency, and improved confidence (Stoller, 2006).

This brings us to the question of how we can introduce a PBL method in a Japanese EFL classroom? One definite way is to adopt a critical thinking approach in a PBL classroom. This is important in a Japanese context to counter the belief and/or the practice that cites traditions of collectivism and hierarchy as cultural constructs that inherently discourage students from developing a distinct identity or voice in their writing and creative original thinking (Atkinson, 1997). Davidson (1995) argued that many Japanese find it difficult to discuss, explain ideas, or justify positions in a classroom situation. A PBL method in this specific language-learning context followed Ennis’s (1998) conclusion that critical thinking works as long as “group thinking” exists and Atkinson’s (2003) idea that critical thinking in East Asian culture is based on collective concordance and compliance. For this study, we adopted the approach that design thinking is definitely one way we introduce critical thinking in a foreign language classroom (Roy, 2014; Roy & Crabbe, 2015).

Focused on design thinking and analysis, this article investigated an innovative PBL-focused pedagogical approach centered on task-based language learning (TBLL). Research suggests that TBLL can incorporate learner-driven active learning in a way that encourages hands-on interaction with physical objects in a classroom before theoretical instructions are incorporated (Nunan, 2005; Skehan, Xiaoyue, Qian, & Wang, 2012). This model of classroom interaction has been suggested by Blikstein (2013). This is arguably the first time in EFL (English as foreign language) teaching that an attempt is being made to incorporate collaborative design pedagogies using physical and online LEGO design. This will subsequently develop language-learning coursework to promote principles of
active learning. The broad idea is to reach a stage in coursework where students are able to use physical and online LEGO design coupled with the use of CAD software to improve communication within a team, help co-author design documents, and in the process develop language instructions and acquisition.

The class projects based on PBL, as discussed in this article, centered on online and physical product design with LEGO toolkit and CAD software such as Tinkercad, Autodesk 123D Design and BuildwithChrome. For this classroom project, LEGO was used to write about engineering team-based communication, collaborative product development, planning and design, analysis, and execution. For class assignments, the idea was to design innovative products with LEGO, write and speak about the design in English, and work towards group analysis and peer review. The objective was to run pilot studies in the classroom focusing on interactive discussion sessions in English about what happened during group interaction and design process? What worked well? What didn’t work so well? What about the team communication? Could we use LEGO tools to learn about another topic? Could we use a “toy” to learn about history, science, art or math? Could we design a futuristic product with LEGO? The short in-class LEGO projects were used for designing various types of products (mostly based on student interest). Students were asked to write short product specifications about the design process, structural feasibility, functional descriptions, reports on product design, recommendations and constructive criticism (product reviews) for improvement. This article reported on student performance focused on understanding the LEGO design process, prototyping activities using Google Sites webpage, and initial observations about the logistics of how the entire creative factory context could possibly be inducted in EFL coursework. Fundamentally, this article investigated how LEGO-based design coursework could be included towards critical reasoning and task-based English language teaching.

2. Research questions

David Nunan in his book “Language learning beyond the classroom” published in 2015 has mentioned the importance of authentic materials and PBL, besides explaining how to integrate classroom learning and autonomous learning (Nunan & Richards, 2015). PBL has been identified as a key driver of ESL instruction (Petersen & Nassaji, 2016). In a Japanese context, Fujimura (2016) investigated ESL students’ learning of content knowledge in project work. PBL is now an integral part of L2 education with focus on student-centered learning, autonomous and collaborative learning (Cusen, 2013; Hedge, 1993). Social interactions in PBL-based L2 classrooms have shown to offer value towards effective language acquisition (Kobayashi, 2006; Verga & Kotz, 2013).

The research questions for this study have been framed to assist the process of finding an answer to how EFL learners handle PBL in a language classroom. The questions are as follows:

- Were students (participants in the study) able to handle the physical LEGO blocks and CAD software towards product design and collaborative document authoring and presentation in a way that suggests that a PBL method in this language classroom is effective? (Liu & Hsiao, 2002; Resnick & Ocko, 1991; Resnick, Ocko, & Papert, 1988; Skehan et al., 2012).
- Were the participants able to handle different types of media such as video analysis, website research and text comprehension with reasonable efficiency towards task completion in this complex information environment? (Slattery, 2007).

3. Review of the literature

The literature highlighted the different issues that contributed towards making a PBL-based EFL classroom possible with its LEGO-focused approach in a critical thinking mode.

3.1. Critical thinking in L2 language classroom

Jean and Wenger (1991) notion of situated learning and social constructivism in the product–process framework of L2 writing (Storch, 2005) are central theoretical constructs that can explain how participants thought about handling the separate projects within a social dimension and
collaborative framework as has been discussed in this study. Today, most college writing programs have emphasized on critical thinking in a writing classroom (Alagozlu, 2007; Massi, 2001). However, the extent to which individual critical thinking is possible in a Japanese EFL writing classroom is something to explore further, as research suggests that students who grew up in societies where social harmony and group behavior are stressed are often deficient in critical thinking abilities (Stapleton, 2001). Cognitively, critical thinking is considered an ongoing activity, and students gradually develop the power to critically think through a problem with process-oriented activities in the classroom (Barnawi, 2011).

3.2. Flipped classroom model and active learning
A flipped classroom model could be a good example of how to promote critical thinking. The current trend in instructions design is towards a flipped classroom model where the class becomes the place to work through problems, collaborate in groups, brainstorm concepts, write co-authored documents, peer review work done for the course, exchange ideas, and plans (Tucker, 2012). Teacher-centered instruction takes the backseat while lectures are recorded and lecture notes are made available online in a blended-learning format. The “posted” materials are accessed outside of the classroom and learnt individually, and such background knowledge is used for in-class assignments. This approach is further interesting because it allows more advanced students to learn independently of the class and weaker students to try out alternatives and watch other partners engaging in useful activities that tie in directly with the lecture content. An effective flipped classroom ties in with the instructional content, equipped with in-class hands-on activities, making the learning process seamless and unified. Such a flipped classroom model could work effectively when the various tenets of active learning models are pursued with rigor in a task-based classroom. Active learning has received considerable attention over a prolonged period of time, but frequently polarized faculty on the issue of its effectiveness. This model has long advocated doing meaningful learning activities in class, and analyzing the activities towards goal-oriented outcomes (Bonwell & Eison, 1991; Prince, 2004). The concept of active learning is an important discussion in the context of this paper. This will allow us to understand how the task-based language-learning course, as discussed here in this article, fits into the various sub-genres of active learning framework.

3.3. Task-based language learning
An interesting approach to the use of both the flipped classroom model and active learning through critical reasoning could be automatically integrated by nature in task-based language teaching (TBLL). TBLL is based on various structural attributes that make it comprehensive and learner-centered. These features are relevance of the task, appropriate level of the task (catering to learner’s current competence level), learning by doing, involvement, and motivation (Wilson, 1986). TBLL approach is gaining popularity in Japan due to its ability to teach language through non-linguistic mediums, and for promoting language learning in different communicative ways. In 1999, the national curriculum in Japan advocated “communication abilities” as the central premise in foreign language education (Butler & Iino, 2005). In 2013, MEXT (Ministry of Education, Culture, Sports, Science and Technology in Japan) ruled that English language education should emphasize learner-centered activities, grammar as a supplemental tool supporting communication, and deemphasized translation methods (Kotaka, 2013). Based on the Blikstein model of active learning, the idea of this discussed pedagogical approach is to integrate physical and screen-based interactive task-based activities in an analytical and critical thinking-based language classroom. This proposal introduces such a concept as part of its creative factory language learning approach. Skehan et al. (2012) has advocated that task characteristics should be divided into strong and weak forms of the TBLT approach. The strong form suggests that tasks should be the unit of language learning, while the weak form suggests that tasks are a vital part of language instructions.

As part of our discussion in this article, we have introduced the idea that use of LEGO for design planning and implementation in class opens up a flipped classroom and active learning approach. Student groups collaborate on creating a physical LEGO product in class, follow design fundamentals in the process, and write about it online in an objective way following document design guidelines. They
make websites with their own procedural instructions on the product assembly, while reading about the associated lectures, and watch design videos on products outside of the classroom. This is a strong form of the TBLT approach. The LEGO physical assembly task and the online web manual design in itself is the unit of language learning. It is important to understand that theoretical instructions are embedded in the process of assembly and group collaboration. Students read about the theoretical fundamentals of the design and writing process outside of the classroom, but in a coherent manner such that they explore the ideas more as part of the physical product assembly processes.

3.4. Project-based learning and LEGO in classroom

Most classroom-based problem-solving activities involve some form of analytical thinking that decomposes problems into sub-problems. Research in education and learning has widely accepted that students using LEGO can learn important mathematical and scientific ideas by incorporating actual design activities while learning about the design fundamentals (Resnick & Ocko, 1991; Resnick et al., 1988). LEGO assignments in the EFL classroom should differentiate between analysis and design. Analysis should help students structure the actual problem into sub-problems and approach it analytically with specific heuristics; while the design job is a relatively more mechanical process based on specific guidelines; and based on iterative developments over time. Design activities thus, according to some are difficult to implement in a classroom, because of lack of specific expectations or guidelines, and so no one really knows what to expect. But that is where the role of LEGO becomes so very important, as it gives a student the opportunity to develop a free-flowing idea, with open-ended questions throughout the procedural assembly process. The use of LEGO opens up several channels of exploration.

The literature on the use of LEGO for PBL is fundamentally based on the use of software such as Mindstorms and Robolab to build LEGO robots. An interesting understanding about such use of LEGO is based on the research of Seymour Papert (1980, 1991) and his colleagues at the MIT Media Laboratory. Papert’s research suggested that the use of physical LEGO or online software promotes the development of a constructionist learning/teaching environment that provide students the possibility to interact with technology at different levels (concrete to abstract). Interestingly, the use of LEGO in a PBL environment make students discover that they need to learn new knowledge and continuously revise existing knowledge before they can begin solving problems. For our writing classroom, students were remotely observed as they went back repeatedly to the design fundamentals that helped them write the answers, searched Google for follow-up concepts, looked for the meaning of words from online dictionaries and used online translation software. Besides, students used the Japanese user manuals that came with the LEGO kit, tried to translate it logically in a way such that it could be used for the extensive user guides they designed subsequently. Thus, the idea was to see them use different resources towards production management such that the problem drives the learning (Hung, 2002).

The design of the LEGO classroom, as discussed in this paper, is not based on measuring the outcomes in a PBL context, but is more about integrating the elearning modules as observable intermediate steps that students produced during their problem-solving processes in a professional course (Carbonaro et al., 2008). Although it’s difficult to identify and write about such observed in-class group interactions, it included continuous consultation, prototyping with LEGO blocks (assembly and disassembly), separate group member roles, where students continuously went back and forth, checking out the assignment instructions and the LEGO manual kit. They worked on taking photos of the assembly processes, and wrote short one-sentence instruction captions in Google Sites webpage. Research has suggested that using LEGO bricks to do even a simple task could cognitively call for extensive demands on students’ creativity and problem-solving ability (Chambers & Carbonaro, 2003). Building and programming a mechanical product is an ideal context in which to situate a PBL experience and this is where students work collaboratively to understand the problem as they construct viable solutions (Liu & Hsiao, 2002). An interesting aspect of this course is the fact that collaborative student projects are published in Google Sites, and that makes it open to comments by a larger community. At the end of the course, students were asked to publicize and share their ideas.
about the LEGO project in blogs. According to Penner (2002), social networking about their projects allows students to experience science concepts in a more meaningful, personalized context.

The PBL method as we followed for the discussed course, primarily followed five processes as part of group engagement. These processes are (a) engagement, (b) exploration, (c) investigation, (d) creation, and (e) sharing. These processes helped students see the complete scope of problem solving through PBL methods (Carbonaro, Rex, & Chambers, 2004). Kafai and Resnick’s (1996) study suggested the importance of constructivist learning in a digital world where students product artifacts (physical and digital, as is the case in this course) that can be shared with a larger audience. In this study, we followed a model of collaborative learning by allowing students to work together in small groups towards a common goal (Laal & Laal, 2012). This study, as discussed here, also caters to cooperative learning as students pursued common goals but were assessed individually (Feden & Vogel, 2003). This is a model for PBL learning because the idea is not to focus on language learning at the beginning of the instruction but rather to focus on discussing design challenges leading up to the LEGO assembly and completing online assembly of the products. In the process of discussing the relevant problems and issues, the projects allowed students to create language learning scenarios and opportunities by brainstorming the ideas, writing about it, writing recommendation and feasibility reports about design assembly, making online English user manuals, sharing observations in blogs, and making class presentations.

4. Materials and methods
The task-based language-teaching course studied in this paper is an undergraduate English language elective titled “Writing and Design with LEGO”. The course is taught as an undergraduate elective in the third year of the BS program in computer science at a Japanese computer science university.

The course had the following goals:

• Reflect on the use of LEGO for team communication and collaborative design.
• Analyze audience, rhetorical, informational, demonstrative, and other situations/contexts for LEGO product design.
• Apply the principles of product design towards systems creation and task-oriented user experience and satisfaction.
• Develop writing skills with focus on content organization, formatting, layout, grammar, and purpose.
• Develop oral skills through multiple oral presentations and peer reviews.

4.1. Participant selection
Forty-eight students participated in the coursework, both for individual projects and group assignments. The students in the course had background with computer science fundamentals, but no prior experience with design and technical writing at the level exposed to during the course. English was a foreign language for the students who participated in this course. The participants were all at the junior level at the undergraduate program and basic English language proficiency was expected. All the participants in the course completed basic English language courses.

4.2. Instruments and materials
In TBLL, tasks include activities in a way where the target language is used for communicative purposes. The three sequential stages in a TBLL course should ideally be pre-task, during-task and post-task phrase (Ellis, 2003). This course is designed such that the pre-task phrase includes task orientation and critical thinking, the during-task phrase includes student performing active learning with physical LEGO blocks and preparing writing drafts collaboratively, and the post-task phrase involves improving writing drafts and iterations in Google Sites and as other submission assignments, design and use of software, and teacher feedback (Willis, 1996). Table 1 shows the tools and instruments used for various purposes during project completion by students, both in groups and
individually. Not all the tools were used to the same extent during coursework but exposure was variable during pre-production, production and post-production. While some assignments focused on pre-production, other assignments combined during-production and post-production stages and used relevant instruments.

During the pre-production stage, the idea was to help students grasp the concepts related to design fundamentals, and in the process read technical text, watch videos on design prototyping, tinker with LEGO toolkit, and plan about a design. Moodle was used continuously throughout the process. During production, the focus was on designing prototypes using physical LEGO toolkit, using the different CAD software and taking notes in Google Drive about the groups’ design processes. During the post-production stage for the major assignments, the focus was on using Google Drive to polish the notes taken earlier, using the notes, and design screenshots to prepare a website using Google Sites, and later use the different technical rubrics for website and oral presentations design and to peer-review the groups about their design projects. SPSS was used to analyze the data for descriptive statistics.

Table 2 demonstrated the different assignments, purpose, and assessment for the major assignments in the course. That should help readers see how the different tools and instruments were used for different assignments in the course.

### 4.3. Procedures

The course was offered as a 90 min session once a week for 16 weeks, including the final exam week. Students were assigned mac workstations, and their identity was recognized during classwork for the computer they were assigned to. For group assignments, each group had four or five members who were physically placed together in the classroom as a cluster, so that group communication could be facilitated. Further, sitting together also helped me figure out if there was any structure to the group communication, how and when group members participated and to what extent. Student attendance was checked with each computer mapped to the student id, and more than one absence per group project qualified for a zero grade. Further, for group assignment, each member had to post the same group assignment separately in Moodle, and failure to do so led to deduction of points. For each class session 30–40 min were assigned to explain instructions, besides need-based follow-up instructions delivered based on group and individual needs. The following pedagogical structures (as assignments) were adopted as materials and methods that should help readers of this article see how the assignments were developed and assigned as experimental tasks so that students can comprehend the importance of LEGO; how it has been traditionally used, and how it could be used as a design tool. All of the following assignments discussed below follow a critical thinking approach to foreign language learning (Shirkhani & Fahim, 2011).

The 15 week course started with a lecture introducing LEGO as a design tool with a discussion about its importance for education, how different class assignments could be designed with LEGO as a tool, etc. The second week started with a class assignment on the history of LEGO. This was a video analysis assignment which was graded on the basis of the readers’ ability to understand the video in English, and successful evaluation of the same as a writing assignment. Week two assignment has
| Assignments                        | Grade | Purpose                                                                 | Assessment                                                                                     |
|-----------------------------------|-------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| History of LEGO (individual assignment) | 5     | Explore students’ ability to understand complex design concepts based on reading and watching videos | • Reading Comprehension Score (based on a reading about LEGO history)  
• Research (based on Google research about LEGO games in a certain period in history)  
• Video Comprehension (watch LEGO commercials and comment)  
• Website Comprehension (Study the LEGO education website and comment)  
• Video Comprehension (watch a video on history of LEGO and comment) |
| Product design (individual assignment) | 5     | Comprehend procedural instructions with reasonable efficiency and respond with answers that are reasonably acceptable | • Ability to understand the lecture notes on product design with some efficiency  
• Ability to understand the assignment instructions with reasonable efficiency  
• Reasonable answers to the questions asked  
• Reasonably well grammatical construction of sentences  
• Attempt to write without use of translation software and direct copy from Internet sources |
| NANO assembly & web design         | 10    | Develop Group communication and ability to communicate well about the physical assembly process | • Ability to complete the physical assembly process  
• Contribution of group members during the assembly process  
• Contribution of group members during the web authoring process  
• Writing skills; mutual consultation and response to all the questions based on the guidelines  
• Overall design and layout of the website |
| 1st creative factory Project stage 1 | 10    | Develop ability to collaboratively author procedural document and promote group communication | • Ability to complete the physical assembly process  
• Group coordination and participation  
• Ability and attempt made to research the real-life variation of the LEGO product  
• Designing the Google Sites webpage based on instructions in the assignment  
• Writing reasonable sentences based on product design essentials  
Accuracy of the design responses was not an absolute criterion to judge the quality of the assignment. Rather, the organizational structure and design of the website based on textual and visual presentation influenced the grading* |
| 1st creative factory project stage 2 | 5     | Ability to author technical presentations with procedural information | • Ability to complete PowerPoint presentation based on technical presentation rubric (organization & layout design)  
• Design the two prototypes using both Tinkercad and BuildwithChrome  
• Following the instructions on content design guidelines for each slide  
• Content authoring in English without evidence of direct usage of translation software or materials copied from the Internet |

(Continued)
been discussed in the findings section. The first two weeks of the course highlighted the readers’ ability to comprehend information based on video and text information, and also think about it critically. So, assessment was based on readers’ ability to explain their points logically, understand the video information with reasonable success, ability for grammatically correct sentence construction, self-authoring with minimal use of translation software, and word limit compliance.

The PBL method was basically adopted from the third week with the third graded assignment where the students started working in groups. Each student group was handed out a LEGO Nano assembly kit and each kit had a pre-designed plan for an object that needed to be assembled. The student groups were expected to assemble the product within a single 90 min class period based on the Japanese user manual showing the assembled object (outcome graphics). No detailed step-by-step process graphics (demonstrating the assembly process) were shown in the user manual. The third graded assignment based on this assembly followed a technical writing approach to design evaluation and procedural information design based on text-graphics coordination (Roy & Grice, 2004). This assignment for the first time introduced the idea of using CAD software to replicate a physical design (using Tinkercad to replicate the physical NANO assembly). More interestingly, this is arguably the first time that CAD software and physical LEGO design has been used to teach technical writing in a foreign language classroom. This NANO assignment was graded based on the group’s ability to complete the assembly task, discussion between group members in English, as observed,

| Assignments                  | Grade | Purpose                                      | Assessment                                                                                     |
|------------------------------|-------|----------------------------------------------|-------------------------------------------------------------------------------------------------|
| 1st creative factory project | 5     | Ability to use technical rubrics as reference towards designing interviews | • Ability to use technical rubrics with a specific purpose
• Use the rubric for interview purposes
• Complete a YouTube video demonstrating the interview process
• The transcript of the interview makes reasonable sense and is consistent with the purpose of the instruction

| Design assignment            | 5     | Ability to use CAD software and develop critical reasoning ability in writing | • Use CAD software such as Tinkercad and BuildwithChrome with reasonable proficiency
• Critical reasoning and thinking to develop arguments about the product being designed using the CAD software
• Design a technical presentation following the instructions as outlined |

| Article analysis assignment  | 10    | Explore students’ ability to understand design concepts based on reading and watching videos | • Understand the articles with reasonable efficiency
• Ability to write short reflective answers critically
• Grammatically correct and meaningful sentences |

| 2nd creative factory project | 10    | Information organization and technical documentation | • Complete the prototype designs using CAD software
• Take all the assembly photographs and organize it properly based on the instructions
• Ability to construct responses to design questions to the best of their ability
• Design a webpage based on the questions asked
• Write grammatically correct sentences to the best of their ability
• Reasonable group participation |

*Only the major assignments in the LEGO course have been discussed. Midterm and final exams were not discussed.
distribution of the task between group members, completeness of the assignment, ability to understand and respond to the questions asked, and ability to write arguments with acceptable proficiency and in their own words. Week 3 basically started with a focus on lectures on product design followed by a reflective reading comprehension exercise. The product design assignment was used as a hook activity that kickstarts the thought process on LEGO. The NANO assignment was the second assignment for week three. The assessment criteria used to judge the product design assignment were simply based on readers’ ability to understand the question and answer them with reasonable efficiency based on the lecture notes on product design, understanding of the associated concepts and ability for critical reasoning. This course primarily had two main projects focused on procedural information design. The product design assignment was based on readers’ ability to understand and act on both declarative and procedural information (Karrerman, Ummelen, & Steehouder, 2005). This project has been designed to understand the significance of configuration and subassemblies in sequential procedural instructions (Roy, 2007).

The fourth week saw the start of the first creative factory production assignment. This assignment included an extensive group authoring of an engineering and design report, based on physical LEGO assembly in the classroom. This was also a critical and technical writing assignment based on readers’ ability to think about the feasibility of a specific design and how it could possibly fit a real-life design and application context. Week four used a series of criteria to help reader groups judge a LEGO design, which they created in class. Answering some of these questions needed real-life understanding of the product. However, in this foreign language classroom and for the undergraduate students, the expectation was more realistic. The course instructor needed to understand if readers tried to think about the product and if they could do some amount of research on the real-life version of their manufactured in-class product. Students groups were asked specific questions about the product in its real-life form as follows:

- Materials (what materials, its physical properties, durability, color).
- Construction (tools and equipment, special skills, special attachment such as stands and handles, shape).
- Functions (main function, size of object, how heavy, mode of operation such as mechanical, electrical, object support).
- Appearance (shape/form, surface texture, color, safety).
- Social/Environmental factor (effect on people and environment, use of waste as fuel or recycled, if used as fuel, is it safe or economical).

Students needed to do some research towards writing the answers to these questions.

The fifth week of the course asked the groups to design a technical presentation based on a predefined criterion.

Research has always highlighted the need to develop professional presentation skills with reference to students’ specialized professional contexts. Based on the context, a transparent assessment framework is also important towards developing skills required of students to perform in competitive communicative environments (Pathak & LeVasan, 2015). The goal of this assignment is to highlight how students explain what they did in the group assignment, and what they think about the assembly processes. Student groups made in-class presentations and a standard technical presentation rubric was used to grade this assignment. As part of this assignment, students had to read two standard rubrics. The group project assessment rubric (rubric A) was referenced by student groups to design interview questions that judged how the other groups handled the project. Every person in the group had a specific role to play. Next, a similar type of assignment was followed with the technical presentation scoring rubric (rubric B), and the interviewed group from Rubric A became the interviewee group. Student groups had to outline a design project from scratch with Tinkercad and BuildwithChrome, followed by a technical PowerPoint presentation to demonstrate how the
product was designed. This is similar to the third graded assignment, but a more elaborate response was expected in terms of design, content, presentation, and analysis.

Following the midterm exam in Week eight, an article analysis assignment was scheduled. The purpose of this assignment was to help readers write critically, based on their readings of the topics related to LEGO use and additive manufacturing (3D Printing) in the real world. Readers were given a series of reference articles to read and videos to watch. Then, they were asked to reflect on those articles and videos. Week 11 witnessed the start of the second creative factory project. This project was entirely a design and analysis project using multiple iterations and prototypes using different CAD software such as Tinkercad, BuildwithChrome and Autodesk 123D Design, and detailed steps were outlined to execute the project. The following sequential steps demonstrate the schema of the second creative factory project as developed for the assignment.

1. Brainstorm in group
2. Search for reference LEGO image online for a complex project
3. Explain the structure and function of the LEGO image product
4. Report on the product to be drawn based on reference LEGO image
5. Develop first prototype with Autodesk 123D Design
6. Develop second prototype with Tinkercad
7. Develop third prototype with 123D Make
8. Write 10–12 steps outline user guide on how to use 123D Design software
9. Take screenshots of the product during assembly and write associated text explanations
10. Design webpage with Google Sites with assembly screenshots; linked pages on how Tinkercad, 123D Design, and 123D Make assembly was undertaken.

The final two weeks of the course included YouTube movie reviews on LEGO and a final exam, which included short answer-type questions on the design concepts, writing skills, and critical reasoning.

4.4. Data collection and analysis
This was a Moodle-based course. Each assignment in the course was designed with a specific purpose and assessment criterion as outlined in Table 2. For each assignment, students were evaluated based on how closely they could follow the assignment instructions, the completeness of the assignment and if reasonable attempts were made to understand the arguments in the readings, and videos. Further, students were also evaluated based on if they could successfully explain in writing and in speech the procedural steps undertaken when designing a product with physical or online LEGO blocks. The student interactions during the class time was not recorded, but keenly observed and notes taken to understand group participation, approach in the discussion process, and contributions during the group authoring process whether in Google Sites, or in Google Drive. Further, the extent to which students tried to write independently with and without using translation software was also noted, although it did not factor in while grading. Also, because the assignment instructions were provided in detail, class observation also focused on the extent to which the assignments were read and re-read as reference during the class interaction. All the course grades were independently entered for each student in Moodle (even for group assignment submissions) using the assessment guidelines as reference for each point assigned. However, since most of the assignments were open-ended, the grades should be considered as a subjective measure.

This section reported on the grades as obtained by students individually and in groups for various assignments discussed in the previous section. The descriptive statistics, as reported below for the various assignments, highlighted the basic performance with several language production and reception-based activities that students completed. This study did not report on inferential statistics.
due to various reasons. First, the groups were not stable and members were reallocated from one assignment to the next due to a few students dropping out, and the uneven character of the groups depending on language and task expertise. So, it was best to report on their performance individually rather than to see how the performance on certain activities changed over time or between groups. Secondly, the overall sample size was not large enough for inferential statistics to add any value to the interpretation of the data or for the data to make any sense when comparing between groups. Finally, the real value of the study is in understanding how the task was completed, the sequential steps followed, the different tools handled, the techniques for online collaborative and individual documentation, and how participants communicated in groups and individually, and to have subjective judgments based on ethnographic participant observations during the classwork, rather than to put an objective numerical score to the performance and make inferences and predictions based on the performance. Also, the assignments were not structured in ways to have a before and after treatment. Every project and category was different, stood as individual activities, and was not designed to be internally comparable in ways such that inferential statistics can make sense. This was primarily because of the different cognitive and metacognitive tools typically used in an EFL context for various assignments and processes, making the list of compounding variables too robust for any between and within analysis to be structurally sound. So, a mixed methods approach was adopted such that descriptive statistics allow readers to see absolute performance, and also class observation and self-reports allow an ethnographic understanding of how participants (students) approached the assignments and completed it in groups, following constructivist and situated learning principles. The course instructor spent quality time observing the participants as they approached the design tasks individually and in groups. It is beyond the scope of this analysis to report on specific group observations about student behavior, handling of tools and instruments, task approach and communication comprehensively.

5. Results
This section highlighted descriptive statistical data for the various major assignments undertaken by students either in groups or individually during the coursework.

5.1. History of LEGO assignment
The history of LEGO assignment was based on student’s ability to understand the content based on reading, website comprehension and video analysis for the different questions asked for the assignment. Table 3 highlighted the mean data and standard deviation for the five categories of questions asked.

Data showed relatively better response for the reading comprehension question about the history of LEGO and research about LEGO use, but the quality of responses for the open-ended questions dipped for the video comprehension category.

5.2. Product design assignment
The third week started with the product design assignment. Figure 1 demonstrated the individual student grades for the product design assignment. Twenty students responded to the assignment. Assignment scores showed a mean value of 3.45 for the student grades and a SD of 1.23. The median score is 4. Although the score variability is not large, but still, we see that some students with the score of 4 or better did well with the production activity related to critical thinking about the product design.

| Table 3. Mean and SD for the grades obtained in five types of questions in the history of LEGO assignment (scale 0–5) |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Descriptive statistics | Reading comprehension | Research | Video comprehension (commercials) | Website comprehension | Video comprehension (history LEGO video) |
| Mean | 3.60 | 3.03 | 2.83 | 2.67 | 2.07 |
| SD | 1.57 | 1.77 | 1.78 | 1.83 | 1.46 |
5.3. NANO assembly assignment

The second major assignment in the third week was the NANO kit assembly assignment. As part of this assignment, students had to assemble a NANO LEGO kit based on a predefined design, and complete various steps along the way (e.g. taking photos, making websites, writing associated process steps etc.) towards designing a Google Sites webpage. Figure 2 demonstrated the performance data below. This assignment was graded in a scale of 0–10. Assignment scores showed a mean value of 6.22 for the grades in the nine groups and a SD of 2.54. The median score is 7.

The score demonstrated some level of competence in the group to complete the projects successfully, and closer observation while grading suggested that in most cases, the assignment instructions were complied with successfully, although there was much room for improvement in the writing and explanation of the design, both in terms of grammatical proficiency and content-related competence.

5.4. First creative factory assignment

The first creative factory assignment and its assessment criterion are explained in Table 1 above. Table 4 below highlighted the individual scores obtained by members in the different groups for the Week four assignment (first stage of the creative factory assignment). In some cases, due to class absence, late participation and uneven number of students in the group, not all groups have equal members and not all participants have equal grades within a group.

Table 4 demonstrated some variability within the groups in terms of participation. It goes on to show that some groups were strong and internal dynamics worked successfully to get the job done, but some of the groups did not function properly and some members dropped out. The following data could not highlight how each member participated in actuality, because the scores are based on the group deliverable, not the group processes or dynamics.

Figure 3 below shows example screenshots of group projects done by creating Google Sites webpages based on LEGO assembly. Webpages showed that the assignment was well understood, and the sequential steps in the LEGO assembly process were well documented and positioned with text captions. However, there was much room for improvement when it came to linguistic proficiency and technical writing skills.
The next section highlighted the group scores for the second and third stages of the first creative factory project. In this stage, students were asked to design a 10-slide PowerPoint presentation about their LEGO assembly in the first stage, and also design a concept map explaining the assembly process (Figure 4).

The group performance data in Table 5 showed variable performance, where some of the groups failed to deliver on the presentations design instructions successfully. In other words, some of the student groups ignored the technical oral presentation rubric to a certain extent. In some cases, the sentence constructions were grammatically inaccurate to a large extent, while in some cases, the slides lacked adequate text explanation for the questions asked, while in others, the slides were over-loaded with example design screenshots based on CAD prototypes, but no follow-up text captioning.

Due to class absence and random participation, some of the groups were reshuffled with new members from other groups. So, the data in Table 5 has been reported by stating the number of participants in each group. The mean score is about 3.0. The concept map as seen in Figure 4 was created using the IHMC concept mapping software and shows an attempt to demonstrate the idea of how the LEGO product was created. There was hardly any problem writing the major sentences that were used to design the concept map. However, the concept map in most cases was designed based on key word connections, and not as subject-verb-object relation that was taught in class.

Figure 5 shows the instructions for the 3rd stage of the creative factory project as was discussed and explained in the class. But the instructions were mostly used as a reference guide. Students primarily worked in a 2-person group due to the class size and issues related to student presence and participation. Class observation showed students mostly engaged in active class discussion and
brainstorming sessions about how to author the questions, how to follow the assignment instructions and how to video record the discussion. However, they clearly lacked the initiative to actively consult the rubrics for group project and technical scoring, and they did lose concentration at times to stay focused on the assignment-related activities. Sometimes, students approached members of other groups for consultation and observe how they have framed the interview questions. It seemed that in some cases, students clearly struggled to get started, but once they did, they carried it forward. Students were strictly told not to copy questions designed by other groups. Once the questions were framed, students met after the class at different times to record their respective interview sessions. Due to the unevenness of the groups and the cross-participation in oral interviews based on rubric analysis and intra-group participation, the individual performance data are not statistically valid and reliable. Unless individual participation is observed and recorded, it would not be correct to measure and report on the overall individual student performance. There was 72% class participation in the third stage of this project based on the number of individuals who took part in recording the videos about the assembly process. Thirty out of 48 students posted their YouTube video in the Moodle submission page (62%). The YouTube videos in most cases reflected the assignment response as envisioned. However, some of the video comments as made by individual students were a little difficult to understand due to lack of English language proficiency and clarity with spoken language. In some cases, some of the responses were somewhat off-topic and failed to nail down the major expected arguments based on the individual group projects. But overall, for the participants, it was a good attempt and instructions were followed reasonably well, although there is much room for improvement in terms of content choice, delivery style, clarity of voice, and non-verbal gestures.

Table 5. Student data for the second stage of the creative factory project (making a presentation about LEGO project)

| Group | Number of individuals | Score |
|-------|-----------------------|-------|
| A     | 4                     | 0     |
| B     | 1                     | 2     |
| C     | 4                     | 3     |
| D     | 5                     | 5     |
| E     | 4                     | 2     |
| F     | 4                     | 3     |
| G     | 5                     | 5     |
| H     | 1                     | 3     |
Figure 5. Screenshot of the instructions related to the 3rd stage of the creative factory project based on which students handled and completed the project.

5.5. Individual design assignment
The individual design assignment was a preparation for the second creative factory assignment. Two major items were graded as part of this assignment; the ability to create prototype with CAD software and the ability to create a technical presentation explaining the process of creating the prototype of the LEGO product. Table 6 demonstrated the mean and SD value for the two categories tested as part of this assignment.

Interestingly, although there were 48 participants in the class, 22 students actually scored 0 in both categories, either because of inferior quality submission or because they failed to submit their assignment altogether. So, in reality, the score above is based on 26 active student participation. The average score in both categories for the 26 students are in the range of 3–3.5, with some scores touching 4.5 and 5 in both the categories.
5.6. Article analysis assignment

The article analysis assignment that followed the individual design assignment was an analytical writing exercise based on a review of different websites and concepts related to 3D printing, rapid prototyping, and LEGO use for rapid prototyping. The assignment was designed to make readers comprehend the concepts in manufacturing based on English reading. As the readings and questions included in the assignment are internally inconsistent and measured different concepts based on readings that are of variable complexity, it is difficult to carry out an evaluation of students based on grades alone. Rather, a few examples of student responses would help readers understand students' ability for conceptual understanding. Some of the responses were not up to the expected level, indicating that students were unable to grasp the basic concepts of the articles. However, few students spent some quality time reading the articles and links as evidenced during class observation. Those students could author responses that are reasonably meaningful and indicate time spent to comprehend the articles. However, clearly the grammatical construction and language ability have much room for improvement. Discussions during the class with the students and close observation of the student assignments demonstrated a better example of how some students could comprehend the crux of the article fairly well and the responses were not way off the mark. Assignment scores show a mean value of 4.936 in a scale of 10 and a SD of 3.286.

5.7. Second creative factory project

Similar to the individual design assignment, this assignment had various elements for evaluation and was based on skills that ranged from understanding the questions asked, ability to brainstorm the design of the website, write the text based on the assembly procedure for each CAD software and expectedly, a reasonable proficiency with language construction and writing text in one's own words was necessary. Some of the groups did reasonably well with their group assignment. Some of the group comments below reflect on the critical thinking that was carried out as a group. The English has been edited at the sentence level for readers to understand the major arguments embedded in the writing. The comments below are text from the student webpages on Tinkercad, 123D design and 123D make.

5.8. Group comment on Prototype 1 (LEGO and Tinkercad)

The role of LEGO is to make rough design. It is used for designing basic structures, but it is an important starting point. We made a cargo boat for this project using Tinkercad. A large scale design was prepared for the project. However, we had many problems along the way. We did not have adequate knowledge about design. The design of this product needed specialized knowledge. For example, we measured and calculated the distance of an angle. We used many materials over and over again. It took a lot of work to make something this way. In addition, it was necessary to start writing about the project on paper, and that was difficult for most of us in the group. However, anyone could easily design a product using LEGO. The challenge with LEGO was only to locate a favorite block freely. If the designer can think of both form and the size, that is freedom. Since we don't need to do anything on paper or using software, the data can be shared easily, and adjust many small parts as we wanted, by many people in the group. This exercise will be good for us. However, we can make similar products using LEGO. We could also use the Tinkercad software to make other designs.

5.9. Group comment on Prototype 2 (123D Design)

We could use 123Design in a better way than LEGO. This tool is suitable for a more exact design. This software helped us focus on a procedure where user sets form and the size of the block and the job is to mainly place it in the right place. This software has high flexibility and can help make various designs. There are many advantages of using this software as compared to LEGO. The first is to be able to draw a curve. The design with the three-dimensional impression is in this way enabled. Practically, we used most of the objects that are round in shape. Secondly, we could use slightly bigger parts, and divided the existing parts, whenever we needed. Out assembled design can show the advantage of these software features. However, assembling becomes somewhat comfortable when we get blocks with same size. The third is whether the design is compatible with 3D printers or for 3D printing. It is apt to think that the process of 3D printing involves difficult design issues.
and modeling. However, we can relatively easily design objects if we use this software. We converted a model afterward and made it ready for 3D printing. Many modeling problems could be solved with these techniques, and with the right environment.

5.10. Group comment on Prototype 3 (123D Make)

123D Make is available on all platforms including the Web applications. The application shown in Sandbox is placed with 123D family as a product for consumers, and a non-commercial version is basically available with a free of charge account. 123D Design is 3D CAD standalone software and is available for Windows and Mac OS X versions, and the Web version works on a Web browser corresponding to iPad version and Web GL is prepared for. It is orthodox for 3D CAD design and is suitable, though the accurate dimensions including the parts of a case and the block of the smartphone model were the required objects that we needed. The standalone version sketches a two-dimensional figure and uses the technique to lift it, and to become a solid mainly for 3D printing, but the models are primitive in the Web version, and we had to modify the three dimensional objects by transforming it from a base. Because we can apply many manufacturing methods such as cutting or the injection molding as well as 3D printer and other output services, if we can make 3D data-set, the choice of the material increases, and width of the manufacturing method opens up. The product could also be mailed and arrives at hand. We can show the 3D data that we uploaded on a cloud, and the fact that we can share data with other users is attractive.

* The instructor helped edit their original text in the webpage, and the text above is modified, and edited version of the original text as authored by the student groups.

The complexity of the text arguments made it difficult to put in a numerical grade for the text reply and critical thinking. So, a total grade was given for the group with a total judgment about how the assessment criteria were met, including the CAD software use and website design.

Table 7 showed the score on various dimensions of the second creative factory project. Fourteen points were assigned for the project.

Few groups faltered when using 123D Make and 123D Design. Close class observation and class interactions with group members suggested that the actual problem could also be related to lack of time management, group participation and coordination, besides the actual software-related learning curve. All the groups had acceptable design of the website. A score of “2” does not indicate a very professional level of website design, but rather it suggests that students tried to put up something reasonably acceptable. Further, data on text editing also suggested that the text had many grammatical errors and errors related to sentence construction. A score of “2” indicates lesser amount of grammatical errors and sentences which make sense when reading (might not be entirely grammatically correct).
6. Discussion

Data from the study indicate that students could use the diverse course tools and instruments in a way that suggest a PBL-based method are an acceptable approach to teaching foreign language. There is further indication from the observed data that critical thinking took place both in individual and group situations, and that it helps in the process of language acquisition. The data reiterate the probable fact that a TBLL approach is justified and valid in a technical university and a technical learning context.

The discussion of student performance in this course depicts an ideal case of Jean and Wenger’s (1991) notion of situated learning and social constructivism because of the product–process framework within which the different collaborative projects and social constructivist learning took place in this EFL context (Storch, 2005) that included extensive design pedagogy and analysis. The most interesting part of this course was the idea to use multiple media and resources towards technical documentation and presentation, and project completion through group collaboration. This approach technically promotes critical thinking in a foreign language context (Alagozlu, 2007; Massi, 2001). The History of LEGO assignment showed a relatively better performance with reading from the website or lecture notes, but a poorer performance when it came to video comprehension. This is probably because students at this level are not used to listening to technical presentations and discussions from any media whatsoever, especially in English. So, when they had to write analytically based on what they heard, the problems compounded even further. So, their listening skills are not up to the acceptable level. This is an interesting observation and a good indicator to understand how listening skills for technical presentations could be further improved in a computer science school, as is the case here. In this institution, EFL students take required listening courses in English during their Freshmen and Sophomore years, but the performance in this course clearly indicates that only 2–3 such courses are clearly insufficient and more work is needed, probably in a PBL context, where there could be more listening and doing tasks outside the classroom, and in a group context. This is probably where a flipped classroom model in a PBL context is more useful and instructionally more robust, promoting brainstorming, group collaboration, and peer review (Tucker, 2012). Extensive technical reading in an EFL context is a widely acceptable pedagogical structure (Iwahori, 2008; Robb & Susser, 1989). Interestingly, the class assignments as discussed here looked into procedure-based and technical topic-based readings as part of a larger project, which is little different from what Robb and Susser (1989) suggested. Robb’s focus was on extensive reading on a variety of topics. For this project, although student performance with the technical reading was better, students often used online translation software and Wordlio to get a grasp of the content in English. So, unlike an ideal technical reading context, it wasn’t possible to control the context in which students read the English text, or in many cases Japanese translation of the English text.

Skehan et al. (2012) advocated a strong form of the TBLT approach where task should be the unit of language learning. Following that strong form of TBLT, we adopted LEGO and CAD software to design products and write about it extensively and make oral presentations as follow-up assignments. Using LEGO in the language classroom was an ideal choice, consistent with past observations about how it help develop ideas in a technical context (Resnick & Ocko, 1991; Resnick et al., 1988). Interestingly, as noticed during class observation and reflected in the assignments, students were quite adept at the processes related to the physical assembly in class, and also when it came to preparing objects using CAD software such as Tinkercad and BuildwithChrome. Students mentioned that they did not have any prior experience handling the CAD software, but yet they did well using the software towards the design process. During the classwork where students worked with the CAD software in groups, different roles were informally assigned in 3–4 person groups, and everyone took care of an activity or provided consulting to the person who was working on the design. This enriched the process of critical thinking as the group had the responsibility to design a product that could work in real life, and so they can explain their design choices in writing as part of the product design report. So, they ideally had to think about what they were designing and how the software was used. With software such as Tinkercad and BuildwithChrome, the learning curve was simpler as compared to Autodesk, but the students tried to complete the project, although the product prototypes
between the software were not exactly comparable. But anyhow, this process of group design with several iterations facilitated group communication and discussions about product design, and that helped with the writing process that followed. Such an approach is consistent with Barnawi’s (2011) idea of how process-oriented activities in the classroom promote and help develop critical thinking.

Writing about own design and prototypes was a good example of constructivist learning (Kafai & Resnick, 1996) and one that promotes students’ creativity and problem-solving ability (Chambers & Carbonaro, 2003). The challenge was more prominent when it came to writing about the design process. Course grades and student interactions did show that without any experience with technical writing and critical reasoning, students struggled to relate to their own project with product and web design principles, as was used during the coursework. Student groups found the first and second creative factory projects particularly interesting, but challenging because not only did they have to work on the design prototypes, but they also had to work on different variations of the same product using multiple CAD software, reflect on how the software worked, write about the steps in the assembly process, and demonstrate organizational skills with website design. The student websites not only included text explanations and guidelines about their design, but also they had to understand how websites are and should be designed. The short lectures and instructions in the class helped them work on the assignments, but with significant communication problems within the group and with course instructor, the assignment completion became a challenging task. Ideally, the assignment should have started with a proper concept mapping of how the website about the product should look like, including the organizational style, the choice of content, the website tree, the importance and choice of linked pages, and so on (Roy, 2014; Roy & Crabbe, 2015). However, since the focus was on writing about the product design, the website design pedagogy itself took a back seat and wasn’t highlighted as much. Probably, in a more advanced technical writing classroom, and/or for courses with more E-learning and instructional design focus, the web design pedagogy would be more relevant.

EFL learners have a lot of anxiety about oral presentations, and preparing them for oral presentation as an effective communicative activity is challenging (King, 2002). However, previous studies in oral presentations in EFL context did not look into how a PBL-based approach could potentially facilitate better technical presentations, based on hands-on work done in collaborative class projects. Interestingly, once the assignments with LEGO and CAD software were completed and websites were designed, students did reasonably well preparing the technical presentations in PowerPoint/Keynote. They enjoyed including screenshots of the online and offline assembly processes in their technical presentations, and writing short captions to describe the processes. During the second creative factory project, students struggled to work on the design prototypes using three different CAD software, but the course was also designed to expose students to different resources, and help them think about the factory project as a summative management of different ideas, thinking, communication, design and documentation skills.

This course includes different activities, which are interconnected, and promotes adequate critical thinking, tinkering with various basic CAD software and physical LEGO blocks in a way that teaches design fundamentals and promote technical writing skills with critical thinking in a situated learning environment. This approach supports the 2013 MEXT ruling that English language education should emphasize learner-centered activities, grammar as a supplemental tool supporting communication, and de-emphasis of translation methods (Kotaka, 2013). The advantage with the PBL and TBLL-based language education is the focus on real task as the unit for language instruction (Skehan et al., 2012), but students with basic English language proficiency need repeated practice with design, sustained exposure, extensive reading, writing, video and website analysis, and other associated activities in a “do it yourself” learning environment.

6.1. Limitations and future research
A major problem in grading the assignment was that subjective judgment had to be used to evaluate the assignments based on the assessment criteria. But this approach to open-ended queries in design helped students to think critically and analytically about the design principles, processes, and
implementation procedures. One of the major drawbacks of the study is that student improvement could not be measured over time, based on very specific and measurable criteria. That could be possible with the help of multiple-choice quiz-based questions that can measure students’ understanding of the design principles, web-based organizational skills, reading comprehension ability from the design and technical text, video comprehension ability, and application contexts. Future research could focus on a specific course in technical writing where very specific critical thinking gets tested based on reading of design principles and technical communication principles. Further, a product–process approach to teaching writing (Badger & White, 2000) and design education is instrumental in guiding students towards better language acquisition skills. Because the creative factory projects, as discussed in this article includes collaborative writing and design, and group communication, the product–process approach ideally should also include interviewing students after each project to explore their individual understanding of the product and process (Storch, 2005). Future research must also explore the use of software such as LEGO Mindstorm in a writing classroom.

6.2. Implications for EFL teachers
EFL teachers teaching such PBL courses should keep in mind the following pedagogical approaches that could be helpful towards EFL language acquisition within a constructivist framework.

• Design is a complex process, and time should be allowed for students to grasp the concepts first, before indulging in any project.

• Use of LEGO could be a great tool and a hook to get students interested in exploring an idea they have. There could be many other physical tools and devices that could be used as a hook to initiate the process of critical thinking and writing in an EFL classroom.

• EFL teachers should have a good idea about the balance between the flipped and traditional classroom model, based on how such a LEGO-based writing course should be taught. That will depend on the context of the course, and the pedagogical orientation and inclination of the instructor, including the language proficiency of the student groups.

• Time should be spent in trying to figure out the balance between the writing and other communication skills and teaching of design principles that are possible in an EFL classroom. The discussed class has been taught as a technical writing course, which was possible because the students are in a technical university. However, in a humanities and/or social sciences context, an EFL course should not necessarily have the same orientation.

7. Conclusion
Process writing is often considered important in a project-based technical writing classroom because of its emphasis on linguistic skills such as planning and drafting, pre-writing with brainstorming, with minimal emphasis on grammar and text structure (Badger & White, 2000). A strong-form task based language teaching is precisely oriented towards this approach. The process approach also provides less feedback into the writing process, as learners are expected to learn language by handling the project itself, and by reflecting on their own potential to learn. This course on Writing and Design with LEGO precisely envisions writing and communication as a process approach. However, there is one difference. Unlike the process approach to writing, this course emphasized on students’ ability to reflect on the context of writing, as design is specific to the context of use and purpose. This course focused on different aspects of media use, critical thinking, and organization. However, a more genre-specific approach to teaching writing is important such that there is coherence between the subject matter, the writer and audience, and the pattern of organization (Martin, 1993).

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