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Articles

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The current issue is the second of the seventh volume of the *Athens Journal of Sciences (AJS),* published by Natural & Formal Sciences Division of ATINER.

Gregory T. Papanikos, President, ATINER.

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Awareness and Compliance on Waste Segregation: Implication to a Waste Management Program in a University

By Bretel B. Dolipas[*], Jennifer Lyn S. Ramos[±], Monica S. Alimondo[‡], Phil S. Ocampo[+] & Danni Loven A. Fulwani[♦]

Proper disposal is among the most important aspects of a waste management program in an educational institution. This study was conducted in a university situated in the northern province of the Philippines and presents students' level of awareness on waste classification and their compliance level on proper waste segregation. A questionnaire was used to measure the level of awareness, whereas compliance level was measured through the audit of disposed wastes collected on segregated waste bins within the vicinity of the university. An average level of awareness on biodegradable waste was recorded among students, except for third year students who showed low level of awareness on this type of waste. Moreover, regardless of the type of residence, students showed low level of awareness in classifying waste. Generally, students' compliance level on waste segregation was very low. Registered low levels of awareness among university students may be linked to inadequate awareness campaign of the university, while low compliance level on proper waste segregation somehow calls for augmented forces to ensure strict compliance. Increased information dissemination and education campaign measures are recommended.

Keywords: *Awareness, Compliance, Waste segregation, Waste audit, Year level, Waste location.*

Introduction

With the aim to address the growing problem on solid wastes in the country, the government of the Philippines has enacted the Ecological Solid Waste Management Act of 2000, known as Republic Act no. 9003, declaring the policy of the state to adopt a systematic, comprehensive and ecological solid waste management program which includes the creation of the necessary institutional mechanisms. The following are included: collection as an act of removing solid waste from the source or from a communal storage point; disposal refers to the discharge, deposit, dumping, spilling, leaking or placing of any solid waste into or in an land; materials recovery facility includes solid waste transfer station or

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sorting station, drop-off centre, a composting facility, and a recycling facility. In addition, segregation at source shall refer to a solid waste management practice of separating, at the point of origin, different materials found in solid waste in order to promote recycling and re-use of resources and to reduce the volume of waste for collection and disposal.

Non-compliance to Republic Act 9003 poses legal obligations. However, it is not only due to legal reasons why proper waste segregation is encouraged. In fact, waste segregation is the first step in a conformable waste management program; it supports the concept of helping keep a good environment for protection of human health; and leads to income generation resources and cost savings for institutions (Premier Waste 2017). Further, taking into consideration the correct waste bin where one puts the type of garbage really matters (EMS 2016).

Practicing proper waste segregation at source accounts for several essential consequences; effective segregation of wastes means less waste goes to landfill. Segregated wastes are cheaper to dispose since it does not call for manual and mechanical sorting of mixed wastes (EMS 2016). For unsegregated wastes, post-collection segregation demands additional time and costs; it can wind up harming the environment especially when recyclable wastes are being sent to landfill (Premier Waste 2017). In addition, financial gains motivated residents of certain community to make the habit of waste segregation (Bulay-og 2010).

Implementation of institutional waste management programme faces different threats and challenges; among the simplest way to deal with these before it starts is by imposing strict proper segregation of waste at source. In 2007, prior to the order of strict implementation of local ordinance on waste management of the local government of (LGU) of La Trinidad, Benguet State University (BSU) implemented the so called "Eco-Waste Management Program" (EWMP) in response to the mandate of Republic Act 9003. The focus and objective of the said programme is proper waste segregation at source. EWMP consisted of four major components namely information, education and communication (IEC); collection and transportation (C&T); materials recovery facility (MRF) and research, training and development (R,T&D). Information and Education Campaign component has been in charge on the orientation of the different stakeholders of the university on proper waste disposal. It endeavored to familiarize the University of the Three-Bin System (recyclable, biodegradable, residual) to pertain to the classification of waste generated by the university.

Implementation of waste segregation at source in the university evolved over time. To facilitate easy compliance, individual garbage bins are removed, non-segregated waste bins were replaced by color coordinated segregated bins which were installed around the campus and offices. However, confusion was observed on what waste goes into the right bin. Further improvements were then introduced. The segregated bins were labeled with pictures. Moreover, to encourage maximum resource recovery, paper bins have been installed among offices; 'bussing' areas have been placed in the canteens to facilitate food waste segregation. Educational signages were installed to reduce stream contamination as much as possible. While it is true that BSU laboratory rooms produce some toxic wastes, these wastes were among the university's limitation when it comes to its proper disposal, thus, these goes out of the university and taken care of by the LGU's general services. Purchase of university garbage truck and installation of material recovery facility (MRF) are proposed to encourage maximum segregation at source, however, due to limited budget, it was yet to happen.

In October 2009, the first BSU waste audit was carried out and results revealed a high degree of misunderstandings about the appropriate disposal of food scraps, wrappers/sachets, plastic bags, tissue/wet paper, plastic bottles and Styrofoam. Two months later, a follow up waste audit and environmental awareness survey was conducted. Results bared a high degree of misunderstanding about the appropriate disposal of non-bottle (hard plastics), drinking straws, electronic equipment, plastic bags and ink cartridges; while disposal of foil, tissue/wet paper, Styrofoam, wrappers/sachets, tetra packs and ink cartridges are misunderstood to a lesser extent. Nevertheless, the BSU community clearly manifested excellent understanding and do practice correct disposal of plastic bottles and food wastes at home; however, these knowledge and awareness is not evident when inside the campus.

Since then, the implementation and compliance on proper waste disposal and segregation in the university was not studied nor evaluated whether it is known to target or not. The researchers perceived that there is a need to heighten waste management measures to ensure full participation and support in the advocacy on proper waste disposal and segregation. It is certain that viable mechanisms to re-introduce the university's EWMP are imperative. To address this concern, the study was undertaken to assess the awareness and compliance levels of students in the university's waste segregation scheme and provide relevant information on ways to improve its waste management program for a wider participation of the university community.

Materials and Methods

The study was conducted in one of the state run universities in the Philippines, situated in the heart of the municipality of La Trinidad, province of Benguet (16.42° N, 120.62° E). It is part of a project spearheaded by several faculty members belonging to one of the departments in the College of Arts and Sciences. As the college was designated to take charge of the IEC component of the university's EWMP, this project was conceptualized in response with the need to assess the mentioned programme.

A total of 511 undergraduate students enrolled during the school year 2015-2016 were randomly selected to participate in the study. Demographic variables such as year level and the type of residence where participants are currently residing were considered. A questionnaire was utilized to determine the level of awareness of students in classifying wastes into the category set by the university's EWMP. The respondents were asked to classify a list of wastes into residual, biodegradable and recyclable by placing a check mark under each type of waste. Percentage of wastes correctly classified was determined and assigned in a 5-point Likert scale as follows: very low awareness (VLA), 1-60%; low awareness (LA), 61-70%; average awareness (AA), 71-80%; high awareness (HA), 81-90%; and very high awareness (VHA), 91-100%.

To measure the level of compliance of students in segregating wastes, a waste audit from randomly selected segregated bins situated outside and inside the building structures within the vicinity of the university was conducted. And to generate the needed data, the contents of the segregated waste bins were checked by recording both the number of pieces of wastes correctly and incorrectly disposed in each bin; red bin for residual, green bin for biodegradable and yellow bin for recyclable. Percentage of correctly disposed waste is then determined. A 5-point Likert scale with the same range as shown previously was assigned with the following descriptions: very low compliance (VLC), low compliance (LC), average compliance (AC), high compliance (HC) and very high compliance (VHC). Test for homogeneity of data based on the groupings were conducted and attained before further analyses were done.

Data was analysed using ANOVA test to compare the level of awareness of students when grouped according to year level and their type of residence. The one-sample t test was used to compare the compliance level of students to average compliance. All data was tested at 0.05 level of significance.

Results

Demographic Variables and Awareness

Results indicate that students in all year levels exhibited a very low level of awareness on residual type of waste while low level of awareness on recyclable type of waste (Table 1). Whereas students in all year levels have average level of awareness on biodegradable type of waste except for third year students with low awareness level. In addition, there are no significant differences on the level of awareness of students in the different year levels on residual and recyclable type of wastes. However, the differences in the level of awareness of third year students on biodegradable type of waste compared to the other year levels is found to be significant given by *F* value of 2.956 significant at 0.05 level of significance.

Table 1. *Level of Awareness of Students on Type of Waste Classification when they are Grouped according to Year Level*

Type of Waste Classification	First Year		Second Year		Third Year		Fourth Year		*F* value
	%	DE	%	DE	%	DE	%	DE	
1.Residual	50.13	VLA	53.35	VLA	50.53	VLA	54.76	VLA	1.080^{ns}
2.Biodegradable	72.00	AA	74.82	AA	65.11	LA	71.24	AA	2.956*
3.Recyclable	69.33	LA	67.56	LA	65.60	LA	69.05	LA	0.633^{ns}

DE-Descriptive Equivalent, VLA-Very Low Awareness Level, *-Significant at 5% level, LA-Low Awareness Level, ns-Not Significant, AA-Average Awareness Level

Students who are not residing within the university premises have a very low overall level of awareness on the type of waste classification while those who are staying within the University have low overall level of awareness (Table 2). This is also true for residual type of waste. Furthermore, students living in the four different types of residence have low level of awareness on recyclable type of waste. As for the level of awareness on biodegradable type of waste, it is average for students residing in their own house and relative's house while low for the other students who are renting. However, the differences in the levels of awareness of students on each type of waste classification when they are grouped according to type of residence are found to be not significant.

Table 2. *Level of Awareness of Students on Type of Waste Classification when they are Grouped according to Type of Residence*

Type of Waste Classification	**Apartment/ Boarding House**		**Family-Owned**		**Relative-Owned**		**Within university**		**t value**
	%	**Des**	**%**	**Des**	**%**	**Des**	**%**	**Des**	
1.Residual	50.51	VLA	53.86	VLA	50.33	VLA	60.42	LA	1.415^{ns}
2.Biodegradable	69.87	LA	71.83	AA	73.33	AA	70.00	LA	$.549^{ns}$
3.Recyclable	67.90	LA	69.61	LA	67.32	LA	63.54	LA	$.484^{ns}$
Overall	50.51	VLA	51.86	VLA	59.33	VLA	68.20	LA	1.535^{ns}

Ns-Not Significant, VLA-Very Low Awareness Level, LA-Low Awareness Level, AA-Average Awareness Level

Compliance at Different Locations

The students have a very low overall compliance level on the segregation of the different type of waste as indicated by the overall mean of 48.14 (Table 3). Further, the residual compartment of the segregated waste bins installed within each building exhibited average to high level of compliance in almost all the buildings, except for the college of Arts and Sciences with a very low compliance level. With the audited biodegradable and recyclable waste bins, the highest level of compliance was recorded at the RSDC building for biodegradable wastes and Animal Science building for recyclable wastes; other colleges/buildings however, had very low compliance level. The RSDC building houses one of the canteens in the university so the bulk of the wastes are food scraps and leftover food which are biodegradable wastes.

The very low result as an overall level of compliance poses a disturbing fact. The university students' compliance on proper waste segregation is significantly lower from the hypothesized average level of compliance (computed t-value = -5.434, highly significant at 0.05 level of significance). Moreover, considering the idea that among the type of wastes, biodegradable seems to be the easiest to comply with; on the contrary, it displayed a very low level of compliance conveying a vituperative implication. Similarly, compliance for recyclable type of wastes is significantly lower than the average level (computed t – value = - 5.737, highly significant at 0.05 level of significance). This communicates a need to examine what lead these young adults to comply poorly, at the lowest level on all type of wastes.

Table 3. *Level of Compliance of Students on Waste Segregation according to Type of Waste Classification at Different Locations*

Waste Bin Location (Building)	Residuals		Biodegradable		Recyclable		OVERALL	
	%	Des	%	Des	%	Des	%	Des
Engineering	76.08	AC	26.69	VLC	16.03	VLC	39.60	VLC
HK	72.62	AC	0.00	VLC	12.50	VLC	28.37	VLC
Open University	79.53	AC	0.00	VLC	53.85	VLC	44.46	VLC
Soil Science	88.08	HC	61.11	LC	40.00	VLC	63.06	LC
Library	77.19	AC	37.04	VLC	75.00	AC	63.08	LC
Arts and Sciences Annex	81.86	HC	31.82	VLC	23.18	VLC	45.62	VLC
Veterinary Medicine	81.97	HC	50.00	VLC	14.35	VLC	48.77	VLC
Teacher Education	86.35	HC	0.00	VLC	0.00	VLC	28.78	VLC
Animal Science	70.70	LC	36.01	VLC	89.58	HC	65.43	LC
RSDC	79.06	AC	86.90	HC	43.48	VLC	69.81	LC
Arts and Sciences	53.54	VLC	25.63	VLC	25.96	VLC	35.04	VLC
Nursing	89.14	HC	51.66	VLC	21.86	VLC	54.22	VLC
Overall	77.86	AC	33.35	VLC	33.22	VLC	48.14	VLC
t value	1.013^{ns}		-5.798**		-5.737**		-5.434**	

**-Highly significant at 5% level of significance, VLC-Very Low Compliance Level, ns-Not Significant, LC-Low Compliance Level, AC-Average Compliance Level, HC-High Compliance Level

Discussion and Conclusions

This study assessed students' awareness and compliance levels in a waste segregation scheme set forth by the university's waste management programme, from which implications were drawn to come up with ways to improve the current program.

With waste segregation at source as the aim of the university's EWMP, a wider understanding of what this entails among all concerned is crucial. However, there appears to be a gap between purpose and implementation. Contrary results emerged from this study where students have difficulty in categorizing wastes into residual, biodegradable and recyclable as indicated by their low levels of awareness. Previous studies share this result where students have limited knowledge on recyclable and residual wastes (Budin et al. 2007); on the range of materials that can be recycled (Kaplowitz et al. 2009); and on what waste is and identifying recyclables (Grodzinska-Jurczak et al. 2003). More importantly, knowing what to put in which bin is fundamental in the segregation process; unfortunately, students did not even reach a level where putting wastes into the proper bin is done correctly. Such implicates a crucial drawback in the manner of waste segregation.

Role of Demographic Variables to Level of Awareness

Whether a student is a senior or freshman does not necessarily translate to having more exposure in the school's waste management programme. All students, regardless of year level, have very little idea on what wastes to put in residual and recyclable bins. It is possible that students have the mistaken idea that everything can be recycled so long as it is in good condition. Wastes that are supposed to be under residual category could have been considered as recyclables. Similarly, Barloa et al. (2016) did not find year level a factor on students' waste management knowledge. However, year level becomes a factor in the case of biodegradable type of wastes. Third year students have lower awareness on this waste category compared with the rest of the students in other year levels.

Where students reside does not indicate how well they know to classify wastes. Findings in this study show that students residing from all types of residence have limited knowledge on the classification of wastes into residual, recyclable, and biodegradable. Surprisingly, students who are staying in the university dormitories did not differ from those staying outside of the university when they were supposed to be more familiar with the university's waste segregation scheme. In addition, most of the students who participated in the study even claim that they practice waste segregation in their current residences (Dolipas et al. 2018). While this might be the case, it appears that the segregation scheme being used is not in consonance with the scheme set forth by BSU-EWMP. In context, this inference corresponds to what McDonald and Oates (2003) identified as respondents "practicing alternative way to the scheme" or "demonstrating a behavior outside of the scheme".

Altogether, demographic variables used in the study were shown not to matter where waste segregation behavior of students is concerned. Thus, when addressing the need to improve the current programme, measures taken should consider all year levels as well as reiteration of the university's critical role in spreading awareness that should reach the students' households.

Compliance Level and Implications

Color-coded segregated waste bins were placed at different buildings within the premises of the university. Yet, students do not know the correct bin to dispose of their wastes as evidenced by the waste audit done during the conduct of the study. This dismal result could be indicative to failure of the current waste management programme to adequately provide waste segregation logistics. If this is the case, then a revisit to the present implementation process becomes a necessity. Logistics issues cited by previous studies that ought to be considered are procedural directions or scheme-specific information such as *what type of waste* and *where to put the waste* could be lacking or inadequate; the size, design, number or location of waste bins might be inconvenient for students to comply; and information campaign and dissemination efforts could be insufficient or non-existent (Barr et al. 2003, Kaplowitz et al. 2009, Kelly et al. 2006, Mason et al. 2004, McDonald and Oates 2003, Sin-Yee and Sheau-Ting 2016).

While the problem could lie in the implementation process of EWMP, other underlying factors might be present as well. This may stem from issues of what happens next after waste segregation at source is done; segregated wastes must go somewhere else. If proper execution of subsequent processes such as materials recovery and collection is not evident to students, then their participation would be perceived as useless (Kelly et al. 2006).

Challenges and Measures for Improvement

The university is faced with two intermingling challenges: firstly, address low awareness and compliance levels by fostering a positive attitude among students towards proper waste segregation as well as increasing their participation in this correct practice; also, address the problematic state of its waste management programme by improving logistics issues to intensify the involvement of students in segregating wastes within the university.

Through its IEC component, the university could address insufficient understanding about the programme, particularly on waste segregation. Focusing on measures that would increase students' awareness level might also lead into correct practice of segregating wastes. Previous studies support this claim where higher levels of knowledge or understanding about waste management correspond to proper behavioural practices (Barr et al. 2003, Kelly et al. 2006). One such measure is by providing clear instructions in segregating wastes; where, according to past studies play a vital role in fostering positive behaviour in waste management (Barr et al. 2003, Budin et al. 2007, Doctor 2015, Kaplowitz et al. 2009, Sin-Yee and Sheau-Ting 2016). Instructions could be in the form of the "what", "how" and "where" (Barr et al. 2003, Kaplowitz et al. 2009, McDonalds and Oates 2003). Hence, improvements should be done in the existing scheme used in the EWMP; instructions on what waste goes into the right color coordinated trash bins should be made very clear – red for residual wastes, green for biodegradables, and yellow for recyclables. This would be easier for the university community to remember and act upon. Moreover, these instructions should also be properly and widely disseminated employing all possible means of communication, whether in written or verbal form and should be done frequently (Iyer and Kashyap 2007, Sin-Yee and Sheau-Ting 2016). Existing signages should be modified and placed strategically; inclusion of these instructions should be revived during orientation programmes; conduct of regular information campaigns should be taken by each college as their responsibility since they know what is suitable for their students. Also, promotional campaigns spearheaded by student organizations and/or the university could be conducted that may involve monetary or non-monetary incentives as these measures were found to motivate students to participate in pro-environmental activities (Iyer and Kashyap 2007, Kaplowitz et al. 2009, Marcell 2004, Sin-Yee and Sheau-Ting 2016). Constant verbal reminders on proper waste segregation practices could likewise be provided by college teachers in their classes, as suggested in a study identifying the characteristics that would promote proper waste segregation behavior (Sin-Yee and Sheau-Ting 2016). Consequently, whatever information dissemination strategy to be used, the design must be tailored to the target audiences (Kaplowitz et al. 2009, Meneses 2006). Further studies could be done in this regard.

In the scheme of the university's EWMP, what is important would be the corresponding action – properly segregated waste at source. Hence, additional measures should also be done to address low compliance levels. From previous studies, having sufficient or high levels of knowledge on waste management does not necessarily translate to correct practice (Barloa et al. 2016, Ehrampoush and Moghadam 2005, Grodzinska-Jurczak et al. 2003). Accordingly, attention should be placed on factors that may hinder people to put into good practice what they already know. Identified in several studies are external condition such as convenience along with internal factors such as attitude and perception (Barr et al. 2003, Kelly et al. 2006, Sin-Yee and Sheau-Ting 2016). The issue on convenience could be addressed through improvement of logistics in the waste segregation scheme such as provision of greater number of segregated waste bins located at accessible areas as well as prompt and proper collection of segregated wastes to prevent overflowing and mixing of separated wastes. Moreover, the university could adopt some actions similar to what past studies have shown that would foster positive attitude among students to proper waste management. An example of this is the implementation of a school-based environmental education programme in which specifically-designed waste management educational sets were utilized in classrooms and practical activities were integrated in the current curriculum (Grodzinska-Jurczak et al. 2003). To make such programme applicable in the university setting, a modification in its design would be done such as involving the students themselves in the actual experience of pro-environmental activities (Marcell et al. 2004, Mason et al. 2004). Another modification may use a project-based approach; suggested for future studies.

In retrospect, the analysis of the present level of awareness and compliance on waste segregation in the university lead to several implications about the state of the current EWMP. This is crucial since waste segregation is regarded as the primary step in a waste management program (Premier Waste 2017). Mechanisms for improvement were put forward with the expectation that the mandates of the university's waste management program would be fully realized, thus, responding to Republic Act no. 9003.

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Identification and Economic Importance of Banana Phytoparasitic Nematodes in Antioquia Uraba, Colombia

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The research work was carried out with the objective of evaluating the populations of phytoparasitic nematodes that affect the banana crop. The research was carried out in the three zones of Antioquia Urabá (North, Central and South), in the rainy season (May-September, 2018). A total of 169 samples were collected from the three zones. Root sampling was done by the technique proposed by Araya and Calvo (2001), the separation of nematodes was done by the sieving and centrifugation method in sucrose solution (Alvarado and López 1985) and its identification was made at the gender level (Maggenti et al. 1987). The following genera were found: Radopholus, Helicotylenchus and Meloidiogyne. In the same way, root damage was found that oscillated 25.2 and 33.4%, without influence on crop production. It was concluded that the populations of dominant nematodes in the Urabá area belong to the genera Radopholus, Helicotylenchus and Meloidiogyne, with high populations, but without significant effect on the yields of the banana crop.

Keywords: *Nematodes in Urabá, Radopholus sp, Helicotylenchus, Meloidogyne.*

Introduction

Banana is a plant native to Southeast Asia, as a crop estimated to be more than 10,000 years old, whose first traces were found in Papua New Guinea in the vii century before Christ. At present, it is still in the wild in the Philippines, Papua New Guinea and Indonesia and cultivated in tropical and subtropical areas. Natural crosses have produced significant genetic diversity and have allowed the production of no-seedless varieties (UNCTAD 2011).

Banana is the most widely eaten tropical fruit worldwide; it has been established as a technified crop in Colombia as well as in other countries of the world. However, this crop has certain associated pests and diseases that can infer in quality and production, among them are: Sigatoka, Moko, Fusarium, some insects and nematodes. After the necrotic lesions caused by fungi such as *Mycosphaderella fijiensis* and *M. Musicola*, the phytoparasitic nematodes (*Radopholus similis* (Cobb) Thorne), the growth and development of this crop can be threatened, generating losses in production between 20 and 100% (Guzmán 2011, Seenivasan et al. 2013).

This fruit is the fourth foodstuff of basic necessity in the world; it is consumed raw, or as fried banana, roasted, dry, in juice or in leaflets, alcoholic drinks or flours. It is rich in carbohydrates and contains little fat. It also contains essential

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vitamins, such as vitamin C, B6, B1, B2 and contains large amounts of potassium and magnesium, which includes it within the group of fruits with great nutritional properties that provide a good amount of carbohydrates, potassium, magnesium, folic acid and fibers. The cultivation of banana requires fertile soil, well drained and frank texture to loam clay; the ideal climate for this fruit is tropical humid, must have a temperature around 18 °C (Rodríguez and Rojas 2015).

The nematodes are segmented bodies of filiform animals and generally do not present coloration. They have marks in their body of striated form, round bodies of transverse form, varied buccal apparatus, without extremities or other complements. In some cases adult females may take a globose or rounded form (Perry and Moens 2006). They are individuals, whose size varies from 300 to 1,000 μm in length and from 15 to 33 μm in width, which hinders their visibility (Luc et al. 2005, Perry and Moens 2006). The nematodes have been characterized as being evolved beings, and adapt to different thermal floors, types of soil and water (sweet and salt), and are of great importance to ecosystems (Bongers and Ferry 1999, Baldwin et al. 2004).

In research related to nematodes, regardless of whether they are evaluated as beneficial or harmful, it is essential to perform the identification with high degree of precision, which is very useful to determine the timely management when required (Mai et al. 1996). Identification at the family level, is the category that most researchers and ecologists reach. However, when they have tools, they can reach the species level, which would greatly facilitate the selection of management practices, since with this information, they can know the behavior, evolution and trophic functions (Power 2001).

In banana, there are many nematodes that can affect the development and production of the crop; the literature reports about 146 species distributed in 43 genera of parasitic nematodes or associated to the *Mussa* species, where migratory endoparasitics (*Radopholus similis, Pratylenchus coffeae*), ecto-endoparasitic (*Helicotylenchus multicinctus* and *H. dihysteria*), sedentary endoparasitics (*Meloidogyne incognita, M. javanica*) and semi-endoparasitic (*Rotylenchulus reniformis*) are reflected (Martínez et al. 2006).

The genus *Pratylenchus* is a species of great importance in banana cultivars, especially for the Cavendish variety; its life cycle takes approximately 30 days and for its development requires a temperature of 25 to 30 °C (Gowen 1994). Likewise, the genera *Helicotylenchus* and *Radopholus* are associated to the banana crop, generating small necrotic lesions around the root bark, which under severe conditions can become a problem for the crop (McSorley and Gallaher 1994, Holguín 2018).

The *Meloidogyne* genus or root-knot nematodes are widely distributed worldwide. This genus, in juvenile state, penetrates the root near or along the radical meristem, invades the endodermis, entering the wake and inducing the formation of multinucleated giant cells derived from the cortical parenchyma or differentiating vascular cells in the central part of the wake (De Waele and Elsen 2002).

Another important genus is the *Radopholus* or banana borer nematode, which can induce the overturning of the plant. This nematode breaks the cell wall with its stylet and feeds on the cytoplasm of the cells, making cavities that subsequently coalesce to form reddish-brown lesions and finally become necrotic by the action of other organisms (Marín et al. 1998).

Nematode management should be done with cultural and preventive practices, such as use of tolerant or antagonistic species, rotation of crops, use of bionematicides based on fungi and bacteria (Rhizobacteria, *Bacillus*), and in the worst case, use of chemical nematicides, which greatly degrades soil biota (Ferraz et al. 2010, Gowen et al. 2005). The use of fungi, forming mycorrhizal symbioses can also be implemented, which generates a root system that could contribute to the mitigation of the nematode problem in the soils (Bautista et al. 2015).

Aim of the Study

The main objective of this study was the identification of nematodes of economic importance in the management of banana plantations. The study was carried out in three areas of the Urabá of Antioquia, in the second semester of 2018.

Materials and Methods

Location

The research was carried out in the three zones, in which the Urabá area is divided: North Zone, Central Zone and South Zone. We chose lots that had irrigation, a condition that can favor an ideal moisture regime for the development of phytosanitary diseases; among them, the attack of phytopathogenic nematodes or phytoparasitics. The Urabá is a coastal area on the Caribbean Sea with heights that do not exceed the 20 m, mostly with a slightly flat topography, average temperature of 26.6 ºC, average annual rainfall of 2,617 mm, 86.2% relative humidity and a solar brightness of 6.2 hours / days. Its climate is classified as semi-humid warm. The soils are of different texture (clayey-silty, clayey, frank, clayey, silty loam and silty clay loam), well-structured and with a pH ranging between 5 and 7.5 (Cárdenas et al. 2017).

Selection of Lots

65 lots were selected in the North Zone, 42 in the Central Zone and 62 in the South Zone. All the lots had an irrigation system and were in productive stage. The area of each plot ranged between 3 and 10 ha cultivars with 12 years of age of establishment within the Canvendis var. Valery and William.

Root Sampling

The methodology proposed by Araya and Calvo (2001) was used; roots of five plants in flowering stage (maximum eight days after having emitted the inflorescence or maximum two open bracts) were collected. The collection of the roots was carried out in a trunk of 17 x 17 cm and 25 cm deep, at the base of the pseudostem, oriented in the interval between the mother plant and the son of succession. All the roots were deposited in a plastic bag previously labeled with the identification of the lot and farm of sampling. The sampling was done in three plants per point and all the roots that were found in the soil volume (7225 cm^3 / plant) were collected. These samples were taken to CENIBANANO Phytopathology Laboratory for processing.

Processing of Root Samples

The collected roots were washed with abundant potable water. Then, the functional roots were separated (live roots, turgid, consistent and brown) and non-functional (dead roots, flaccid, completely necrotic and blackish). Both roots (functional and non-functional) were weighed using a balance with a precision of ± 0.1 g. For the evaluation of the roots the scale proposed by Araya and Calvo (2001) was used. It is illustrated in Table 1.

Table 1. *Classification of Ranges for Banana Roots to Weigh*

	Deficient	Regular	Optimal
Total Root	< 70	70-90	> 90 g/plant
Functional Root	< 60	60-75	> 75 g/plant

Source: Araya and Calvo 2001.

Evaluation of Root Damage by Nematodes

Local scale methodology for evaluation of root damage by nematodes described by Moens et al. (2001) was used; 10 functional roots of the collected sample were taken randomly. Afterwards, they were cut into pieces of 10 cm in length and finally they were cut longitudinally. Each half was evaluated, measuring the length of the necrotic tissue with a ruler. To calculate the total necrosis of the functional root, the value of the necrotic tissue measured in each half was added, divided by 2, and this result was divided by 10 and then multiplied by 100.

$$\%\ DE\ DAÑO = \frac{r1 + r2 + r3 \ldots + r10}{10} x100; donde\ r = \frac{b1 + b2}{2\ x\ 10}$$

r: Root damage ratio
b: Length of edge damage (cm)

Extraction and Counting of Nematodes

The methodology of liquefied-sieving adjusted by Alvarado and Lopez (1985) was used. The functional roots were cut into pieces of 0.5 to 1 cm in length, homogenized and 25 g were taken, to perform the extraction. These 25 g of root were deposited in a beaker together with 100 ml of potable water. This process was carried out in a conventional two-speed blender. The first solution was made at low speed (1000 to 1500 rpm) and the second at high speed (2000 to 2500 rpm), both for 10 seconds.

Subsequently, all the solutions were added to a set of superimposed sieves of 250, 125 and 25 μm opening (No. 60, 120 and 500 respectively). In the 250 micron sieve, the pieces of roots were washed with potable water for two minutes, then in the 125 micron sieve they were washed for one minute and finally the material retained in the 25 micron sieve was deposited in a beaker and completed to 200 ml of potable water for later reading. The suspension was homogenized for 30 s with a glass stirrer. A 4 ml aliquot was then taken from the center of the beaker and deposited in a reading chamber with 2 ml effective for counting. The number of nematodes was expressed by 100 g of functional root.

Identification and Quantification of Nematodes

Processed samples were examined under the 4x objective Microscope and were identified using the taxonomic keys described by Guzmán (2016), published in the manual for the identification of phytoparasitic nematodes (Maggenti et al. 1987).

Bunch Sampling

At each sampling point within a radius of 30 m, a total of 3 bunches were marked with ages of 3 and 4 weeks after apparition of banana bacotte, with a white ribbon tied at the end of the stem, which contained the information of the sample coordinate and three replicates per point demarcated as R1, R2 and R3. These bunches were harvested at 11 weeks and then the weights in kilograms were taken with the aim of correlating populations of phytoparasitic nematodes with production.

Data Analysis

The information was tabulated in Excel tables and analyzed with descriptive statistics. There was also proof of abundance, diversity and similarity among the lots of the three evaluated areas, for which the Shannon-Wiener Index was used, which is calculated by formula, in which the number of genera *i* found between the total number of species in the relevant zone. The diversity index was estimated with the following formulas:

$$pi = \frac{ni}{N} \qquad H = -\sum pi * Ln(pi)$$

where:

pi = relative abundance of species i.
ni = number of individuals of the gender i.
N = number of total individuals.
H = Shannon-Wiener diversity index.
Ln = natural logarithm.

For interpretation, the relative abundance index will oscillate between 0.0-1.0, being more abundant as it approaches 1.0, while the diversity index (H) will be interpreted as a positive value with the following scale, <2: low diversity, 2-3: medium diversity, and >3: high diversity. Ggenerally, ecological systems, in general terms, are below 5.0 (Pla 2006, Pla and Matteucci 2001).

Results and Discussion

Presence of Nematodes

Three genera of phytoparasitic nematodes were found (Table 2). The North Zone was where the greatest number of nematodes was found, with an average of 70,055 individuals/100 g of root, while the South Zone had the lowest values of total nematodes, with an average of 16,122 individuals/100 g of roots. Of the phytoparasitic nematodes found, the genus *Helicotylenchus* outperformed the other genera in the North and South Zones, but in the Central Zone it was surpassed by the genus *Radopholus*.

Table 2. *Weight of Samples of Banana Roots and Average Number of Nematodes per 100 g of Roots Collected form South, North and Central of Antioquia Uraba, Colombia (2018)*

Zone	NS	Rs	Hspp	Mspp	NT	TR
South	62	4,632.3	8,903.2	2,587.1	16,122.6	36.9
North	65	27,987.7	42,055.4	12.3	70,055.4	58.0
Central	42	25,847.6	23,161.9	100.0	49,109.5	48.0

NS: Number of Samples, Rs: *Radopholus similis*, Hspp: *Helicotylenchus* spp, Mspp: *Meloidogyne* spp, NT: Total Nematodes, TR: Total Root (g/plant).

These results are in the ranges reported in the literature. However, the population of *Radopholus similis* of the South Zone is below the average of 10,000 individuals/100 g of root reported by Araya and Calvo (2001), enough to cause economic damage to banana plantations. The Central and North Zones exceed the economic damage threshold reported by the above-mentioned authors, whose averages were 25,847.6 and 27,987.7 individuals/100 g of roots respectively.

The populations of the nematodes evaluated, differ; this can be explained because of the biological cycles of each genus. The tendency of *Helicotylenchus* spp to be found in larger populations may be due to its biological habit, as it is a semi-endoparasitic nematode (Yeates et al. 1993) or ectoparasite which feeds on the nearby tissue of the rhizodermis (Dropkin 1989). As it is shown in Table 2, populations of *Helicotylenchus* spp were the highest in the three zones evaluated. However, it has not been shown that this nematode migrates through the cortical tissue of banana roots (Siddiqi 1973).

The Population of *Meloidogyne* spp was relatively low in the three zones of Uraba-Antioquia. However, it is lower than the economic damage threshold for the AAA banana crop which is in accordance with the findings of Araya et al. (1995), who state that populations of this genus are detected in local conditions with few frequencies and population densities.

Abundance and Diversity

Despite the high populations of phytoparasitic nematodes, the Shannon-Weiner Index indicates that there is low diversity (H = 0.67) in the North Zone. *Helicotylenchus* spp was the dominant species with 60%, followed by *Radopholus similis* with 39.95%, and the species *Meloidogyne* spp with 1%. Similar dynamics were found in the Central Zone - low diversity (H = 0.69). However, in this zone the species *Radopholus similis* was dominant with 52.7%, followed by *Helicotylenchus* spp with 47.2%. In the South Zone, there is greater diversity (H = 0.97) and as in the North Zone, the species *Helicotylenchus* spp was dominant (55.2%), followed by *Radopholus similis* (28.7%). It is noted that in this area, there is a high population of the *Meloidogyne* species, although its dominance was low (16%).

Necrosis Caused by Nematodes

The average percentages of necrosis in functional roots which were evaluated in each batch and in each zone, showed that the average of necrosis for the North Zone was 25.2%, while for the Central and South Zones, was 26.6% and 33.4%, respectively, with a standard deviation that ranged between 9.2 and 10.3 (Table 3). For the analysis of the severity of damage in each batch of each zone, three evaluation ranges were established: less than 20%, 20 to 50%, and more than 50%, indicating low, medium and high, respectively, as illustrated in Table 2. In this table, it can be seen that only in the North Zone there is a low percentage of lots that exceeds the damage threshold and that could be a problem for the management of the banana crop. The great majority of the lots in the three zones has medium infestation (Table 3) and it is not economically important.

Table 3. *Percentages of Lots Grown with Bananas Infested by Phytoparasitic Nematodes in the North, Central and South Zones of the Uraba-Antioquia (2018)*

Ranges	**North Zone**		**Central Zone**		**South Zone**	
	Lots	%	Lots	%	Lots	%
< 20%	10	37.03	5	26.32	2	9.1
20-50%	16	59.26	14	73.68	20	90.9
> 50 %	1	3.7	0	0	0	0
Rank (%)	5.9-52.5		8.5-43.0		16.9-47.1	
Average (%)	25.2		26.6		33.4	
Standard Deviation	10.3		10.1		9.2	

Correlations between Nematodes and Yield (Bunch Weight)

No significant correlations were found between the amount of banana plant parasitic nematodes and their yield (bunch weight). The highest correlation was found in the Central Zone with the species *Helicotylechus* spp, but no-significant statistics (Table 4). Likewise, in none of the cases, this figure indicates dependence among the intervening factors and that means that the weight of the bunch is not affected by the three types of phytoparasitic nematodes that were found in the studied banana.

The distributions reflected for the yield component with respect to the phytoparasitic populations that were evaluated in the Central Zone, had a high disaggregation of the values with respect to the mean, generating, thus, a low degree of confidence for this variable, demonstrating that the phytoparasitic nematodes do not affect the yield of the banana. Likewise, the same behavior was observed in the populations of *Radopholus similis* and *Meloidogyne* spp, but with lower values of correlation in comparison to those released for *Helycotilenchus* spp. This analysis predicts that other factors may influence the decline in yields, other than the nematode populations.

Very low correlation is presented in the healthy root components for the Central Zone, with the highest numbers, being these of the populations of *Radopholus similis* and *Helicotylenchus* spp (Table 4), although these are not sufficient figures to explain the variability of yields bananas crop from the study zone and therefore, are not important economically.

The South Zone, like the other zones studied (North and Central), does not present a correlation for the production variable compared with the populations of nematodes; none of the values obtained in the Pearson correlations explain the variability of banana crop yield. Similar explanations are given for the three zones, in terms of necrosis of the functional roots and the effect of this component on the components of yield (bunch weight), a condition that leads to the prediction that banana crop yields for these three zones studied do not depend on the populations of phytoparasitic nematodes, but on other factors, perhaps those associated with soil problems. For example, physical soil problems (low aeration), salt accumulation, nutritional imbalance, and can be a good subject for other research work.

Table 4. *Pearson Correlation (R) between Populations of Phytoparasitic Nematodes and the Variables Bunch Weight, Root Necrosis (%) and Total Root (g/p) of the Three Zones (North, Central and South) of the Antioquia Urabá*

	Hspp	Mspp	NT	%RF	RS	Wbunch	%Necro
North Zone							
Mspp	0.0253						
NT	0.6898	0.1061					
%RF	-0.1042	0.0907	-0.0200				
RS	-0.1403	0.1149	0.6201	0.0853			
Wbunch	-0.1092	-0.1411	-0.1342	-0.0732	-0.0648		
%Necro	-0.0396	-0.0019	0.1974	0.0445	0.3064	-0.1901	
WRT	0.1434	0.0252	0.1876	-0.0301	0.1012	0.0272	0.1368
Central Zone							
Mspp	0.3172						
NT	0.6959	0.1055					
%RF	-0.4146	-0.1243	-0.3074				
RS	0.3472	-0.0555	0.9150	-0.1686			
Wbunch	-0.3336	-0.1007	-0.3926	0.2260	-0.3247		
%Necro	0.2948	0.0226	0.2525	-0.0838	0.1653	-0.0240	
WRT	0.1081	0.2027	0.0894	-0.1426	0.0530	0.1926	0.1595
South Zone							
Mspp	-0.0745						
NT	0.6789	0.4096					
%RF	-0.5245	0.1099	-0.3900				
RS	0.1396	-0.0806	0.6265	-0.1935			
Wbunch	-0.1988	-0.0098	-0.1621	0.1274	-0.0533		
%Necro	-0.1431	-0.0414	-0.1685	0.0126	-0.0981	0.0932	
WRT	-0.0655	-0.1084	-0.0158	0.0611	0.1091	0.1384	-0.1845

Mspp: *Meloidogyne* spp, Hspp: *Helicotylenchus spp*, RS: *Radopholus similis*, NT: Nematodes Total, %RNF: % Root Functional, WRT: Weight Total Root, WBunch: Weight Bunch.

Production of Total Roots of Banana

As it is shown in Table 5, the three zones, in general, presented values below 70 g/plant, which would be classified according to Araya and Calvo (2001), lots with a deficient root system; only for the North Zone a 11.1% of the lots evaluated are root systems in the regular range, 3.7% are root systems in the optimal range and finally 85% are in the deficient range. These differences can be explained by the intrinsic conditions of the sampling site (soil type and nutrition, among others).

Table 5. *Total Root Production of Banana Plants from Three Zones (North, Central and South) of Urabá Antioquia*

Ranges	North Zone	Central Zone	South Zone
Range (g/plant)	36.0-95.3	25.7-65.7	22.3-50.6
Average (g/plant)	58.9	47.2	36.7
Standard Deviation	14.4	10.5	9.0

For the Central and South Zones, all the lots (100%) evaluated are in the deficient range, with values lower than 70 g/plant, having averages of total root weight per plant 47.2 g and 36.7 g, respectively. These low values predict that there are soil problems, possibly because of the long time that these lots have been exploited (more than 30 years) For example, they may be problems of soil aeration.

Conclusions

From the research that has been done the following conclusions can be drawn. Firstly, the lots under study belonging to the three zones of Urabá Antioqueño have low root production, perhaps due to abiotic rather than biotic problems. Secondly, the development of the biological cycle of each genus of phytoparasitic nematodes in banana cultivation can influence the final populations registered in each evaluation. Thirdly, Averages of root necrosis are not enough to affect yield components (bunch weight) in the three zones studied (North, Central and South) and finally, the Urabá banana zone has the three genera of phytoparasitic nematodes of the greatest care in the management of banana crops. However, their populations are not important economically.

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Computational Thinking and Teacher Education: Can Digital Game Building Help?

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Background: *Computational thinking (CT) is an important 21st century skill that needs to be mastered by every k-12 student. Teachers are, therefore, increasingly called upon to teach CT and integrate CT into curriculum. Teachers who are equipped with the needed skill sets and knowledge based to teach CT remain scarce. Teacher education needs to be changed to address this shortage of teachers. We need more empirical studies that explore class-based intervention related to CT education for teachers.* ***Purpose:*** *This study examines the potential of digital game based learning to enhance teachers' understanding of computational thinking (CT) skills grounded in enactivism - a relatively new theoretical perspective. Specifically, this study examines the extent of CT skills and pedagogical aspects demonstrated in teacher self-created games. It also investigates the potential connection between CT and pedagogy as reflected in teacher created games.* ***Sample:*** *participants are 80 teachers enrolled in a graduate course focusing on digital game based learning.* ***Design and methods:*** *A quantitative design was adopted. Data collected include the teacher created games containing their design documents and the digital version of those games. A total of 57 games created by these 80 teachers were analyzed to answer the research questions.* ***Results:*** *First, the process of game design and building offers teachers' opportunities to exercise CT and enhanced their understanding of CT concepts. Also, a few pedagogical perspectives have been fairly or extensively represented in teacher created games, indicating their deep understanding of and ability to apply these aspects.* ***Conclusions:*** *Digital game building has great potential to help teachers develop CT skills and thus should be considered as an effective venue to promote CT education. While game building is a complex problem-solving process that involves critical thinking, strategizing and other important skills in real world contexts, teachers still need support to transfer these important thinking skills into their self-created games.*

Keywords: *Computational thinking, Digital game, Enactivism.*

Introduction

We live in an ever-changing society where the advancement of technology has significantly changed our ways of working, living, socializing, playing and learning. This calls for the change not only the way we educate our students, but also the types of skills and knowledge to be learned. It has been widely documented that 21st century skills are a necessity for our students to acquire so that they can become competent citizens (Jenkins 2007).

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Computational thinking (CT) has been argued as an important 21st century thinking skill. Wing, who first coined the term, defined CT as "the thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer-human or machine-can effectively carry out" (Wing 2014). In recent years, various groups, including the White House, start to recognize its significance and claim that CT has become a new "basic skill" just like mathematics, reading and writing skills, that every k-12 student needs to master (Smith 2016, Yadav et al. 2014). Consequently, teachers are increasingly called upon to teach computational thinking skills and integrate CT into curriculum. While there is a nationwide push on teaching CT for all students , there is a lack of teachers who are equipped with the needed skill sets and knowledge base to teach CT (Lockwood and Mooney 2017). This calls for changes in teacher preparation programs and professional development to help teachers of all subjects and age levels to gain the required knowledge. In fact, researchers have claimed that teacher education is critical for the improvement of CT education and argued the need of empirical studies that explore class-based interventions related to CT education (Grover and Pea 2013, Lockwood and Mooney 2017). Experts also suggest that CT need to be integrated into different areas of teacher education (Lockwood and Mooney 2017). However, many questions remain unanswered due to the infancy of CT education. For example, can CT be organically incorporated into all subjects in existing teacher education programs? If yes, how? If no, what subjects are more suitable for embedding CT learning, and how?

Digital game based learning, especially digital game building, offers rich opportunities for learners to interact with programming - a key area closely related to CT, and thus may provide a fit breeding ground for CT learning. This study, therefore, examines the potential of digital game (hereafter game) based learning to enhance teachers' understanding of CT skills grounded in enactivism - a relatively new theoretical perspective.

Theoretical Framework

Enactivism, a relatively new philosophical perspective, provides the theoretical framework for this study. Current prevailing theoretical perspectives in cognitive science and education like constructivism and behaviorism, though looking very different on the surface, share similar dualistic assumptions that separate mind from body, self from the world, and perception from action (Davis and Sumara 2002). Such shared assumptions, according to Davis and Sumara (2002) take the Cartesian-dualist perspective that separates mind from body, self from the world. For example, behaviorist view that reality is external to us, not only is structured but also can be modeled. Learning is to mirror objective reality onto learners. Constructivism considers that reality lies inside our mind that is separated from our body and the environment (Jonassen 2001). Whether considering reality resides outside the knower (e.g. behaviorism) or inside the knower (e.g. constructivism), these perspectives treat reality as a separate entity from the mind, believing that cognition lies inside the knower's body that is separated from the world and other people. Recognizing various limitations and criticisms brought by such dualistic views, scholars have called for alternative theoretical standpoints and proposed enactivism to be a fit philosophical view that can address these limitations (Davis and Sumara 2002, Hutto et al. 2014, Li et al. 2010).

Rejecting such dualism and the representational views of the mind, enactivism considers cognition is not only embodied but also inseparable from the environment. In other words, our mind, body, and world are conjoined and cannot be separated (Li et al. 2010).

The origins of enactivism can be traced back to the work of Maturana and Varela (1991). Phenomenological perspective based on Merleau-Ponty's work and Buddist viewpoints also contribute to enactivism (Reid and Mgombelo 2015). Enactivism focuses on the importance of action in cognition and embodiment. It regards cognition as an active process where "perception consists in perceptually guided action" (Varela et al. 1991). Rather than considering perception as passive, enactivists believe that cognition is active, dynamic and situated. According to Varela et al. (1991), structural determinism is a fundamental concept of enactivism. In this view, all living systems are structurally determined and cognition is based on our bodies. When an organism continually changes its structure so that "it goes on acting adequately in its medium, even though the medium is changing" (Maturana 1987), learning has occurred.

Doing is at the heart of enactivism, as reflected in the famous enactivist slogan: "all doing is knowing, and all knowing is doing" (Varela and Maturana 1992). The core focus of gaming on doing provides an optimal condition to apply enactivism. Teacher game building, therefore, offers an ideal context for us to study teachers' cognitive process of learning different topics such as pedagogy and CT. From the enactivist viewpoint, teachers' understanding of CT is reflected in their acts of the game design and development tasks where CT skills are integrated. Therefore, whether teachers are conscience about their understanding of the specific CT knowledge or not, their building of the specific games in which different CT skills were employed demonstrates their knowing of CT.

Another essential enactivist concept is co-emergence of our mind and the environment (Li et al. 2010, Reid and Mgombelo 2015). In this view, a carefully designed world that merges our physical, biological and electronic systems can greatly enhance learning. Gaming has a unique ability to let players easily immersed in the virtual world and real world simultaneously. Game building thus has a great potential to promote co-emergence of our biological and electronic systems. When teachers designing and developing their educational games, they need to consider the learners' game playing (i.e., involving our physical and biological systems) in the game environment (i.e., electronic systems), thus uniting these different systems.

Literature Review

Definitions of CT and Games

To date, there is no universally accepted definition of computational thinking. In addition to Wing's definition stated at the beginning of this paper, the Royal Society (2012) considered CT as "the process of recognizing aspects of computation in the world that surrounds us, and applying tools and techniques from computer science to understand and reason about both natural and artificial systems and processes" (p. 29). Many scholars attempted to define CT by considering its core characteristics (Voogt et al. 2015). The International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA) provided an operational definition of CT as "a problem-solving process that includes (but is not limited to) the following characteristics:

- Formulating problems in a way that enables us to use a computer and other tools to help solve them.
- Logically organizing and analyzing data.
- Representing data through abstractions such as models and simulations.
- Automating solutions through algorithmic thinking (a series of ordered steps).
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources.
- Generalizing and transferring this problem solving process to a wide variety of problems.

These skills are supported and enhanced by a number of dispositions (http://www.iste.org/docs/ct-documents/computational-thinking-operational-definition-flyer.pdf). While different definitions exist, a review paper states that it is widely accepted that CT involves the following attributes:

- Abstractions and pattern generalizations (including models and simulations).
- Systematic processing of information.
- Symbol systems and representations.
- Algorithmic notions of flow of control.
- Structured problem decomposition (modularizing).
- Iterative, recursive, and parallel thinking.
- Conditional logic.
- Efficiency and performance constraints.
- Debugging and systematic error detection.

(Grover and Pea 2013)

There are various definitions of CT in the literature and many focus on cognitive outcomes. However, CT goes beyond these cognitive outcomes and affective aspects are equality important. Examples of these attitudes and dispositions include, as defined by CSTA, "confidence in dealing with complexity, persistence in working with difficult problems, tolerance for ambiguity, the ability to deal with open-ended problems, the ability to communicate and work with others to achieve a common goal or solution" (http://www.iste.org/docs/ct-documents/computational-thinking-operational-definition-flyer.pdf). This study, although recognizing the importance of these affective variables, focuses on cognitive outcomes. Further review and discussions of the affective aspects are beyond the scope of this paper.

Computer programming, computer science, and CT are different concepts and fields of study even though they are closely related. Although computational thinking is by no means a new concept and the importance of CT skills has long been realized, it is not until recently that CT is considered as basic skills that need to be obtained by everyone rather than just experts in computer related fields (Oluk and Korkmaz 2016, Rehmat et al. 2020). The growing interest in CT and computer science in k-12 education resulted in an increasing number of research studies and the development of tools that foster CT. The tools took a variety of forms, starting from Papert's pioneer work of *LOGO*, to *Scratch, Alice,* and *Kodu* (Grover and Pea 2013).

While preparing teachers to teach with k-12 computing curricula would be the logical first step to insure successful integration of CT in k-12 education, equip teachers with needed skill sets remains a great challenge (Grover and Pea 2013, Rehmat et al. 2020). Though limited, there are studies that explored how digital games can be used to teach CT skills (Kynigos and Grizioti 2020), however, these efforts focused on CS education instead of teacher education. For example, one study (Kazimoglu et al. 2012) used a Flash game to teach coding and basic CT concepts to college CS introductory course. In the game, players need to control a robot using "solution algorithms" through programming commands. The game was designed where the game structure was mapped to certain CT concepts. An informal test of 25 students who had taken at least one programming course was conducted. The feedback from these students showed that the game involved the following CT skills: algorithm building, conditional logic, tracking a simulation, debugging, unfortunately empirical evidences were missing. As well, the game enhanced these students' interest in coding and problem-solving skills. A review paper (Kafai and Burke 2015) of 55 research studies indicates that abundant existing work has shown the benefit of game building in helping k-12 students learn program concepts and computational practices. Further review of this area is beyond the scope of this paper.

CT & Teacher Education

While CT has gained new impetus in the field of education and studies of CT exist, research focusing on teacher education remained scantily (Cetin 2016). Cetin (2016) examined the impact of using Scratch, a visual programming software, on preservice teachers' learning of basic CT skills and their attitudes toward coding. Adopting a mixed-methods approach, data collected included achievement tests, a survey and interviews. Participants were 74 preservice teachers enrolled in a technological application class. The results indicated that using Scratch, preservice teachers' understanding of basic computing concepts was significantly improved.

Yadav et al. (2014) believed that teacher preparation programs provide an ideal milieu to help teachers not only learn CT skills but also how to integrate CT into content. Yadav et al. (2014) investigated the impact of a one-week workshop aiming to improve preservice teachers' CT understanding and attitudes. Using a quazi-experimental design, participants were preservice teachers enrolled in a required introductory psychology course. The experimental group learned through a module focusing on CT topics while the control group did not work on the module. Their results showed that the module did enhance teachers' understanding of CT. On the one hand, the preservice teachers in the control group misunderstood CT as technology integration into classrooms. On the other hand, a majority of the preservice teachers in the experimental group considered CT as using algorithms to solve problems. Additionally, when compared with the control group, participants from the experimental group had a better sense of how to integrate CT into their teaching practices.

Angeli et al. (2016) convincingly argued that rather than only consider CT/CS education in secondary schools, it is vital to integrate CT starting from Kindergarten learners. They proposed a curriculum framework for k-6 CT education, specifying indicators of competence for five CT skills: abstraction, generalization, decomposition, algorithmic thinking and debugging. They stressed the importance of the holistic approach for designing CT curriculums. Further, they conducted a study of 15 in service elementary teachers' experience of CT learning. The participants were graduate students enrolled in an instructional technology course focusing on CT integration in k-6 classrooms. All participants had no prior CT knowledge. Meeting 3 hour weekly for 13 weeks, teachers learned CT by designing models of real world phenomenon and then translate them to computer programs using Scratch in order to solve real life problems. Their preliminary analysis showed that developing a model, even without coding, was extremely challenging for the teachers because teachers could not effectively use the abstraction skill. Through on going practices, along with the instructor's assistance, these teachers eventually had enhanced understanding of abstraction. Explicit instruction on how to create models such as identifying important constructs and their characteristics of the model deemed to be critical. With respect to teaching programming, CT topics including data process, sequencing, loops, parallel processing, events, conditions, operators, variables and data flow of control were all introduced. When ample programming examples were used to illustrate those topics, teachers could easily understand these concepts, although variables and conditional logic were considered the more difficult ones.

Cabrera (2019) examined 24 existing papers and identified that teachers tended to hold preconceptions impacting their understanding of CT. Specifically, they often equate CT to one of the following concepts: 1) technology integration, 2) coding, 3) problem solving, and 4) "thinking like a computer". Further, preconceptions included CT should not be part of k-12 education for various reasons, ranging from CT is too difficult to learn, to certain student groups could not manage to acquire such skill, to conflicts with the curriculum, to constraints such as time limitation and instruction structure of schools.

In summary, while CT has gained increasing attention from various groups, studies that focused on teacher education are still relatively limited. At the same breath, while numerous studies exist indicating that school students could learn coding and programming through designing and building their own games, few studies have emphasized on teachers (Kafai and Burke 2015). Amongst this limited exploration, even less work has examined teacher game building in connection with CT. This study bridges this gap by exploring the potential of practicing teachers' experience of designing and building their own instructional game through the new theoretical lens of enactivism.

Research Questions

The study aims to examine, through the lens of enactivism, teachers' experience of designing and developing educational games for their own students, with a focus on CT in connection with pedagogy. Specifically, this study is guided by the following research questions:

1. What levels of computational thinking do teachers demonstrate in their self-created games?
2. To what extent do different pedagogical components emerge when practicing teachers develop games?
3. Does the level of computational thinking connect to the pedagogical level as reflected in teacher created games?

Methods

The current study was part of a large project focusing on digital game based learning. Adopting a qualitative research approach, this study focused on CT skills and pedagogical components practicing teachers employed when designing and building their own games.

Participants and Context

The participants were 80 graduate students (31 males and 49 females) enrolled in a digital game based learning course. A majority of these students were practicing teachers in k-16 schools and a few were trainers working in organizations or private sectors. For simplicity, the participants were referred to as teachers in this paper.

The course was designed based on enactivism, with carefully crafted rich stimuli integrated. The learning environment was complex where varied incitements were intertwined to guide teachers' attention to specific content and educational goals, while specific outcomes were negotiated and revised throughout the process (Li et al. 2010). As well, doing was placed at the center of learning, reflecting the enactivist view of embodiment. Knowledge coauthoring, a critical aspect of enactivism, was partially realized through the adaptation of teacher game creation promoting teachers' development of new relationships with knowledge. Teacher collaboration was promoted throughout the course.

The course was an introduction to digital game based learning for teachers to explore theories, possibilities and considerations related to the design of instructional games, and the use of games for education in classroom and out-of-class settings. CT, however, was not the focus of the course.

The 15-week course offered 7 times: twice were administered on campus and five times online. The on-campus version of the course was about 70% of face-to-face meeting times and 30% online, while the online course meant that 90% or more of the class meetings online. Among the teachers, about 90% of the teachers had no or limited programming background. Nobody had prior game design experience. Regardless of the format, the course followed this general procedure: it started with an introduction to digital game based learning (GBL) where fundamental theories and principles of GBL were discussed (about 3 weeks). Teachers were then asked to explore various games and considered how games could be integrated into their teaching practice (about 4 weeks). Towards the second half of the course, the teachers designed their own educational games, producing their game design documents. The culminating project was the digital version of their proposed games (or initial levels of the games) using different software. While allowed to resubmit their work if there were deficiencies, no body resubmitted their assignments. During the first meeting, Scratch was introduced to teachers by showing the homepage of the Scratch website (https://scratch.mit.edu/) and asking teachers to freely explore the projects shared on the website. This introduction of *Scratch* lasted less than 15 minutes if the first meeting were face-to-face. In the subsequent classes, small Scratch tasks were built in to the weekly assignments to scaffold teachers' skills of using Scratch. For example, a week 2 Scratch task was: "whirl a photo: choose a photo and make it whirl by moving the mouse around the screen".

Instruments

CT skills were measured using Dr. Scratch, a free web based instrument that could automatically evaluate projects created by the software: Scratch. Dr. Scratch rated the CT levels of a Scratch project based on the following 7 aspects: *abstraction, synchronization, analogy/parallelism, data representation, user interactivity, logical thinking,* and *control flow* (Moreno-León and Robles 2015). It was claimed that Dr. Scratch was a valuable tool to evaluate CT skills. For instance, a study of 5th graders compared Dr. Scratch scores with their Computational Thinking Levels Scale. Their statistical analysis showed that Dr. Scratch was reliable and could appropriately assess CT skills (Oluk and Korkmaz 2016).

Pedagogical aspects were evaluated using the Pedagogy Rubric of Teacher-Created Games adapted from the original pedagogical and cognitive rubric (Li

2014). The prior work based on the original rubric showed that this was a reliable tool that included the key aspects to effectively assess teacher designed instructional games. The original rubric was developed based on enactivism where doing and knowing were placed at the center of learning. Stressing the learners' active role in cognition, categories in the knowing area were created, which included but not limited to: *problems soling, critical thinking/reasoning, scaffolding*. At the same time, the importance of emotion underscored in enactivist view led to the creation of *engaging* and *motivating* categories. Co-emergence and structured coupling, two critical enactivist concepts, argued that a new transcendent harmony would arise when people engaged a shared action (Varela et al. 1991); hence, the inclusion of the categories: *social learning* and *connecting*. Embodied cognition, a foundation of enactivism, led to the development of the doing categories, such as *ease of using* and *strategizing*.

The Pedagogy Rubric of Teacher-Created Games (see Appendix for details) included the following 12 categories: *problem solving, critical thinking/reasoning, strategizing, connecting, engaging, motivating, visual learning, ease of using, multiple representation, scaffolding, social learning,* and *assessing*. The definitions of these categories are:

- Problem solving: using prior knowledge or generic methods to find a solution of a problem. Recalling simple facts (e.g. simple algebra equation) without any context does not count as problem solving.
- Critical thinking/reasoning: using different types of reasoning (e.g. deductive) that is appropriate for a given situation, or analyzing a situation objectively in order to come up with a conclusion (Partnership for 21st Century Skills 2007).
- Strategizing: the mental process including planning, control and working memory to attain a particular goal (Diamond 2013). In gaming, it relates to how gamers use different approaches to reach the objectives.
- Connecting: presenting leaning materials that ties different topics, subject areas, or real-world problems.
- Engaging: the degree of effort or time spent on a particular task, which is often related to motivation (Trowler 2010). The amount of time is determined based on the game artifacts created by the learners.
- Motivating: referring to perceived challenge and/or perceived enjoyment of the game.
- Visual learning: designing of visual components in order to achieve learning objectives and/or to create memorable experiences.
- Ease of using: the level of clarity of the game objectives and the degree of difficulty associated with the navigation of the game.
- Multiple representation: align with the Universal Design for Learning (UDL) (Rose and Meyer 2007), representing materials in multiple ways, including text, audio, illustrations, animation, and video.
- Scaffolding: providing structures to support students' learning. Examples of scaffolding include tutorials, guides to help learners while the game progress.

- Social learning: game elements promoting collaboration and or social learning. For example, the player is asked to help non-player characters (NPC) or involved in social interaction, or allowing/encouraging collaborative game play.
- Assessing: providing structures to inform the learners about their current state of skills/knowledge. For example, scoring systems or hit points are typical assessing structures in games.

Data and Analysis

This study was part of a larger research project in which various data sets were collected. The focus of this paper was on teachers' educational game design in connection with CT. Specifically, two sets of data: teachers' game design documents and the games they developed based on these design documents were used in this study. Teachers' design documents included their design rationales, educational objectives of their games, design constraints and ways in which the games could be used for learning. The games were initial levels of the games described in their design documents, supplied with the prototypes and tutorials.

Because teachers had the option to work collaboratively, the 80 participating teachers developed a total of 59 games amongst which 57 were accessible (2 games became inaccessible due to technical problems). Amongst these 57 functional games, only 48 were created using Scratch and therefore could be analyzed by Dr. Scratch. The 9 non-Scratch games were created by Java (5 games), Starlogo TNG (1 game), and Kodu or other software. As a result, CT skills and pedagogical perspectives were calculated for these 48 games.

Enactivists believe that reality exists inside the observer (Maturana and Varela 1987), hence research is an active process in which we form a complex world. Accordingly, it is critical to work from multiple perspectives which might include the embracement of different researchers as well as examination and reexamination of multiple forms of data (Reid 1995, Reid and Mgombelo 2015). In this study, multiple perspectives were adopted at different levels and using different approaches. For example, varied forms of data sets were collected and constantly re-visited for the purpose of deep analysis. Additionally, different researchers were involved in order to compare and contract divergent perspectives and enrich the interpretation of the results.

To answer the first and second research questions, descriptive statistics were adopted with the frequency counts and percentages reported. CT levels were assigned the following numbers: basic level= 1, developing level=2, proficient level =3. To answer the third research question, inferential statistics were conducted. Specifically, Fisher's exact tests were used to test the relationships between the CT levels and the Pedagogical levels demonstrated in teachers' games. Initially, chi-square tests were planned to examine these relationships. However, due to the fact that at least one cell had a sample size smaller than 5 in all the data tables, chi-square tests were replaced by Fisher' exact tests.

A total of 3 researchers were acted as the evaluator of the games. Realizing the subjective nature of some subscales of the Pedagogy Rubric of Teacher-

Created Games, consistent training to the evaluators was provided. Inter-rater reliability was also tested. First a total of 5 representative games were selected that reflected the wide spectrum of the teacher-created games. The 3 evaluators scored the 5 games and results were compared. The inter-rater reliability was lower than 0.80, a meeting was conducted to discuss the process, with a special focus on the discrepancies and possible reasons that caused the differences. An agreement was reached towards the end of the meeting. Then, the evaluators scored another 3 representative games and the inter-rater reliability was calculated again, reaching a score of 0.80.

Results

The first research question: "What levels of computational thinking do teachers demonstrate?" was answered by descriptive statistical analyses of the data. Dr. Scratch was used to calculate the levels of CT integrated in the games. Note that teachers were allowed to work in small groups, many chose to collaboratively develop their games. As a result, 57 games were created and within which only 48 were created using *Scratch*. Since *Dr. Scratch* can only apply to games created by *Scratch*, these 48 games were calculated for their CT skill levels. The frequency counts are detailed in Table 1.

Table 1 showed that all the games demonstrated a developing level of *user interactivity*. This is the only CT concept that was demonstrated by all the games, although no game scored proficiency. Similarly, almost all games (over 95%) scored developing for the concept of *abstraction*, while one game achieved proficiency level. *Parallelism* was the concept with the highest mean score where almost 89%, the highest percentage, of games achieved the proficiency level. This score was followed by the CT skill *synchronization* where over 60% (30 games) marked as proficient plus almost 30% (14 games) of the games were at the developing level. The concepts: *logic* and *flow control* both had over 40% (21 games) reached proficiency level, and about another 40% of the games achieved developing level. The means scores illustrated that on average, all the games scored at least the developing level for each of the CT concept evaluated.

Table 1. *Frequencies of CT Demonstrated in Games (N=48)*

	None	Basic (%)	Developing (%)	Proficient (%)	Mean score
Flow control	0 (0)	9 (18.8)	18 (37.5)	21 (43.8)	2.25
Data rep.	0 (0)	4 (8.3)	34 (70.8)	10 (20.8)	2.13
Abstraction	0 (0)	1 (2.1)	46 (95.8)	1 (2.1)	2.06
User Interact.	0 (0)	0 (0)	48 (100)	0 (0)	2.00
Synchronization	2 (4.2)	2. (4.2)	14 (29.2)	30 (62.5)	2.50
Parallelism	2 (4.2)	6 (12.5)	2 (4.2)	38 (79.2)	2.58
Logic	4 (8.3)	4 (8.3)	19 (39.6)	21 (43.8)	2.19

The frequency counts for the overall all CT levels and the mean score for all the games were also calculated, as shown in Table 2. According to Moreno-León and Robles (2015), an overall CT score with up to 7 points are considered at a basic level, scores between 8-14 points indicate a developing level, and 15 points or more are referred to as proficient. Table 2 shows that only 1 project scored 7, which belonged to the Basic level of CT. Over 40% of the projects demonstrated a developing level of CT skills. The majority of the project, that is, over 55% of the projects showed that teachers were able to demonstrate their CT skill at the proficiency level. The mean score of 15.71 indicated that on average, the games created by the teachers demonstrated an overall proficiency level of CT skills. Almost 98% of the games demonstrated the developing or proficient levels of CT skills.

Table 2. *Overall CT Levels as Demonstrated in Games*

	Basic level* (%)	**Developing level (%)**	**Proficient level (%)**	**Mean score**
Projects	1 (2.1)	20(41.7)	27 (56.2)	15.71

*basic level=1, developing level=2, proficient level=3

The research question 2 focused on the extent of pedagogical components teachers considered when building their own games. The descriptive statistics of pedagogy scores were detailed in Table 3 and showed that some interesting patterns emerged. First, *visual learning* had the highest percentage of games that is over 80%, scored fair or extensive presentation. Additional four pedagogical components also had more than half of the games achieved a rank where they fairly or substantially represented every category. These categories were *engaging* (72.7%), *ease of using* (63.2%), *assessing* (63.2%), and *motivating* (56%). In comparison, only 5 of the 57 games, i.e., less than 10% integrated *strategizing*, while similar number of games (i.e., close to 90%) only minimally integrated *problem solving*. For the categories *scaffolding*, *connecting* and *critical thinking*, only about one in four games represented them fairly or substantially.

Table 3. *Frequencies of Pedagogical Components Integrated in Games (N=57)*

	Level 0* (%)	**Level 1 (%)**	**Level 2 (%)**	**Mean**
Pro. Solv.	50 (87.7)	5 (8.8)	2 (3.5)	0.16
Cri. Th./ reasoning	42(73.7)	12 (21.1)	3 (5.3)	0.32
Connecting	42 (73.7)	12 (21.1)	3 (5.3)	0.32
Strategizing	52 (91.2)	4 (7.0)	1 (1.8)	0.11
Engaging	19 (33.3)	28 (49.1)	10 (17.5)	0.84
Motivating	25 (43.9)	28 (49.1)	4 (7.0)	0.63
Visual learning	10 (17.5)	41 (71.9)	6 (10.5)	0.93
Ease of using	21 (36.8)	31 (54.4)	5 (8.8)	0.72
Multiple representation	33 (57.9)	19 (33.3)	5 (8.8)	0.51
Social learning	33 (57.9)	23 (40.4)	1 (1.8)	0.44
Scaffolding	43 (75.4)	13 (22.8)	1 (1.8)	0.26
Assessing	21 (36.8)	31 (54.4)	5 (8.8)	0.72

*Level 0= minimally represented; level 1= fairly represented; level 2= substantially represented

The third research question aimed to investigate whether the level of computation thinking was connected to the pedagogical levels. Fisher exact tests were used to examine possible relationships between CT variables and Pedagogy with an alpha of 0.05. Due to the relatively small sample size, both the CT levels and pedagogy categories were reorganized. The CT levels were regrouped into 2 categories: the *None* and *Basic* levels were grouped together defined as the *Entry* level, and the *Developing* and *Proficient* levels were grouped into the *Competent* level. Similarly, the pedagogical levels were regrouped into 2 categories: level 0 was considered as the *Trivial* level, while the levels 1 and 2 were combined to form the second category named as the *Ample* level. Significant relationships were identified in five sets of variables. See Tables 4-9 for the Fisher exact tests results.

Table 4. *Fisher's Exact Test -Flow Control*

		Entry	Competent	p-value
Problem Solving	Trivial	9	36	1.00
	Ample	0	3	
Critical Thinking / Reasoning	Trivial	7	29	1.00
	Ample	2	10	
Connecting	Trivial	8	29	0.66
	Ample	1	10	
Strategizing	Trivial	8	38	0.34
	Ample	1	1	
Engaging	Trivial	4	14	0.71
	Ample	5	25	
Motivating	Trivial	5	19	1.00
	Ample	4	20	
Visual Learning	Trivial	1	9	0.66
	Ample	8	30	
Ease of Using	Trivial	2	17	0.29
	Ample	7	22	
Multiple Representation	Trivial	5	25	0.71
	Ample	4	14	
Social learning	Trivial	7	23	0.45
	Ample	2	16	
Scaffolding	Trivial	8	32	1.00
	Ample	1	7	
Assessing	Trivial	3	15	1.00
	Ample	6	24	

Table 5. *Fisher's Exact Test - Data Representation*

		Entry	Competent	p-value
Problem Solving	Trivial	4	41	1.00
	Ample	0	3	
Critical Thinking / Reasoning	Trivial	3	33	1.00
	Ample	1	11	
Connecting	Trivial	4	33	0.56
	Ample	0	11	
Strategizing	Trivial	4	42	1.00
	Ample	0	2	
Engaging	Trivial	4	14	0.02*
	Ample	0	30	
Motivating	Trivial	4	20	0.11
	Ample	0	24	
Visual Learning	Trivial	3	7	0.03*
	Ample	1	37	
Ease of Using	Trivial	3	16	0.29
	Ample	1	28	
Multiple Representation	Trivial	3	27	1.00
	Ample	1	17	
Social learning	Trivial	3	27	1.00
	Ample	1	17	
Scaffolding	Trivial	4	36	1.00
	Ample	0	8	
Assessing	Trivial	4	14	0.02*
	Ample	0	30	

Table 6. *Fisher's Exact Test - Abstraction*

		Entry	Competent	p-value
Problem Solving	Trivial	44	1	1.00
	Ample	3	0	
Critical Thinking / Reasoning	Trivial	35	1	1.00
	Ample	12	0	
Connecting	Trivial	36	1	1.00
	Ample	11	0	
Strategizing	Trivial	45	1	1.00
	Ample	2	0	
Engaging	Trivial	17	1	0.38
	Ample	30	0	
Motivating	Trivial	23	1	1.00
	Ample	24	0	
Visual Learning	Trivial	10	0	1.00
	Ample	37	1	
Ease of Using	Trivial	18	1	0.40
	Ample	29	0	
Multiple Representation	Trivial	29	1	1.00
	Ample	18	0	
Social learning	Trivial	29	1	1.00
	Ample	18	0	
Scaffolding	Trivial	39	1	1.00
	Ample	8	0	
Assessing	Trivial	18	0	1.00
	Ample	29	1	

Table 7. *Fisher's Exact Test - Synchronization*

		Entry	Competent	p-value
Problem Solving	Trivial	4	41	1.00
	Ample	0	3	
Critical Thinking / Reasoning	Trivial	4	32	0.56
	Ample	0	12	
Connecting	Trivial	4	33	0.56
	Ample	0	11	
Strategizing	Trivial	4	42	1.00
	Ample	0	2	
Engaging	Trivial	3	15	0.14
	Ample	1	29	
Motivating	Trivial	4	20	0.06
	Ample	0	24	
Visual Learning	Trivial	1	9	1.00
	Ample	3	35	
Ease of Using	Trivial	2	17	1.00
	Ample	2	27	
Multiple Representation	Trivial	3	27	1.00
	Ample	1	17	
Social learning	Trivial	3	27	1.00
	Ample	1	17	
Scaffolding	Trivial	4	36	1.00
	Ample	0	8	
Assessing	Trivial	2	16	0.62
	Ample	2	28	

Table 8. *Fisher's Exact Test - Parallelism*

		Entry	Competent	p-value
Problem Solving	Trivial	8	37	1.00
	Ample	0	3	
Critical Thinking / Reasoning	Trivial	8	28	0.17
	Ample	0	12	
Connecting	Trivial	8	29	0.17
	Ample	0	11	
Strategizing	Trivial	8	38	1.00
	Ample	0	2	
Engaging	Trivial	5	13	0.13
	Ample	3	27	
Motivating	Trivial	7	17	< 0.05*
	Ample	1	23	
Visual Learning	Trivial	2	8	0.67
	Ample	6	32	
Ease of Using	Trivial	5	14	0.24
	Ample	3	26	
Multiple Representation	Trivial	7	23	0.23
	Ample	1	17	
Social learning	Trivial	7	23	0.23
	Ample	1	17	
Scaffolding	Trivial	7	33	1.00
	Ample	1	7	
Assessing	Trivial	4	14	0.45
	Ample	4	26	

Table 9. *Fisher's Exact Test - Logic*

		Entry	Competent	p-value
Problem Solving	Trivial	8	37	1.00
	Ample	0	3	
Critical Thinking / Reasoning	Trivial	8	28	0.17
	Ample	0	12	
Connecting	Trivial	7	30	0.66
	Ample	1	10	
Strategizing	Trivial	8	38	1.00
	Ample	0	2	
Engaging	Trivial	5	13	0.13
	Ample	3	27	
Motivating	Trivial	7	17	< 0.05*
	Ample	1	23	
Visual Learning	Trivial	3	7	0.34
	Ample	5	33	
Ease of Using	Trivial	4	15	0.70
	Ample	4	25	
Multiple Representation	Trivial	6	24	0.70
	Ample	2	16	
Social learning	Trivial	7	23	0.23
	Ample	1	17	
Scaffolding	Trivial	8	32	0.32
	Ample	0	8	
Assessing	Trivial	5	13	0.13
	Ample	3	27	

The Fisher exact tests showed a total of 5 significant relationships, which are described below. *Data representation*, a subcategory of CT, demonstrated significant associations with 3 pedagogical elements: *engaging*, *visual learning* and *assessing*.

First, a Fisher exact test indicated a significant association between *engaging* level and *Data Representation* used in the games, $p=0.02$. A significant greater number of games with high engagement representations demonstrated high levels of data representation than low engagement games.

Second, *Data Representation* integrated in games was positively associated with *visual learning* level, as indicated by a Fisher exact test, $p=0.03$. That is, significantly more high-visual learning games than low-visual learning games showed competent level of Data Representation.

Third, *Data Representation* integrated in games had a positive relationship with *Assessing* level as indicated by a Fisher exact test, $p=0.02$. That is, a significantly greater number of games with Competent level of data representation had Ample level of assessing than the games with only the entry-level of data representation.

Fourth, a Fisher exact test demonstrated that Parallelism skills in games was positively connected with Motivating levels, $p<0.05$. More games with Competent level of Parallelism had the Ample level of Motivating when compared with games of only entry-level Parallelism skills.

Last, *Logic* integrated in games was positively associated with *Motivating* level, $p<0.05$. That is, a greater number of Competent *Logic* games had the Ample level of *Motivating*.

Discussion

Aiming to understand enactivism through the application of the theory to practice, this study has successfully implemented the theory in a teacher education classroom. The enactivist learning world incorporates complex real-world problems to stimulate learners' curiosity while providing them great freedom of exploration.

Major Findings

This study of teacher game design in relation to CT reveals a few key findings worthy of further discussion. It is important to note that all the teachers had created games individually or collaboratively. Because many teachers worked in small groups, only 57 games (48 games created using Scratch) have been developed by the 80 teachers.

While shedding new lights on several fields of study, the most significant result is that the enactivist learning world has created rich opportunities for teachers to grow professionally, allowing them to develop competencies in both digital game based learning and CT. On average, the teacher created games demonstrate an overall proficiency level of CT skills. This is particularly interesting because CT has never been the focus of the content learning. In the course, although some small coding tasks have been integrated in the course to scaffold teachers' game development, it is important to note that the learning have been aimed to enhance teachers understanding of pedagogical knowledge related to game based learning rather than CT. Further, almost all of the Scratch games evaluated were created by teachers with limited or no prior coding experience. Yet, the teachers, through the *doing* of game design, have learned a great deal of CT skills, as proved by the fact that on average, the games demonstrate the overall CT skills at the proficiency level, and almost all the games created achieved either the developing or proficiency level of CT. An important implication is that learning through game design can provide a valuable platform to integrate CT education while learners study different content subjects. Since finding time for standalone computer science/CT courses remains to be a significant challenge, the idea of integrating CT in learning of different subject matter deem to be optimal. As researchers have argued (Yadav et al. 2017), teacher education programs need to prepare teachers with required skills, knowledge, and pedagogy to incorporate CT into their teaching practice. The current study suggests that learning through game building can provide an ideal setting to help teachers gain essential skills to embed CT into their classrooms. This, of course, depends on the readiness of the environment, including the technical requirements for making digital games are enabled. It also confirms previous work (Yadav et al. 2017) that although coding is a critical aspect of CT, standalone courses focusing on teaching programming per se in teacher preparation programs is not required. Rather, as illustrated in this study, CT can be organically embedded in the teachers' content learning.

Enactivism views that knowing is a process of adaptation and evolution (Maheux and Proulx 2015). In this view, learning is the learner's interaction with the environment where s/he and the environment coevolve in an adaptive fashion: teachers' behavior, their gaming experience, their coding, their explorations, although may not be the best, are adequate acts that allow them to function in the environment, in this case to build functional educational games. To know, from an enactivist perspective, is to be functional in the environment. Teachers' knowing of CT is the coevolving acts of the teachers and their milieu that enable them to respond sufficiently in the course, e.g. to produce operable games. In this study, an enactivist learning environment has been built where teachers unintentionally gain CT skills through the doing of game design and building. Teachers continued interaction with their environment, including the software, the games, the design conversations, the fellow teachers, their own students, all contributes to their learning of both CT and pedagogy, and enables them to maintain their fit into the context.

Secondly, in a vast majority of the teacher-created games, five (i.e., visual learning, engagement, ease of use, assessment, motivation) of the 12 pedagogical components are fairly or extensively represented. The fact that over 80% of the games scored fair or extensive in the visual learning components indicates that most of the games have a highly visual design. This is exciting because sight is the dominant sense for most of us to understand the world. Good visual design in educational games, therefore, can significantly aid students' learning (Plass et al. 2014). Previous research (Ruecker et al. 2007, Taylor and Baskett 2009) shows that good visual design can improve confidence and make players to be more engaged in the gaming experience. In this study, these games with high levels of visual design mean that the teachers not only understand the significance of visual learning but also able to successfully integrate the visual design elements in their games.

On the one hand, the motivational value of good games has long been recognized (Gee 2009). Although not surprising, we applaud that the teachers have put considerable amount of efforts on making the games engaging and motivating for their audiences and are able to transfer such pedagogical aspect into their game design. On the other hand, three aspects (i.e., scaffolding, connecting, critical thinking) are fairly or extensively represented in only one fourth of the games, while strategizing and problem solving are barely expressed in almost 90% of the games. This points to a significant issue that deserves further exploration. Game design and building is a complex process demanding teachers to constantly solve problems, connect different content knowledge, and think critically. In the course, scaffolds have been provided throughout their development of the games. Yet, as shown in study, transferring these skills into their own educational games remains to be challenging. This is consistent with previous results that transferring knowledge into action is difficult (Ward et al. 2009).

In this study, although most of the teachers had zero or limited prior programming experience, let alone game design knowledge, all the teachers eventually have mastered enough skills within the gaming software to generate adequate games that at the very least give a fair representative score on the Pedagogy Rubric. Koehler and Mishra (2005) suggest that while teachers' knowledge of technology is important, it is what teachers can do with technology that is specifically critical to them in the conveyance of content knowledge. Technology in this respect is games. This puts forward the possibility that the game design approach may be able to create a contextual platform for learning of content as well as CT. Game building may provide a great platform for cross-curricular embedding and merging several contents, whether math, social studies, science or other topics, into one location: the game itself.

Third, the results of this study also show interesting relationships between some CT concepts and pedagogical aspects demonstrated in these teacher-created games. For one, affective pedagogical perspectives like *motivating* are related to both *parallelism* and *logic*, while *engaging* is positively associated with *data representation*. Since the engagement value is a common part of gaming, and the teachers often realize the significance of this value in learning, it makes sense to encourage the integration of affective perspectives when teachers develop educational games as it may also enhance their understanding of various CT skills. As well, *visual learning* is positively correlated with *data representation*. The educational benefit of visual learning associated with games is already proven, suggesting that we should stimulate teachers' interest in visual design elements while designing their games. This may in turn, enhance teachers' understanding of certain CT skills.

A fourth key finding relates to the topic of unintentional learning. Unlike other theoretical perspectives such as behaviorism and constructivism that ignore unintentional learning, enactivism pays particular attention to such learning (Davis et al. 2008). In this study, many of the teacher-created games fairly or extensively represented in the rubric categories, suggesting that game building is complex yet manageable for teachers. One might question that since the focus of the course is on pedagogy of digital game based learning, why do some games not score high enough in certain pedagogical aspects? It is important to point out that the focus of the course is to help teachers develop pedagogical knowledge to integrate games into classrooms rather than integrating pedagogy into game design/development, two separate, but overlapping, concepts. Since the strategies of using existing games for instructional purposes or learning through game building are different from integrating sound pedagogy into instructional game development, it is not surprising that discrepancies are identified. That is, while teachers have good understanding of how to appropriately employ instructional games in classrooms (as demonstrated in their course grades and other artifacts which are beyond the scope of this paper), some may not know how to incorporate good pedagogy into game design.

The fact that almost all the games demonstrate at least a developing level in CT skills and an average score of the overall CT skills at the proficiency level highlights the value of game building in helping teachers exercise their CT skills, probably even without noticing. In here, teachers' co-evolvement with their environment, including the game developing software, to create functional games for their learners has resulted in their advanced understanding of CT skills - an outcome that is not originally considered and has never been the focus. This confirms the significance of such inadvertent learning as emphasized in enactivism.

Another important contribution of this study is the adoption of quantitative design to explore enactivism. A review of the existing literature related enactivism shows that a vast majority, if not all, of enactivist studies have employed qualitative approaches. Enactivism stresses the importance of multiple perspectives, which therefore, suggests a dire need of enactivist works utilizing varied research design to broaden our understanding of this theoretical framework and its application. This study adds to the field of enactivism through a quantitative design to examine teachers' game building experience.

Conclusions

Like any educational research, this study has its limitations. First, although 80 teachers participated, many worked in small groups of two or three. As a result, only 57 games are developed and only 48 games are available for the analysis related to CT due to the limitation of the analysis tool: *Dr. Scratch*. Future studies with a larger sample size of the games are therefore recommended. Another limitation is the teacher created games are analyzed without involving the intended audience-their students. Future work is suggested to integrate long-term testing, allowing teachers to work directly with their audience to iteratively produce a mutually successful game and at the same time practicing CT skills.

Another limitation is the narrow focus of CT studied in this paper. Although the definitions described in the literature section contains rich concepts that go beyond programming alone, this study only focuses on the cognitive aspects. Future work is recommended to include other essential components, such as affective factors.

From an enactivist perspective, it would be challenging, if not impossible, to teach someone else skills that are not currently embodied or experienced by the teachers. As such, providing teachers with opportunities of practicing CT skills may help them better facilitate these skills in their own classrooms. Further, the focus of the current study is not on the development of effective games but rather on the teachers' development of sound pedagogy situated in the context of game design and building. This suggests that teachers spend more time on pedagogical learning of how to integrate games into classrooms instead of polishing the quality of the games, although we see from the results discussed above that the teachers have produced 'good enough' games. The unintentional outcome of teachers' enhanced CT skills underscores the significance of the successful development of the enactivist learning world.

As discussed above, game design process encompasses complex problems that require the designer to constantly solve problems, think critically, connect learning to different subjects and the real world, and strategize. Yet, the results of the study show that teachers require support to transfer their experiences in these fields to their games. While involving teachers in their own game design and building is a positive move forward, additional guidance in this area would further benefit teachers. The potential of digital game building is unlimited and we can expect that it can empower teachers and their students in this information era.

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Appendix

Pedagogical Rubric

#	Category	Minimal Representation	Fair Representation	Extensive Representation
1	Problem solving	No events or one small event that promote problem solving.	One substantial event, or two to three distinct events that promote problem solving.	More than one substantial event, or more than three distinct small events that promote problem solving.
2	Critical thinking	No events or one small event that promote critical thinking.	One substantial event, or two to three distinct events that promote critical thinking.	More than one substantial event, or more than three distinct small events that promote critical thinking.
3	Connecting	No events or one small event that showed the connection of the learning materials to the other context/real world problem.	One substantial event, or two to three distinct events that showed connection of the learning materials to the other context/real world problem.	More than one substantial event, or more than three distinct small events that showed connection of the learning materials to the other context/real world problem.
4	Strategizing	No events or one small event that promote executive functions/strategy.	One substantial event, or two to three distinct events that promote executive functions/strategy.	More than one substantial event, or more than three distinct small events that promote executive functions/strategy.
5	Engaging	The game can be done in less than five minutes, and gamers most likely do not want to replay the game.	The game can be done in five to ten minutes but gamers are not likely willing to replay the game. Or gamers are likely willing to replay the game and the game can be done in less than 5 minutes.	The game can be done in more than 10 minutes and the gamers may not want to replay the game. Or the game can be done in more than five minutes and gamers are likely willing to replay the game.
6	Motivating	The game play/activity is not challenging or fun to play	The game play/activity is challenging and or fun to play	The game play/activity is extremely challenging and or really fun to play
7	Visual learning	The game has unappealing or	The game a clean and coherent visual design	The game has exquisite visual design that is

		incoherent visual representation. And/or contains unnecessary visual elements that distract game play and or learning.	without unnecessary visual elements that distract game play or learning process. It is somewhat aesthetically pleasing.	unique and creates memorable learning experience. All visual elements are carefully designed without anything distracting players.
8	Ease of using	Confusing or unclear objectives and or instructions. Five or more elements that caused major frustration in play and may cause player to stop playing	Clear objectives and instructions of the game. One to four elements that cause minor frustration in play	Very clear objectives and instructions of the game. No elements that cause frustration.
9	Multiple representation	The game relies on single representation of the learning materials.	The game presents the learning materials on two kinds of representation.	The game presents the learning materials on more than two kinds or representation.
10	Social learning	The game doesn't promote any form of collaborations/social interaction with other players or with other objects in the game.	One substantial event, or two to three distinct events that promote collaboration/social interaction whether it is with non-player characters or with other players.	More than one substantial event, or more than three distinct small events encourage collaborations/social interaction whether it is with non-player characters or with other players in the game play.
11	Scaffolding	No scaffolding occurs within the game. There is no support for progression of knowledge or concepts in the game	The game creates scaffolding through tutorials or guides, but the scaffolding is incomplete or in appropriate in some way.	The game includes very clear scaffolding structures. It sets up stages and levels so that the concepts progress in an increasingly challenging way.
12	Assessing	The game has no structure that helps gamers assess their level or situation within the game. Gamers may feel lost when trying to understand their abilities and/or achievement in the game.	The game provides tools (e.g. hit points, level ups, etc.) to assess the gamers' progression in some but all aspects.	The game is set up in a way that makes the gamer knows how his/her character is doing, what levels have been achieved or need to be, and is able to make conjectures on the gameplay because of it.

Total Score: xx/ 24

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Assessment for Ensuring Adequately Qualified Instructors in Maritime Education and Training Institutions

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Introducing new technologies, knowledge, understanding and proficiency for seafarers is a challenging task for maritime instructors in the consideration of maritime safety. Effective teaching strategies depend on qualified instructors working both within the International Convention of Standards of Training, Certification and Watchkeeping (STCW Convention) requirements and having adequate teaching arrangements. According to the STCW Convention every party shall ensure that all instructors of Maritime Education and Training institutions (MET institutions) are appropriately qualified for the particular type and levels of training they are responsible for delivering. This article presents a review of factors that are not included in the STCW Convention requirements and are considered important for the development of instructor's competences and appropriate best practice strategies for teaching and learning. Adoption of a wider set of guidelines, currently proposed by the International Maritime Organization (IMO), but not broadly adopted is advocated based on a fast growing industry and a need to continuously challenge and review safety standards.

Keywords: *Maritime science, Maritime education, Maritime safety.*

Introduction

According to analysis conducted by the United Nations Conference on Trade and Development (UNCTAD 2018), world seaborne trade has gathered momentum and reached 10.7 billion tons per annum, with an annual growth rate of 4%. The world's commercial fleet exceeded 100 gross tonnages in seagoing merchant vessels and, as of the 1st January 2018, consisted of 94,171 vessels and circa 1.9 billion dwt, representing an annualized growth of 3.31% when compared to 2017. Furthermore, world seaborne trade is projected to further expand at a rate of 3.8% between 2018 and 2023 annually. The current average age of the commercial fleet is 20.8 years, which would be considered old or outdated, and most probably, modern new ships will be equipped with the latest technology not present on the majority of current merchant vessels (UNCTAD 2018).

Advances in ship building, incorporating the latest technologies to comply

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with current and future requirements and expectations, make ships more complex to operate and maintain. Larger modern ships, with these new technologies (for example ECDIS) and operational complexities (such as different propulsion systems), potentially increase the risk both of maritime accidents and efficiency of seaborne transportation if operating personnel are not properly educated (Bielić et al. 2017). In order to increase adequacy of education International Maritime Organization (IMO) enforced model courses as an aid to instructors and lecturers in their work (Vujičić et al. 2018, Horck 2003). The International Transport Workers' Federation recognized the value of ongoing qualified personnel in paper from 2013 (p3), "the shipping industry depends on competent, well-trained seafarers to ensure safety of life at sea, maritime security, efficiency of navigation and protection and preservation of the marine environment" (International Transport Workers' Federation 2013). According to the Baltic and International Maritime Council's (BIMCO/ICS) Manpower report 2015, crew manpower increased significantly between 2005 and 2015. An estimated 1,647,500 seafarers (774,000 Officers and 873,000 Ratings) were working on commercial vessels during 2015. One of three main challenges presented by BIMCO is MET related. These include availability and flexibility of training, quality of MET delivery/ facilities and the effectiveness of competency assessments (The Baltic and International Maritime Council & International Chamber of Shipping, Manpower Report 2015). Each of these aspects is critical and form independent nodes which need to be combined to ensure optimal outcomes.

The quality of MET is crucial for effective seafarer development. Therefore, it became an imperative for countries wishing to effectively develop and sustain their maritime industry. New technologies and ship operations, followed by practices and STCW requirements, influence the demand for highly qualified instructors and assessors across the maritime industry and dictate the defined quality standards for education. New standards that are driving updates to critical navigation equipment such as ECDIS, emergency communications and cyber security regulations introduced more complexities.[1] Consequently, norms should be established regarding the proportion of on-shore vs. on-board experience which is required to impart the best level of knowledge to students or seafarers.

As per STCW Code, all seafarers should be appropriately qualified for the position that they hold onboard, as well as instructors, supervisors and assessors (IMO 2017d). Each Administration (IMO member states) will decide upon adequate requirements for instructors, supervisors and assessors in accordance with their respective national regulations. Of equal importance, Maritime college lecturers have to be properly qualified to have an appropriate level of knowledge and understanding of their subject matter and have an up-to date appreciation of modern day ship operations and of new technologies prevalent aboard modern ships (The Nautical Institute 2012). In order to increase safety at sea, seafarers need to be well educated and qualified (Belev et al. 2018). Training must be provided before and during sailing time, together with training assessment in order to ensure that the training goals of are achieved (Bal Besikci et al. 2019).

[1]https://www.marinemec.com/news/view,be-prepared-for-regulatory-changes-on-the-bridge_536 23.htm.

Regulations and Standards

Besides STCW Convention which sets requirements for seafarers and lecturers, International Organization for Standardization (ISO) ensures, among many others, consistency and quality of organization that provides education for seafarers.

Not only do instructors in MET institutions need to have an appropriate level of knowledge and understanding of their subject matter but should also receive appropriate training in instructional techniques and assessment methods.

Training and assessment requirements as part of Regulation I/6 and Quality standards Regulation I/8 as per STCW Convention, place particular emphasis on maritime education. Guidance concerning the aforementioned regulation is part of section B-I/6 and B-I/8 of the STCW Code. Measures in section B part are not mandatory but provide effective suggestions and examples for administrations in terms of best compliance with certain Convention requirements (IMO 2017d).

As per STCW Regulation I/6 and section A-I/6 of the STCW Code, each IMO member state shall ensure that those responsible for the training and assessment of competence of seafarers, instructors, supervisors and assessors are appropriately qualified for the particular type and level of training or assessment they are delivering. This may vary depending on whether this is either on board or shore based (IMO 2017d).

As per the STCW Code, every person conducting in-service training, the assessment of competence or providing training and assessment within an institution shall (IMO 2017d):

- have a full understanding of the specific objectives of the particular training being conducted and have knowledge and understanding of the competence to be assessed;
- be qualified in the task for which the training is to be conducted;
- in the instance of simulator training, every instructor shall receive appropriate guidance in instructional techniques and gain practical operational experience on the particular type of simulators used.

According to the recommendations of Section B-I/6 of the STCW Convention (which is currently non-mandatory) any person, supervisor or assessor on-board or ashore, conducting in-service training of a seafarer intended to be used in qualifying for certification, should have received (IMO 2017d):

- appropriate guidance in instructional techniques and assessment methods using relevant IMO Model Courses;
- appropriate guidance in assessment methods and practice;
- gained practical assessment experience under the supervision of an experienced assessor;
- for those individuals responsible for supervising in-service training, should have appropriate knowledge of instructional techniques, training methods and practices.

IMO Member countries shall ensure that qualification and experience of instructors and assessors are covered in the application of the Quality standards provision of Section A-I/8 which incorporate appropriate training in instructional techniques, training and assessment methods and practice (IMO 2017d).

As per the non-mandatory section B-I/8 each Party or member country should ensure that the quality standard model implemented in MET institutions includes academic and administrative organization structure, staff responsibilities and procedures, qualifications of staff and sufficiency of equipment. MET institutions should ensure quality control at all levels of teaching, training, examination and assessment through internal and external audits (IMO 2017d).

The correct and widespread adoption of the IMO Model Courses could help to effectively implement the STCW Convention requirements with regard to knowledge, understanding and proficiency. The main purpose of IMO's Model Courses is to support training providers and competent teaching staff in designing and delivering new training courses but they do not extend to the provision of a comprehensive teaching package which instructors should follow blindly and are not an official interpretation of the STCW Convention.

The International Organization for Standardization (ISO) and its committees collaborate with national bodies in particular fields and set standards for institutions. As for ISO/IEC 17024 Conformity Assessment, the development of certification schemes, in response to the ever increasing velocity of technological innovation and specialization of personnel, can compensate for variation in education and training and thus facilitate the global job market. Assessment is systematic method and procedure for ascertaining work-related knowledge, skills, abilities or performance of a group or individuals (ISO/IEC 10667-2 Assessment Service Delivery 2011). Assessor training should be an integral part of any assessment training programme and have clearly stated performance guidance and training objectives which include training content, length and performance (Development Dimensions International (DDI) Task Force on Assessment Center Guidelines 2000).

General provisions about education, certification, training, knowledge and assessment of MET lecturers are set by national bodies of member states and can differ in each state. Factors affecting teaching practices and instructors' competences are elaborated in the next chapter.

Factors Influencing Teaching Practices and Instructors Competences

Maritime instructors should have all necessary teacher competences and be aware of all topics required by SCTW. They should also be cognisant of human elements and potential issues experienced by trainees that can affect the teaching progress. Awareness of the factors which could influence teaching and spill over into the behaviour of both the trainees and instructors is of outmost importance for adequate transfer of knowledge.

In author's opinion, factors influencing instructors' competences and defining the appropriately qualified instructors are the following (Figure 1):

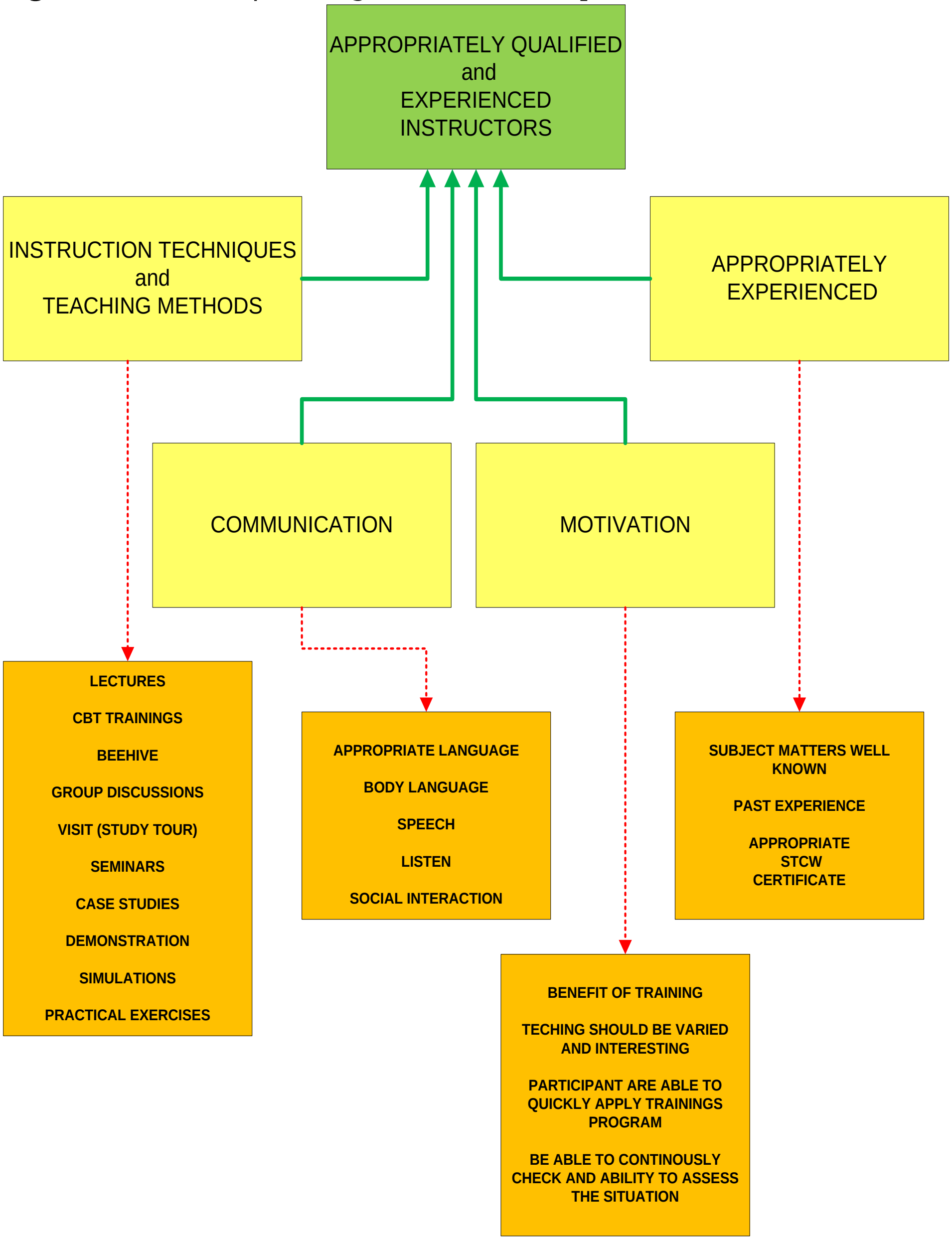
- Motivation – ability to self-motivate and motivate others (Tang and Sampson 2017, IMO 2017c, Kalulu 2018).
- Instruction techniques and teaching methods – accessibility to a conducive learning environment and teaching aids and ability to devise an appropriate training programme for delivery (IMO 2017c, Justice et al. 2007.
- Communication – ability to effectively monitor and communicate (behaviour analysis) with their students (IMO 2017c).
- Appropriate experience – having marine background and holding STCW certificates (The Nautical Institute 2012).

It is preferential for instructors to be respected in their field of work and to be acknowledged professionals who have the student's attention. Language barriers and cultural awareness can influence the teaching and learning processes and therefore instructors should be fully aware of the importance of clear delivery of both oral and written communication and materials. Ideas have to be presented in a clear and simple manner and instructors should be confident in their presentations (both in individual and group work). After delivering course materials the instructor should continuously and objectively adopt a systematic approach of the classes' effectiveness by looking for possible causes and effects (IMO 2017c). The aim should be to resolve any ambiguities and continually improve the materials for future use.

Motivation of trainees in each training, is critical to the success of a training course and it is also one of key factors for successful learning (Tang and Sampson 2017). Motivation can be described as the processes that can guide a trainee's behaviour in an appropriate direction (IMO 2017c). Trainees can be motivated through various methods such as feedbacks, surveys and course evaluations (Kalulu 2018). Intrinsically motivated trainee is the one who shows an interest in or is self-challenged to understand the subject matter. An extrinsically motivated trainee has a fear of consequences of failure or responsibility in a given topic (Zeigler-Hill and Shackelford 2016).

The instructor should be familiar with teaching strategies and should be able to select appropriate teaching skills for a certain group of trainees (IMO 2017c). The authors' experience shows that unmotivated group usually consists of over-experienced or over-confident mariners. Teaching should be diverse and interesting, and trainees should be able to understand the concept of the training programme. Instructors should continuously check and assess the motivation and the trainees (IMO 2017c). Occasionally, an overly experienced instructor and a jaded attitude due to a long-term teaching routine and a lack of diversity may also influence the motivation of trainees.

Figure 1. *Factors Influencing Instructor's Competences in MET*



Source: Authors as per (The Nautical Institute 2012, IMO 2017c, Tang and Sampson 2017, Justice et al. 2007, Kalulu 2018).

The instructor's STCW qualification has to be at least at the same level as the STCW qualification of trainees. 'Appropriately qualified' implies knowing the present situation on board modern commercial vessels. Refresher sailing periods are the best way to assure this (The Nautical Institute 2012). The trainees' sea experience, their personality, cultural background and age could have a strong influence on the teaching method to which they respond best. Experienced instructors can assess the situation and resolve any potential problems by communicating with trainees or individuals in advance or after the first training session.

Appropriate teaching methods could improve effective instructor qualification. Simulation and practical exercises, effective demonstration skills, group discussions, case studies and controlling trainee's behaviour are effective teaching methods, which together with technical knowledge should improve the instructor's effectiveness. As part of research of this topic, authors have solicited the opinions of a number of MET institutions as to their use of the appropriate IMO Model courses and training for their instructors to build appropriate teaching competences (questionnaire).

The education systems and cultural background of trainees across the maritime sector considerably vary globally. Any MET institution must be accredited by an authorized professional or governmental authority, either national or international, in order to ascertain that a continued high standard of quality is assured. Brief requirements from The Code of Qualifications and Seafarers' Certificates of Qualification in the Republic of Croatia are given in the text below as an example. The Code is published by the Official Gazette of The Republic of Croatia (No. 130/13) and it regulates qualifications, educational requirements, examination programmes, qualification programmes, conditions and ways of obtaining certificates and additional qualifications for the Master, Chief Engineer, Mates and other crew members of seagoing vessels. Besides the aforementioned, The Code also regulates the following (Učur 2014):

- Conditions which must be fulfilled by the universities and high schools which educate candidates for certificates for qualification.
- Conditions which must be fulfilled by the examiners and members of the examination committees.
- Procedures and the way of issuing the approval to the institutions which organize seafarers' qualifications,
- Procedures and ways of issuing certificates for qualified seafarers education.

The Code has been compiled in accordance with certain EU Directives (Učur 2014). Part G1 of the Code covers basic requirements and part G2 covers specific requirements including quality standards, technical requirements for instructors and educational programmes (The Official Gazette of The Republic of Croatia No. 130/13). When concerning teaching staff every teacher or instructor should have:

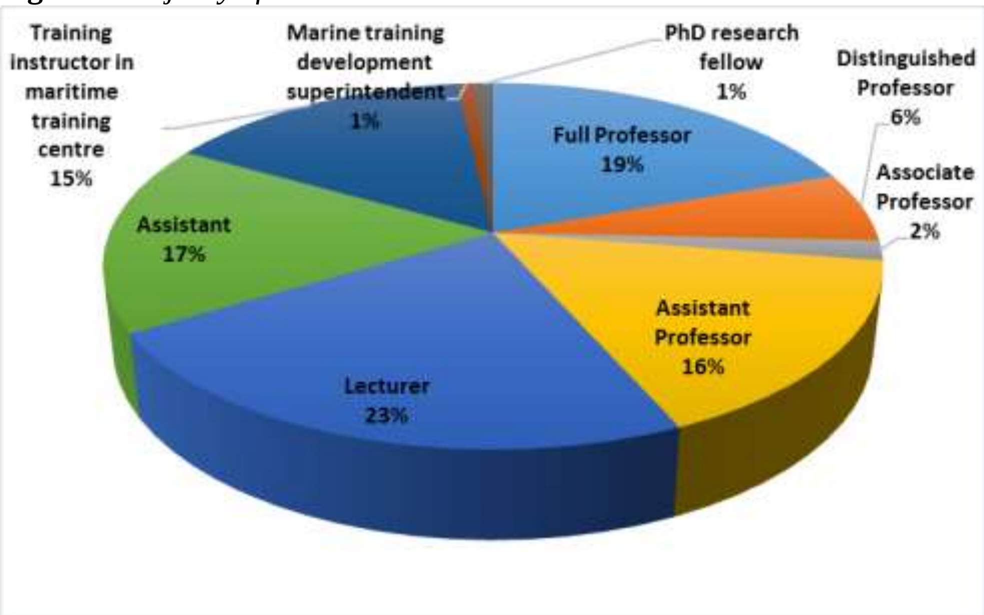
1. Sufficient sea-experience and knowledge in the relevant subject.
2. Knowledge of the entire programme of education/training in which the teacher participates.
3. Knowledge of the specific objectives of the relevant education or training.
4. Knowledge of relevant teaching methods, their application and effects.
5. A conscientious and consistently adaptable approach to incorporating technological and other changes in shipping into teaching activities.
6. An ability to evaluate and favourably shape the professional and human personalities of the participants, as future seamen.

Methodology

In order to determine current situation and address the main problems in teaching the authors conducted a survey. Tool for the survey was questionnaire based both on literature review and authors expert opinion. It was available online (google forms) over social media networks and in a paper form. In order to avoid a biased participation in the questionnaire it was anonymous and confidential. Furthermore, before final survey, pilot survey was prepared in order to avoid the response bias. Authors did not offer any incentive since it could also result in speed runs of some respondents. All questions within survey were as neutral as possible in order to avoid stereotype bias. Finally, it was disseminated all over the world in several MET institutions in order to compile answers from as many different institutions as possible.

Questionnaire involved 113 instructors of different nationalities and ranks working in MET institutions all over the world. Nationalities of respondents were Croatian, Turkish, Montenegrin, Panamanian, Singapore, British, Latvian, Indonesian, Polish, Italian, Russian, Spanish, Japanese, Georgian, Filipino, Swedish, Vietnamese, German, Canadian, Peruvian, Egyptian, Bangladesh, French, Dutch, Norwegian, Indian and others.

Figure 2. *Majority of Academic Ranks and Non-Academic Ranks*



Source: Authors.

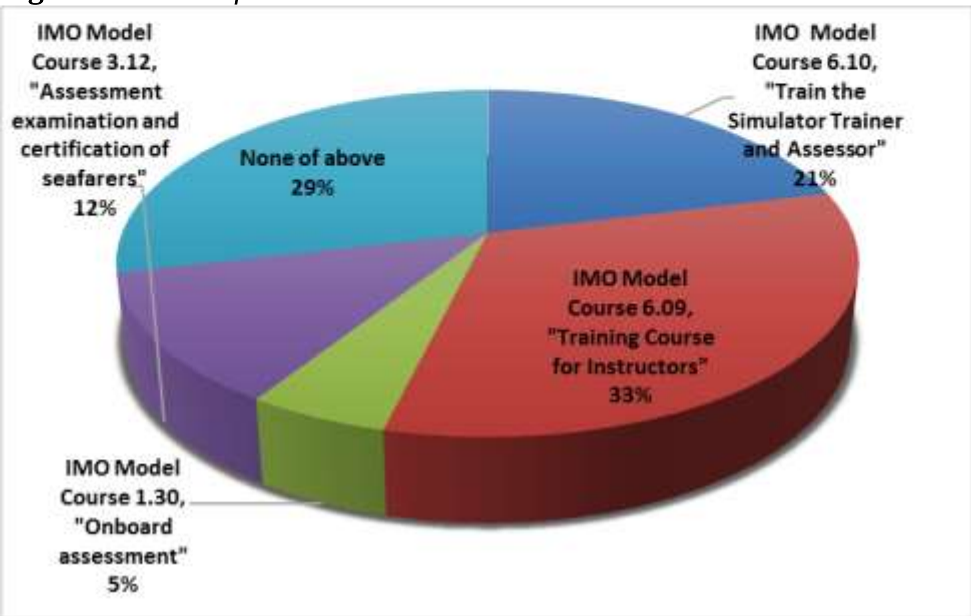
Academic ranks and non-academic ranks represented in survey were aged between 35 and 45. Academic ranks were Full Professor, Distinguished Professor, Associate Professor, Assistant Professor, Lecturer and Assistant working in Faculty of Maritime Studies or University. Non-academic ranks in maritime trainings centres were Training instructor in maritime training centre and Marine training development superintendent working in maritime training centres (Figure 2).

Results

Basic difference between section A-I/6 and Section B-I/6 of STCW Convention are that specific requirements in section A are necessary for instructors' competence and B are some recommendations on how those competences could be achieved. For instance, in part B it is mentioned that relevant IMO Model Course(s) may be the assistance in preparation of the training courses. There are also relevant IMO Model Course(s) and methods which could assist maritime training instructors in their teaching.

In one question respondents were asked to tick course or courses that they have attended. The analysis of answers shows (29% respondents) that this guidance is at best overlooked and at worst unrecognised. Only 33% respondents were familiar with the additional recommendations of the IMO Model Course 6.09 which is recommended as a supplement to the STCW code in the section B (Figure 3). This highlights a gap in the understanding of certain individuals in the current thinking on safety and preventive measures.

Figure 3. *Courses for Instructors*



Source: Authors.

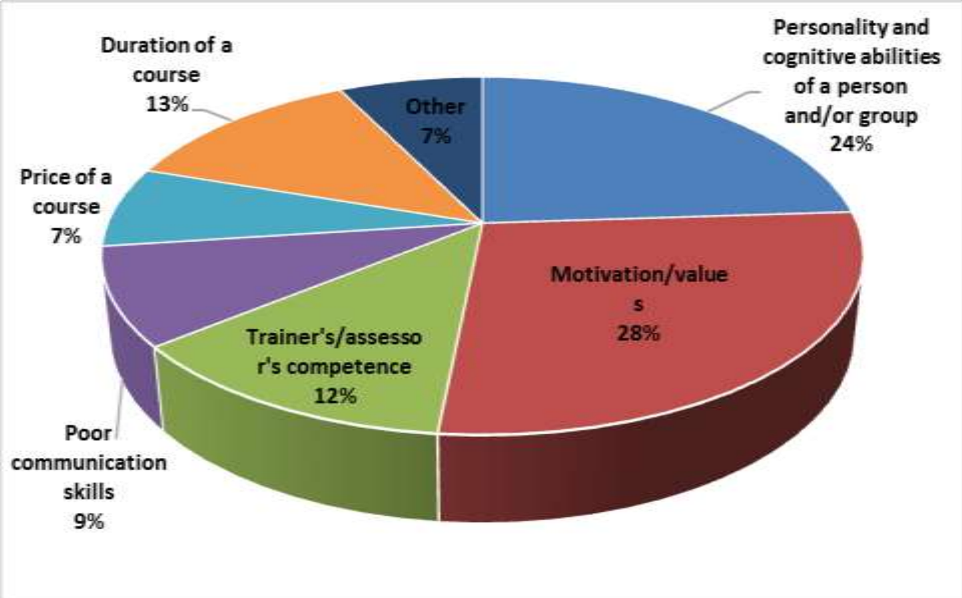
IMO Model Course 6.09 includes planning and preparation for effective teaching, methods and instructions and evaluation of the teaching and learning process (IMO 2017c). IMO Model Course 6.10 provides necessary knowledge and skills in instruction techniques using simulator. It is intended for nautical and engineering instructors as a tool for effective teaching (IMO 2012). IMO Model Course 1.30 and 3.12 could be suitable for experienced shore-based instructors with sufficient onboard experience and personnel of the training institution who conduct examination leading to the award of COC and other documents (IMO 2017a, 2017b).

When asked if they are satisfied with the available teaching materials, 71.4% of the respondents answered affirmatively and 28.6% negatively.

According to questionnaire analysis 55.8% of respondents have the highest Certificate of Competency (COC) Master and Chief mate (Management level) 500 GT or more and 16.3% Certificate of Competency (COC) Chief engineer and second engineer more than 3000 kw (Management level).

As for the analysis of the given answers, the major problems of disruptions during courses by attendees are motivation (28%), personality and cognitive abilities (24%) followed by the duration and the price of courses (Figure 4).

Figure 4. *Reason of Attendees Disruption the Classes*



Source: Authors.

Personality could be defined as a natural tendency to act spontaneously in a certain way when in a specific situation and it is usually consistent during lifetime and is making people different. The BIG 5 Model consists of open mindedness, control, enthusiasm, affection and emotional stability (Murugesan and Jayavelu 2017). Cognitive abilities are perception/attention, reaction times and reasoning skills (Ispas and Borman 2015). Motivation could be defined as an energy that activates, supports and maintains behaviour towards certain direction or individual concern in a specific situation. Competence in social interaction (activate the participant), teaching and continuous assessment of understanding could motivate trainees. Motivation can be influenced by adequate environment, interesting and varied teaching, involvement of participants, etc. (IMO 2017c). Instructor qualification, motivation and personality can influence motivation of the trainees.

Conclusions

Whereby the STCW puts a significant emphasis on the qualifications required from instructors and assessors, it gives very little specific information as to how training should be best delivered and associated with the teaching methodologies. Maritime instructors, supervisors and assessors are to be properly qualified for the specific type of training and courses they provide in accordance with the STCW Convention. However, it is up to each respective Administration to decide the adequate requirements and competencies required for teaching and instruction in accordance with individual national regulations. Authors propose the IMO Model courses to be an obligatory component of qualification for MET instructors and assessors given that almost all factors which have been identified as potentially problematic are included as the main topics of some IMO Model Courses. Finally, the authors propose that pedagogical competencies and a minimum knowledge of the IMO Model Courses 1.30, 3.12, 6.09 and 6.10 should be part of the minimum requirements for 'adequate' instructors in MET institutions. Besides courses, 'appropriately qualified' implies knowing the present situation on board modern vessels. Refresher sailing periods are the best way to ensure this. Therefore, the quality of instruction will largely depend on the experience and expertise of the staff in the training institute; which means that, despite the global acceptance of the STCW, there still will be considerable differences between various MET institutions and consequently between the product of their educational efforts.

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