Teaching Work Measurement Through Origami in Developing Countries

Boris Christian Herbas Torrico
Exact Sciences and Engineering Research Center (CICEI)
Bolivian Catholic University
Cochabamba, Bolivia
bherbas@ucb.edu.bo

This article attempts to describe challenges and opportunities for teaching work measurement in developing countries using the Japanese art of origami (paper folding). I initially present background information about the challenges of teaching work measurement to students from developing countries. Next, I suggest that origami-based instruction is related to Problem Based Learning (PBL) and can be used to teach work measurement, or other industrial engineering concepts, without depending on laboratories. Specifically, I present an origami-based project and its implementation by students from a Bolivian university. The basic strategy of the project is for students to put their hands to work to shape origami figures, and thus develop intuitions about work measurement for the calculation of average, normal, and standard times. Moreover, this strategy can also be used to teach students other industrial engineering concepts, such as learning curves, work standards, workplace cleanliness, poka-yokes, etc. As a consequence, origami-based instruction offers new opportunities for the development of practical, cheap, and environmentally friendly learning experiences. Therefore, *industrial engineering students will discover the joy of product creation by their own hands, where the possibility of creation from a paper is infinite.*

Keywords
Origami, PBL, Work Measurement, industrial engineering, and developing countries.

1. Introduction

Work measurement is included in virtually every operations management course. Probably, is one the must-studied subject in every industrial engineering undergraduate course. In particular, work measurement is concerned with determining the length of time it should take to complete a job (Stevenson 2015). Measured job times are vital inputs for capacity planning, workforce planning, estimating labor costs, scheduling, budgeting, and designing incentive systems. Despite global firm's process-automation, labor-intensive work in a factory is still common. Factory operators create value and their performance is instrumental in successful manufacturing firms. Thus, the measurement of operator's performance is a central part of their improvement and the factory's success. Arguably, it should not be surprising that the operator who is the fastest is generally the best performer.

Reporting operator's performance requires the development of standardized procedures for determining the standard time for an operation. The most direct method developed to date (time study), uses a stopwatch to measure the elapsed time for an operator working. The operator is timed and the analyst should also evaluate its relative pace through the estimation of a rating factor. When completing the worker´s time, the analyst multiplies the average observed time for each element of the operation by the performance rating factor for each element and sums these products to arrive at the expected rate of performance at a normal pace (normal time). Operators are not expected to work without rest or other allowances, and thus a non-work time is added to the normal time to obtain the standard time for the operation under analysis (Xandin 2001).

The materials needed to teach time study vary from university to university. Some universities have specialized laboratories with equipment dedicated to teaching it. For example, some universities use Legos or other assemblable objects to teach time study. However, as Xandin (2001) suggests, an analyst can make a usable time study with only the back of an envelope, a wristwatch, and a stubby pencil. In a higher education context, the time study should be accurate, understandable, and verifiable. Thus, most tools to teach work measurement are related to:

1. Time study watch with a digital display.
2. Clipboard with a bracket for time study forms.
3. Time study forms on paper or a spreadsheet.
4. Pencil.
5. Tape, ruler, or micrometer (depending on the distances and precision needed).
6. Stroboscope (in machine and equipment settings).
7. Calculator, cellphone, or a PC with a spreadsheet for arithmetic calculations.

Due to technological advances, although not precise but highly useful, many students also use:

1. Chronometer apps for PC or cellphone.
2. Spreadsheet apps for PC or cellphone.
3. Tablets.
4. Cellphone cameras.

The procedure for measuring the operator's performance generally needs:

1. Methods study: (i) analyze the job, (ii) operations analysis, (iii) equipment, and (iv) motion study.
2. Time study: (a) standardization, (b) selection of operator; (c) explanation to operator; (d) information recording (operation, equipment, part); (e) element breakdown; (f) time measurement (overall time, performance rating); (g) elemental time, (h) leveling, (i) allowances, (g) verification; and (k) record and file.

This article is about the educational use of origami in work measurement in a Bolivian University. The available literature, suggests that origami is a useful educational tool considering its several benefits ranging from cognitive to motivational gains (Arici and Aslan-Tutak 2002). Specifically, from a cognitive perspective, origami is connected to teaching science and technology. For example, research made by Hull (2013) suggests that origami has implications for teaching science and technology subjects, such as mathematics. Moreover, Cakmak et al. (2014) indicate that origami is also recommended to enhance geometric reasoning and spatial visualization. In particular, geometric reasoning is necessary for humans, robots, or other automation to manipulate, attach, and test parts and subassemblies (Wilson 1998). However, many people still think of origami as an art or a hobby without appreciating its teaching benefits. As I showed above, literature shows it has many applications for science and technology, such as industrial engineering, because it allows fitting big things into small spaces. Therefore, origami can be used to teach subjects related to industrial engineering, such as work measurement, in developing countries where there is limited availability of materials or specialized equipment.

2. Problem framework and related literature

2.1 Teaching work measurement in developing countries

Despite the apparent simplicity to teach work measurement, teaching industrial engineering in developing countries is challenging. One of those problems that affect the quality of teaching includes an increasing number of students in public and private universities (Maslen 2012). Another important challenge is the language universities use in teaching in developing countries (Dirk 2001), In Bolivia, all industrial engineering courses are taught in Spanish. It poses a challenge in the education sector as it becomes difficult for students to understand updated engineering content that is generally published in English. This challenge limits the student's capacity to study new scientific and technological advances, making them over-reliant on past literature. Moreover, globalization has caused a high demand for higher education in developing countries (Suresh and Kumaravelu 2017). Competition in the job market is causing individuals to compete for better positions. Moreover, the improvements in technology create a greater need for quality higher education for a growing number of students. However, a large number of students and scarcity of financial and technological resources make it difficult, for universities and faculty alike, to develop quality content and share enough educational resources for their students.

One of the limitations affecting public and private industrial engineering schools in developing countries is the lack of laboratories. Laboratory lectures in developing countries, due to a large number of students, lack of equipment, or unqualified staff, are scarce or short in course contents. This problem leaves the students with lots of practical knowledge written in handouts to study on their own, and without knowing its practical implementation, Thus, many industrial engineering graduates lack the practical knowledge to work to compete with students from privileged universities or students that studied abroad. Moreover, due to the COVID-19 pandemic and countries' quarantines, students are increasingly using virtual education to reduce the risk of infections (World Economic Forum 2020). Industrial engineering students are not strangers to this situation, and thus cannot physically attend university laboratories. Therefore, teaching industrial engineering in developing countries requires the development of innovations that overcome the lack of laboratories, resource limitations, and changes in physical education to virtual education.

2.2. Problem Based Learning (PBL)

According to Brodie (2011), education traditionally used the approach of learning by showing concepts in identifiable blocks, in a linear, or at least in a logical sequence. This approach implicitly suggests that learning is related to acquire a set of "rules" which must be practiced separately to be learned and only then can be applied. The practice of those learned knowledge relies on applying those rules to similar situations and with enough practice comes understanding and then the knowledge and rules can be applied to new or novel situations (Norman and Schmidt 2000). However, students are not empty vessels waiting to be filled with new knowledge. Moreover, those teaching practices may result in surface learning through memorization without a deep understanding of the subject under study.

Problem-based learning (PBL) is a constructivist approach to education that organizes curriculum and education around "unstructured" issues (Ram et al. 2007). The students learn critical thinking, problem-solving and collaborative skills directed by professors as coaches, to find problems, to devise ideas, to scan evidence, to perform tests, to generate solutions, and to determine the best solutions for the situation under analysis. Problem-based education allows students to adopt uncertainty, find meaning, and enjoy studying and improve their ability to solve real-life problems in innovative and responsible ways. PBL is grounded on adult education with cognitive psychology (Norman and Schmidt 1992), and has three stages: (i) the student faces a problem, as opposed to a fact or a theory; (ii) the problem is discussed and deconstructed in a small group setting; (iii) the problem and discussion motivate the student to undertake self-directed study and research framed by prior knowledge, understanding and gaps within these areas; and (iv) new knowledge is applied and learning summarized by reflection.

Students indicate that their lack of interest is due to the poor real-world relevance of their subjects. Studies by educational and cognitive psychologists indicate that problem- and project-based learning is centered around authentic problems and is more likely to motivate students to think deeply about the domain being learned (Ram and Leake 1995). In PBL, students are required to take on the responsibility of learning. Such students tend to be more motivated and to become better learners (Bereiter and Scardamalia 1989). Participation in the subject as if students are working on a daunting assignment leads to improved retention of students in science and technology (Ram et al. 2007).

Available evidence suggests that industrial engineering students learn better via PBL (Gosavi and Fraser 2013). Moreover, PBL makes engineering students think alone. PBL allows them to understand very substantially that all of the ideas in industrial engineering have been generated for one purpose and do not always exist in the body of knowledge. Industrial engineering is a creative, team-based, problem-solving profession that sits at the interface of science, technology, and society. Thus, students need the basic tools of industrial engineering and their applications to make management decisions, validate results, and solve actual managerial problems using PBL. However, is equally necessary the need to solve these problems in a team environment to meet future ethical, business, and organizational needs. The National Academy of Engineering (2004) suggests that the desirable attributes of future engineers must include:

- Working globally in a multicultural environment.
- Working in interdisciplinary and multi-skilled teams.
- Sharing of work tasks on a global and around-the-clock basis.
- Working with digital communication tools.
- Working in a virtual environment.

Therefore, universities need to give students different skills to cope with evolving technology and the global demands of the industrial engineering profession through the use of PBL. Future industrial engineers should be working not only in face-to-face teams but also in virtual teams. Particularly, working in virtual teams is challenging when students need to work in laboratories with specialized equipment, for example, work measurement. Moreover, since 2020, the pandemic of COVID-19 has moved most of the university courses to online learning (World Economic Forum 2020). Although online learning has shown to increase retention of information, and take less time (Chernev 2020), virtual methods cannot fully replicate the atmosphere of laboratory-based and face-to-face learning experiences. Moreover, as I mentioned above, in developing countries the lack of laboratories and resources furthers the problem. Therefore, in this article, I propose that industrial engineering instructors from developing countries should use PBL, such as origami projects, as a means that supports learning and teaching operation management in physical or virtual settings.

2.3. Origami and work measurement

In the last few years, there's been a lot more excitement about the engineering and science applications of origami (Morrison 2019). Origami is the art of paper folding. Using a sequence of folds, a piece of paper is turned into a 3-dimensional object or modules that may serve a utilitarian purpose (Meyer and Meyer 1999). Folding gives the student a way to think about shape transformation (Morrison 2019). Origami is recommended to enhance geometric reasoning and spatial visualization (Cakmak et al. 2014). Specifically, according to Wilson (1998) geometric reasoning is necessary for humans, robots, or other automation to manipulate, attach, and test parts and subassemblies. Moreover, spatial visualization is critical in operations management, for tasks such as product design, layouts, product assembly, line balancing, etc. Without spatial ability, students won't be able to modify spatial patterns and forms (Arici and Aslan-Tutak 2015). Thus, through origami projects, industrial engineering students can improve their geometric reasoning and spatial visualization abilities for operation management-related tasks.

Specifically, different attributes of the nature of origami can provide the potential for its use in teaching operations management, such as work measurement:

- Developing an origami project involves following a procedure (methods study).
- Different origami projects can be related to one another by examining the modification of general procedures (methods study).
- The procedure involves the manipulation of the paper by the student (time study).
- Teaching the creation of an origami project does not need a classroom, laboratory, or expensive equipment (suited for physical and virtual learning in universities from developing countries).
- Time measurement of an origami project is cooperative, applied, and student-centered (PBL).

The next section describes a PBL project in the form of an *origami work measurement project*. It is followed by an example. Finally, I present a summary and share my recommendations in the conclusion section.

4. Origami Work Measurement Project

The origami work measurement project has two parts. The first part depends on the instructor, whereas the second part involves teamwork. Initially, the instructor presents the origami project to the students in a physical or virtual setting. The strategy is to show an origami, with low to medium complexity, that motivates the students to finish it. Instructors have to consider that if the origami is too simple the students feel that the task is not worth their time. On the other hand, if origami is too complex, the students do not feel their abilities are enough and feel stressed. Moreover, in the selection of origami, the instructor should consider the element breakdown of the project, which should be easy for the students. When the origami does not allow any clear identification of work elements, the students feel confused and won't be able to correctly record the allotted time for each work element. Moreover, when students cannot identify work elements, their recorded times per element: (a) do not follow the normal distribution; and (b) show high skewness, variability, outliers, or multimodality.

Next, the instructor should assign students to manageable groups (3 to 5 students per group). To assign students to different groups, the student should decide from three methods: (i) allowing students to choose their own groups, (ii) allowing students to groups randomly (or arbitrarily), and (iii) attempting to engineer groups according to personal characteristics (Huxham and Land 2000). Afterward, each group, internally, should assign tasks for each group member (for example, who is going to be the operator? who is going to record the work elements? sample size? etc.), In distant learning settings, the students can work remotely using video-communication services such as Zoom, Google Meet, Skype, etc. For example, during the 2020 COVID-19 lockdown in Bolivia, students used their cellphones, tablets, or PCs to synchronically meet and record their times for the origami project using their built-in cameras. When students could not meet synchronically, they video-recorded themselves making the origami and then sent their videos to their group members to record the work times per element. The instructor should remind the students that the recorded times per work element should follow the normal distribution, and thus they should perform normality tests. Additionally, depending on the course contents, the instructor can ask the students to use the Westinghouse Performance Rating System (Freivalds and Niebel 2014), or any other methodology, to rate the operators and calculate normal times per work element. Furthermore, to calculate the standard times the instructor can give the students the standardized time allowances that he considers necessary.

Finally, the group is required to write a report documenting the rationales applied to each task. It is of vital importance that the group should report the definition of each work element and the recorded times per element. Moreover, the students have to present evidence of the normality tests for each work element. The quality of their distributions is important, as well as the logic for defining each work element because it will define good standard times. The report can include pictures or a video link showing the students making the origami as evidence of the activity. After the presentation of student reports, the instructor can use a virtual or physical class for the presentation of the reports and the exchange of learning experiences among students.

4.1. An example

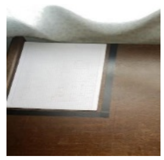
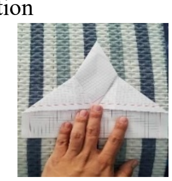
Project for the students: *In the next project you and your group should make an F15 Paper Origami Project (Lee 2005; Origamics 2017). This origami has particular steps that you and your group should follow. The links and detailed explanations of the origami are in the following links: (a) Lee (http://www.amazingpaperairplanes.com/fighterjet-FoldingF15Eagle.html); and (b) Origamics (https://youtu.be/NjmZUErPpmY). You and your group should write a report documenting the following activities:*

1. *Define the work elements that make up the origami.*
2. *Define responsibilities. For example, who records the data, who operate the stopwatch, who makes the origami, etc.*
3. *Develop a histogram for each work element and perform normality tests. If the recorded data meet the statistical criteria for the normal distribution, go to the next item. If the data does not meet the normality criteria, perform the data collection again.*
4. *Calculate the average time per work element.*
5. *Use the Westinghouse Performance Rating System to calculate the normal time per work element.*
6. *Calculate the standard time per item using the following time allowances: interference (0%), necessity (5%), contingency (2%), and fatigue (5%).*

Depending on the complexity of the origami project and the course contents, the instructor can also ask the students to develop other operation management-related activities, such as process layout design, line balancing, methods improvement, lean workstations, poka-yokes, value-added analysis, etc.

In the next table (Table 1) we show how one group of Bolivian students defined the work elements that make the assigned task:

Table 1. Work element definition

Work element	Activity start	Activity finish
Paper aircraft base	A rectangular sheet of paper 	• Fold the sheet of paper in a vertical position • Fold the 2 upper corners 
Folding of the aircraft wings	Fold the tip towards the top forming a rectangle at the back 	Fold the wing's ends to the center 
Folding the aircraft cabin	Formation of a triangle at each lower end 	Completion of aircraft cabin construction 
Shaping the plane and store	Folding the main wings and rear wings 	Paper aircraft finished and stored 

Next, the students recorded the time for each work element (Table 2):

Table 2. Recorded times

Start time day 1: 05:00 P.M. **End time day 1:** 06:00 P.M.

Start time day 2: 9:30 P.M. **End time day 2:** 10:15 P.M.

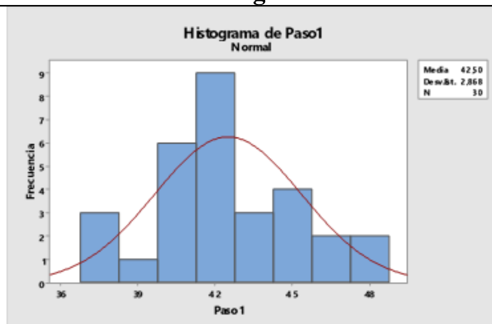
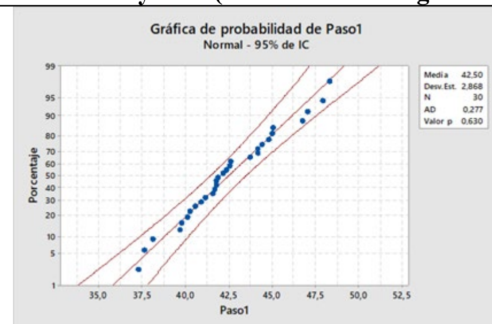
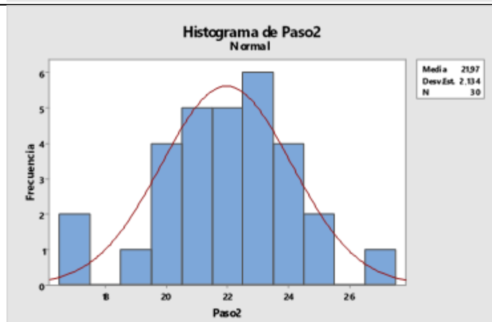
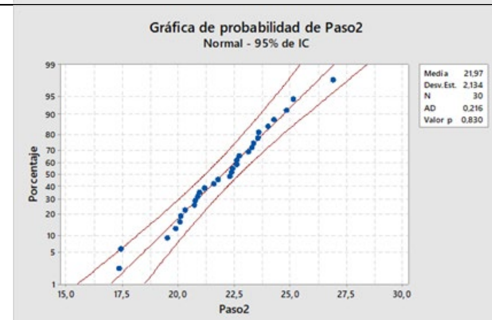
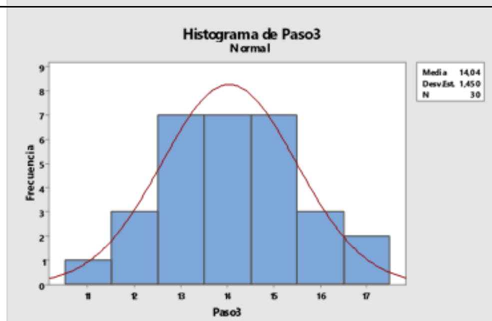
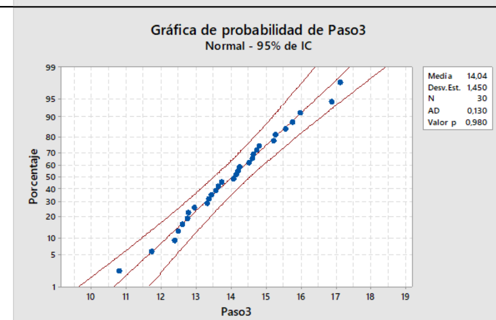
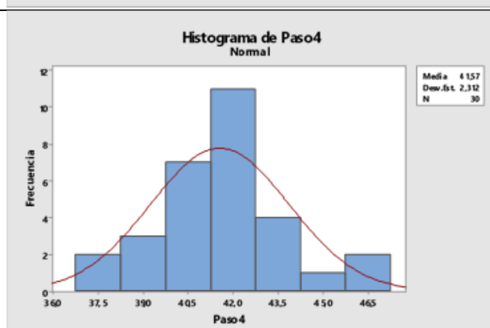
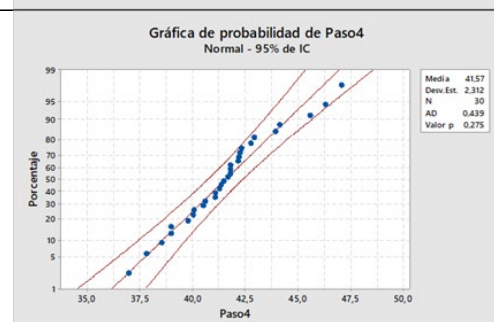
Analyst: Student Maribel Aguila **Date:** 30/11/20 to 31/11/20

Operator: Student Pablo Rivas **Sample size:** 30

Measurement Number	Paper aircraft base		Folding of the aircraft wings		Folding the aircraft cabin		Shaping the plane and store	
	T (sec)	R (sec)	T (sec)	R (sec)	T (sec)	R (sec)	T (sec)	R (sec)
1	46,74	46,74	26,88	73,62	14,72	88,34	47,08	135,42
2	47,93	183,35	23,11	206,46	14,81	221,27	41,80	263,07
3	45,06	308,13	23,36	331,49	15,22	346,71	41,28	387,99
4	42,60	430,59	22,59	453,18	15,75	468,93	41,34	510,27
5	43,73	554.00	22,28	576,28	13,32	589,6	42,24	631,84
6	41,78	673,62	20,74	694,36	14,60	708,96	41,46	750,42
7	40,53	790,95	22,38	813,33	12,61	825,94	41,07	867,01
8	44,97	911,98	25,14	937,12	13,63	950,75	38,99	989,74
9	39,67	1029,41	19,49	1048,9	15,27	1064,17	40,01	1104,18
10	40,11	1144,29	17,42	1161,71	14,64	1176,35	41,77	1218,12
11	47,03	1265,15	22,72	1287,87	15,97	1303,84	42,18	1346,02
12	39,78	1385,80	23,56	1409,36	17,12	1426,48	45,59	1472,07
13	42,18	1514,25	24,24	1538,49	14,13	1552,62	42,32	1594,94
14	41,78	1636,72	17,33	1654,05	15,57	1669,62	40,58	1710,20
15	41,87	1752,07	24,82	1776,89	16,88	1793,77	38,53	1832,30
16	40,25	1872,55	21,76	1894,31	13,43	1907,74	36,94	1944,68
17	40,87	1985,55	23,27	2008,82	13,35	2022,17	41,78	2063,95
18	41,66	2105,61	23,99	2129,6	14,52	2144,12	42,92	2187,04
19	44,16	2231,20	23,54	2254,74	12,94	2267,68	41,06	2308,74
20	44,79	2353,53	22,58	2376,11	13,73	2389,84	43,94	2433,78
21	44,17	2477,95	19,88	2497,83	13,55	2511,38	42,75	2554,13
22	41,14	2595,27	21,59	2616,86	14,23	2631,09	44,12	2675,21
23	44,39	2719,60	20,29	2739,89	12,75	2752,64	39,76	2792,40
24	48,30	2840,70	20,12	2860,82	12,39	2873,21	42,15	2915,36
25	42,56	2957,92	20,70	2978,62	12,78	2991,40	46,31	3037,71
26	41,59	3079,30	20,08	3099,38	12,47	3111,85	38,99	3150,84
27	42,36	3193,20	22,40	3215,60	11,73	3227,33	41,66	3268,99
28	38,10	3307,09	21,16	3328,25	10,79	3339,04	37,81	3376,85
29	37,61	3414,46	20,94	3435,40	14,18	3449,58	40,51	3490,09
30	37,26	3527,35	20,85	3548,20	14,07	3562,27	40,06	3602,33

Then the students developed the histograms and normality tests for each work element (Table 3):

Table 3. Histograms and normality tests

Work element	Histogram	Normality Test (Anderson-Darling Test
Paper aircraft base		
Folding of the aircraft wings		
Folding the aircraft cabin		
Shaping the plane and store		

As the histograms and Anderson-Darling test showed, the student recorded times for each work element are normally distributed ($p > 0.05$). Therefore, the average time per work element are as follow: (a) paper aircraft base, M = 42,50 and SD = 2,87; (b) folding of the aircraft wings, M = 21,97 and SD = 2,13; (c) folding the aircraft cabin, M = 14,04 and SD = 1,45; and (d) shaping the plane and store, M = 41,57 and SD = 2,31.

During the physical or virtual project presentation class, based on the histogram and the descriptive statistics, the instructor can ask questions to students regarding the form of the distributions, outliers, etc., such as (i) the importance of clear identification of work elements, (ii) the required time needed by the students to acquire the new skills or knowledge needed to record stable origami production times (learning curve), (iii) the effect of variability on production times, etc. Moreover, the instructor can relate those results with a manufacturing operator's performance due to idleness, boredom, trouble, difficulty, etc.

Next, the students used the Westinghouse Performance Rating System to calculate the normal time per work element and standard times. The results are summarized in the next table (Table 4):

Table 4. Normal and standard times

Westinghouse System of Rating	Paper aircraft base	Folding of the aircraft wings	Folding the aircraft cabin	Shaping the plane and store
Skill	0,06	0,06	0,03	0,03
Effort	0,08	0,05	0,08	0,05
Conditions	0,02	0,02	0,02	0,02
Consistency	0,01	0,01	0,03	0,00
Algebraic sum	0,17	0,14	0,16	0,10
Performance rating	**1,17**	**1,14**	**1,16**	**1,10**
Average time	**42,50**	**21,97**	**14,04**	**41,57**
Normal time	**49,73**	**25,05**	**16,27**	**45,73**
Standard time	**55,70**	**28,06**	**18,22**	**52,12**

In the physical or virtual project presentation class, the instructor should discuss the meaning of students' results. For example, in this particular student report, the algebraic sum showed that the operator was above the average (performance rating higher than 1). Moreover, the results showed that time allowances of the standard time are on average 6 seconds higher than the average time per working element. Moreover, the instructor should discuss the implications of these results in a manufacturing environment. For example, the inexistence of time allowances causes the dehumanization of the work environment and its negative effects on the operator's wellbeing. Additionally, the instructor can discuss the effects of having badly calculated standard times and their relationship on workers' morale, productivity, and the country's labor laws.

5. Conclusions

Generally, using origami in universities is far from a regular phenomenon, particularly because this art is not adequately marketed and many instructors are not aware of its implications for the development of learning experiences. Moreover, they tend to regard origami as *child's play*. However, as this article showed, it helps to convey industrial engineering concepts without mentioning the joy of creating something yourself. Moreover, allow students to learn critical thinking, problem-solving and collaborative skills (PBL). Furthermore, solves a common problem in developing countries: lack of laboratories. Also, origami can be used to teach industrial engineering concepts in virtual education settings (e.g. during the COVID-19 lockdowns). Therefore, due to its visual and practical nature, origami-based instruction helps students from developing countries to see more easily the connections between origami projects and industrial engineering concepts.

Although origami-based instruction has many benefits, it can also be challenging for industrial engineering instructors. First, origami-based instruction requires a lot of time from instructors for decisions regarding the generalization of concepts from an origami project. Second, the instructor should ensure that the student does not walk away with an incorrect understanding of the concept under analysis. Third, the learning curve for origami-based learning depends on the instructor, until he gets used to origami-based instruction. Thus, instructors would dismiss origami-based instruction because is easier to teach from textbooks that do not use PBL. Therefore, preparing origami-based instruction will increase the time needed to prepare the class, and needs extra effort by the instructor.

Despite the limitations mentioned above, in developing countries, origami-based instruction offers new opportunities for the development of practical, cheap, and environmentally friendly learning experiences. Specifically, from an attitudinal perspective, it is clear that the students change when working on origami-based projects. Over the last five years, I have been using origami-based instruction to teach work measurement (and other industrial engineering concepts). As a consequence, I found that student analytical capabilities have increased as a result of working with origami projects, and at the same time, students have consolidated concepts of industrial engineering (particularly methods development). Besides, certain industrial engineering concepts (e.g. learning curves, work standards, workplace cleanliness, poka-yokes, etc.) are best learned by students because they can use them in a new context, which is both meaningful and pleasurable. Moreover, as already mentioned above, in developing countries due to the lack of laboratories and resources, this practical learning context generally is absent in actual industrial engineering courses. Also, concerning the creative aspect of origami, the mixture of forms and colors seems to have enabled students to grow their esthetic sense, creativity, and artistic sensibilities, which is necessary for industrial design. Furthermore, the recycling of paper increases students' awareness of our climate and the environmental harm created by throwing to garbage used paper that can still be used to create origamis. Therefore, *industrial engineering students will discover the joy of product creation by their own hands, where the possibility of creation from a paper is infinite*.

References

Arici, S., and Aslan-Tutak, F., The effect of origami-based instruction on spatial visualization, geometry achievement, and geometric reasoning, *International Journal of Science and Mathematics Education*, vol. 13, no. 1, pp. 179–200, 2015).

Bereiter, C., and Scardamalia, M., *Intentional Learning as a Goal of Instruction,* In *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser*, Lawrence Erlbaum Associates Inc., Hillsdale, NJ, U.S., 1989.

Brodie, L., Delivering key graduate attributes via teams working in virtual space, *International Journal of Emerging Technologies in Learning*, vol. 6, no. 3, pp. 5–11, 2011.

Cakmak, S., Isiksal, M., and Koc, Y., Investigating effect of origami-based instruction on elementary students' spatial skills and perceptions, *The Journal of Educational Research*, vol. 107, no. 1, pp. 59–68, 2014.

Chernev, B., 27 Astonishing E-learning Statistics for 2020, Available: https://techjury.net/blog/elearning-statistics/#gref, 2020.

Damme, D. Van., Quality issues in the internationalization of higher education, *Higher Education*, vol. 41, no. 4, pp. 415–441, 2001.

Freivalds, A., and Niebel, B. W., *Niebel's Methods, Standards, and Work Design,* 13th Edition, McGraw-Hill, New York, 2014.

Gosavi, A., and Fraser, J. M., Problem-based learning and industrial engineering, *Proceedings of the ASEE Annual Conference and Exposition*, Atlanta, U.S., June 23 – 26, 2013.

Hull, T., *Project Origami: Activities for Exploring Mathematics*, 2nd Edition, CRC Press, Florida, U.S., 2013.

Huxham, M., and Land, R., Assigning students in group work projects. Can we do better than random?, *Innovations in Education and Teaching International*, vol. 37, no. 1, pp. 17–22, 2000.

Lee, K., F-15 Eagle Paper Airplane Folding Instructions, Available: http://www.amazingpaperairplanes.com/fighterjet-FoldingF15Eagle.html, 2005.

Maslen, G., Worldwide Student Numbers Forecast to Double by 2025, Available: https://www.universityworldnews.com/post.php?story=20120216105739999, 2012.

Meyer, D., and Meyer, J. Teaching mathematical thinking through origami. *Bridges: Mathematical Connections in Art, Music, and Science*, pp. 191–204, 1999.

Morrison, J., How origami is revolutionizing industrial design, Available: https://www.smithsonianmag.com/innovation/theres-origami-revolution-industrial-design-180972019/, Accesed on March 19, 2021.

National Academy of Engineering, *The Engineer of 2020: Visions of Engineering in the New Century*. National Academies Press, Washington, D.C., 2004.

Norman, G. R., and Schmidt, H. G., The psychological basis of problem-based learning. *Academic Medicine*, vol. 67, no. 9, pp. 557–565, 1992.

Norman, G. R., and Schmidt, H. G., Effectiveness of problem-based learning curricula: Theory, practice and paper darts. *Medical Education*, vol. 34, no. 9, pp. 721–728, 2000.

Origamics, Easy Paper F-15 Fighter Jet, Available: https://youtu.be/NjmZUErPpmY, 2017

Ram, P., Ram, A., and Sprague, C. From student learner to professional learner: Training for lifelong learning through on-line PBL. *Proceedings of the International conference problem-based learning* (PBL-05), Singapore, March 15 – 17, 2007.

Ram, A., & Leake, D., *Learning, Goals, and Learning Goals*. In *Goal-Driven Learning,* MIT Press, Cambridge, MA, U.S., 1995.

Stevenson, W. J., *Operations Management*, 13th Edition, McGraw-Hill Higher Education, New York, 2015.

Suresh, E. S. M., and Kumaravelu, A., The quality of education and its challenges in developing countries, *2017 ASEE International Forum,* 2017.
Wilson, R. H., Geometric reasoning about assembly tools, *Artificial Intelligence*, vol. 98, no. 1–2, pp. 237–279, 1998.
World Economic Forum, The COVID-19 Pandemic has Changed Education Forever: This is How. Available: https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/, 2020
Xandin, K. B., *Maynard's Industrial Engineering Handbook*, 5th Edition, McGraw-Hill, New York, 2001.

Biographies

Boris Christian Herbas-Torrico is a Professor of industrial engineering at the Bolivian Catholic University in Cochabamba, Bolivia. He earned his B.S. in Industrial Engineering from the University Mayor of San Simon in Bolivia. In 2007 he was awarded the Monbukagakusho Scholarship from the Japanese Ministry of Education, Culture, Sports, Science, and Technology to do his graduate studies in Japan. He received a master's and doctoral degree in industrial engineering and management from the Tokyo Institute of Technology (Japan). He has published journal and conference articles in the U.S. Japan, Europe, and South America. He received the 2012 Research Award from the Japanese Society for Quality Control. Additionally, in 2013 he was awarded the Nikkei Quality Control Literature Prize (Nikkei Keizai Shimbun). Moreover, in 2018 he was recognized by the Bolivian Senate for his contributions of science and technology to the country. In 2019 he was a visiting researcher at Waseda University (Japan). He has written two books and is an editorial board member for journals and conferences in Bolivia and abroad.