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INFLUENCE OF TEACHING ACTIVITIES, ENVIRONMENTAL CONDITIONS AND CLASS SCHEDULES ON TEACHER STRESS MEASURED WITH A SMARTWATCH: A PILOT STUDY

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Abstract

To recognize and assess the job stressors that teachers face in daily practice is essential. One of the most used objective measures of stress is the heart rate (HR). This pilot study explored the use of a wearable device (smartwatch) to monitor the HR of two teachers over two weeks in the classroom. Educational context variables (subject, class size, timetable, activity learning performed) and environment variables (temperature, humidity, sun irradiance) were related with HR. The results showed significant differences on HR among the teachers according to the educational activity, time of the day, or day of the week. The environmental variables were related differently in each of the participants. The study showed the practical implications of using a smartwatch, or smart bracelet, in the field of education. It provides systematic data that be analyzed and linked to other variables, opening the possibility of measuring real-time stress in the classroom, as an alternative or complement to stress self-reports.

Keywords – Teacher stress, Heart rate, Smartwatch, Environmental factors, Secondary school.

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1. Introduction

Teacher well-being is a fundamental topic for schools and society (Hascher & Waber, 2021). The World Health Organization (WHO) provided an initial contribution about the importance of well-being. By 1946, the WHO had already defined health as a state of complete physical, mental, and social well-being, as opposed to the simple absence of disease.

On the other hand, stress is an inherent part of the normal human experience; stress response provides a valuable mechanism by which an organism can respond appropriately to internal and external stressors. According to the model of Lazarus and Folkman (1984), stress involves the relationship between the person and the environment, in which the subject perceives environmental demands as a danger to his or her well-being if they exceed or equal his or her coping resources.

Stress has negative consequences on the physical and mental health of teachers. Teachers who show high job stress have lower job satisfaction and less commitment and are less able to support their students emotionally and academically (Travers, 2017) and tend to report intentions to drop out of teaching within five years (Thomson & Hillman, 2020). Chronic or continuous stress it is related to the burnout syndrome (Wang, Ramos, Wu, Liu, Yang, Wang, J. et al., 2015; Vargas-Rubilar & Oros, 2021; Zhao, Liao, Li, Jiang & Ding, 2022). Burnout syndrome is a response to chronic work stress and identified three components: high levels of emotional exhaustion and depersonalization or cynicism, combined with low personal accomplishment (Maslach & Jackson, 1981, 1982).

Stress is a common problem among teachers in Spain, where we conducted the study. 84.4% of teachers feel stress, and 30.6% of them consider it "very high" (ANPE - Sindicato Independiente, 2019). The main reasons are work overload, lack of recognition, lack of resources and student indiscipline. Another study revealed that 70% of teachers suffer from stress, and 27% consider it "severe" (Unión de Docentes de la Enseñanza [UDE], 2018). Furthermore, 88% of respondents indicated that the Spanish education system is not designed to prevent and manage teachers' work-related stress.

This pilot study is part of a bigger aspiration, comprising the development of a smart classroom (SM). We define SM according to Palau and Mogas (2019), a place of learning with three levels: environmental conditions (architecture, furniture, and environmental indoor factors), pedagogical process (contents, process of teaching and learning, systems support), and technology (hardware, devices, software, new paradigms as Artificial Intelligence, Internet of Things...). The diagram in Figure 1 shows the elements and relationships that compose the Smart Classroom.

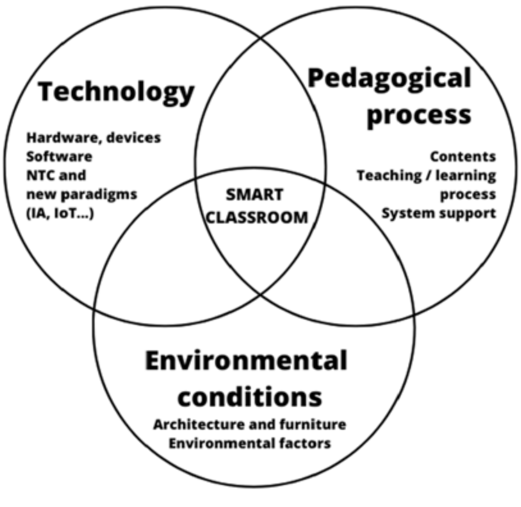

Figure 1. Smart Classroom elements (Palau & Mogas, 2019)

In recent years, research into stress has grown and included biological measurements of stress in correlation to stressful experiences. This situation, together with the widespread use of smartwatches and similar devices to assess biometric markers, means that the aim of our study focuses on to explore the smartwatch as a tool for monitoring the teacher's stress through the measure of HR parameters in diverse conditions. The specific objectives are:

- To explore the relationship between the teachers' HR during the class session and learning activities.
- To explore the relationship between the day, time of day and teacher's HR.
- To explore the relationship between the environmental conditions (temperature, solar irradiance) and teacher's HR.

1.1. Job Stressors

Continued high demands on the job are a key predictor of teacher stress. Increased use of high stakes official testing may exacerbate this problem by limiting teachers' control over the content and pace of their own work and increasing threats of teacher termination and school closure (Greenberg, Brown & Abenavoli, 2016). The teachers facing concurrent and constant job demands, such as time pressure related to increase in homework assignments and workload, discipline problems, low motivation of students and dissonance in educational values (Skaalvik & Skaalvik, 2017), among other stressful conditions that are detrimental to well-being.

The students' problem behaviors may relate to teachers' stress. Students' misbehavior of individual students or the whole class was with 43% the most reported stressful classroom event (Admiraal, 2020). Friedman-Krauss, Raver, Neuspiel and Kinsel (2014) found that higher levels of externalizing student problem behaviors in the fall subsequently predicted higher stress in spring among teachers working in preschool classrooms. Alter, Walker and Landers (2013) indicated that externalizing behaviors (not paying attention, being disruptive...) were considered more of an issue than internalizing behaviors (self-stimulation, staying isolated...), according to teachers' reports.

Low student motivation is a less studied construct than discipline problems in stressful school environments. Skaalvik and Skaalvik (2017) confirmed that low student motivation and discipline problems are different but moderately related constructs ($r = 0.45$).

Finally, about class size, a variable that we included in the study, is commonly defined as the student-to-teacher ratio in a classroom (Blatchford & Russell, 2019; Harfitt, 2012; Solheim & Opheim, 2019), and it equals the number of students in a classroom if only one teacher is present. Teachers frequently express stress associated with teaching in large classrooms. Huang, Richter, Kleickmann and Richter (2022) discovered the average HR and subjective stress ratings were both significantly higher in the large class size condition.

1.2. Measures of Stress

Teacher stress has been object of study and can be assessed through questionnaires, such as the "Escala de Fuentes de Estrés en Profesores-EFEP" (in English, Sources of Stress in Teachers Scale), created by the National Institute for Safety and Hygiene at Work (INSHT) in Spain, or related to burnout, the widespread used Maslach Burnout Questionnaire (Maslach, Jackson & Leiter, 1997). However, this type of method does not allow access to real-time experience and how it is affected by the things that happen. Subjective measures provide valuable information, but when objective measures can be obtained for the variable of interest and are free of errors, they perform better than subjective measures (Jahedi & Méndez, 2014). Considering the fact that HR is the most commonly used indicator of physiological stress reactions (Bodie, 2010), it could be used as an objective parameter instead of or in addition to subjective self-reports.

Few studies consider the correlation between pulse and wellbeing/stress. Böckerman, Bryson, Viinikainen, Hakulinen, Hintsanen, Pehkonen et al. (2017) found a positive correlation between pulse in childhood and happiness in adulthood in a longitudinal study. In the study of 216 middle-aged men and women, found that greater happiness, assessed through repeated of the working day, was associated with a lower HR rate among men, but not among women (Steptoe & Wardle, 2005). On the contrary, it routinely reported increased HR in highly stressful job scenarios (Galy, Cariou & Mélan, 2012).

Using a wearable device as a smartwatch to measure health parameters is well accepted. Seifert (2018) explored the use of wearable devices to track self-recorded health data and the willingness to share this data with researchers. Results indicated that 43.3% of all participants used one or more mobile devices (activity tracker, smartwatch, smartphone, or tablet), and that 27.6% used those devices for recording health data. Also, there are studies to detect stress using wearable sensors among other methods (Sano & Picard, 2013).

It is possible for wearable devices to monitor mental health and physiological stressors, allowing users to make sense of their emotional awareness and regulation, or for the data to be transferred on to a professional for subsequent action (Lui, Loughnane, Polley, Jayarathna & Breen, 2022). Ciabattoni, Ferracuti, Foresi, Freddi, Monteriù and Pagnotta (2017) proposed a real-time detection of mental stress during different cognitive tasks by processing HR, Galvanic Skin Response (GSR), and Body Temperature (BT) acquired by a commercial smartwatch in an experimental context.

On the other hand, using a smart bracelet or smartwatch for stress assessment in the educational field is not widespread. There are studies about the use of a smartwatch in students for tracking attention, learning interactions, and physical data (Liang, Su, Chen, Wu & Chen, 2019), or as a device to measure pulse rate in cardiovascular classes of Biology in secondary school (Dolenšek, Kos, Stožer & Špernjak, 2022).

Thus, this study is novel, as it applies an existing technology, the smartwatch, to the monitoring of teacher HR in the school, an aim and field that had not been considered before. This implies a new instrument for measuring stress in teachers,

1.3. Environmental Conditions

The quality of indoor classroom conditions influences the stress/well-being of its occupants, in this case teachers and students. According to Thach, Mahirah, Sauter, Roberts, Dunleavy, Nazeha et al. (2022), higher satisfaction with air quality, thermal comfort, noise and lighting was associated with a decrease in work stress.

Over the previous several decades, investigation established elements of learning environment and has found relations between the classroom ambience and student results. Acceptable indoor conditions would not be achieved unless a holistic acceptance in air quality, thermal, acoustical, and visual comfort at the same time. And any changes in these measures leads to discomfort and productivity loss in classrooms (Dorizas, Assimakopoulos, Helmis & Santamouris, 2015).

Regarding temperature, the Köppen-Geiger climate classification has been used to group the classroom thermal comfort field studies. In the review of Zomorodian, Tahsildoost and Hafezi (2016), data showed that most of the studies (65%) are conducted in group C, that includes Mediterranean climates as Spain. In this sense, the temperatures detected in the analysis are useful for our context: the minimum is 16 degrees Celsius; comfort is 21,66 degrees Celsius, and the maximum is 30,70 degrees Celsius.

We considered it appropriate to explore the influence of some environmental variables. For contextualization, our study, it took place at a time after the COVID confinement. To ensure safety, masks were still mandatory in classrooms and windows were to be opened for a minimum of ten minutes per hour of class, with the doors open whenever possible.

The sample was taken in winter and, despite the southwest orientation of the building, the sun shines in the morning from the first classes until 3:00 p.m. when the last class ends, although the windows are protected from the sun by movable louvers.

2. Design/Methodology/Approach

The methodology used is exploratory because it addresses the use of the smartwatch for the first time as a tool to monitor the biodata of teachers, specifically the HR. It focuses on the study of two volunteer teachers who used the device during several class sessions over a week. This will allow for a more in-depth study after the first results have been obtained. The approach is quantitative.

The data obtained through a Huawei smartwatch. Participants' physiological stress reactions were operationalized as the average HR during the teaching practice (dependent variable). The other contextual data, such as the day of the week, the class time, the subject taught or the learning activities, are analyzed. In addition, environmental data such as temperature, humidity and solar irradiance provided by the weather station closest to the school, obtained through the official meteorological service of Catalonia (meteo.cat), have been incorporated.

The study classified the teacher's activity, based on observation in the classroom, into the following categories:

- Explanation: the teacher makes an expository class.
- Observation: the teacher waits, sitting or standing, for students to complete a task.
- Attention: the teacher moves around the classroom, monitoring the work of the students.
- Interaction/discussion: students carry out teamwork, guided by the teacher.
- Logistic activity: not an academic activity; it is the specific displacement of the teacher outside the class.

The various data sources were transferred to a spreadsheet for further analysis. Data analysis was performed with the open-source statistical program JASP. Figure 2 represents the dependent variables from different sources that could affect the independent variable HR.

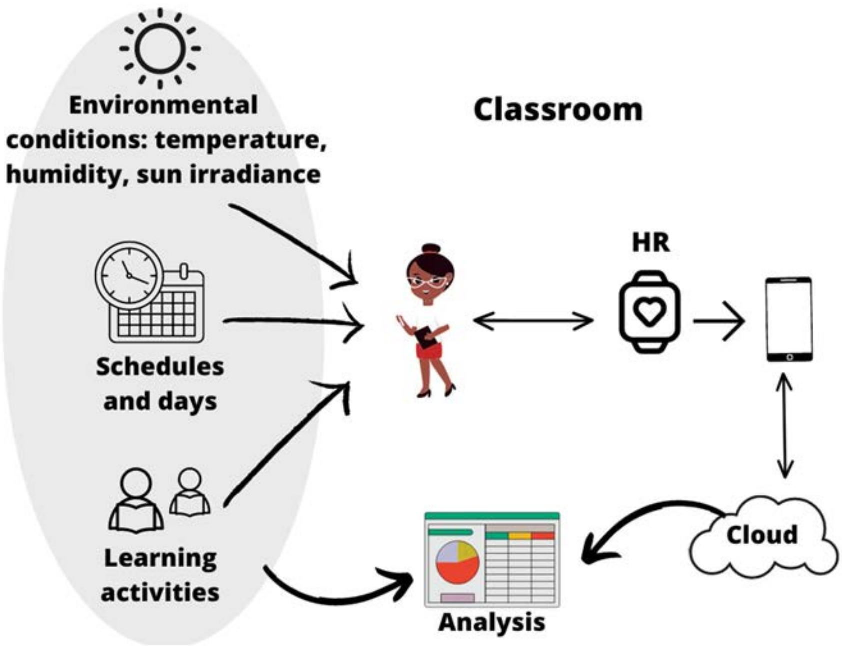

Figure 2. Data sources set

2.1. Participants

Two secondary school teachers volunteered to participate in the study, one male (M) and one female (F). Teacher F is 42 years old, and she has 16 years of experience. Teacher M is 39 years old and has 15 years of teaching experience.

Both wore the smartwatch between 2 and 6 hours per day, according to each teacher's schedule, for 10 days, in 2 weeks, during class time in the subjects of Social Sciences and Technology and Computing. The biometric data were recorded automatically, and the storage was manual. They also recorded the educational activities that took place during the lessons.

Teachers were informed of the characteristics of the study and signed an informed consent form. The study was approved by the Ethical Committee for research in people, society, and the environment of the Rovira i Virgili University.

3. Results and Discussion

HR by teachers. There are significant differences in the HR of the two participating teachers, according to the Mann-Whitney test (U=1701.500, p<0.001). Mann-Whitney test (U=1701.500, p<0.001). Teacher F had a lower HR (M=69.617, SD=5.291) than teacher M (M=94.067, SD=5.291) (Figure 3)

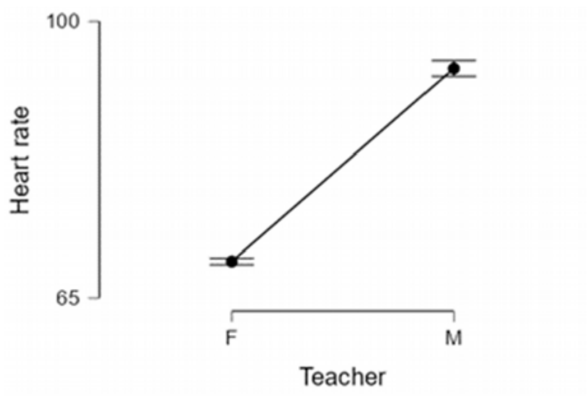

Figure 3. Comparison HR by teachers

HR and day of the week. We found differences between the RH according to the days of the week, as can be seen in the figure below (Figure 4)

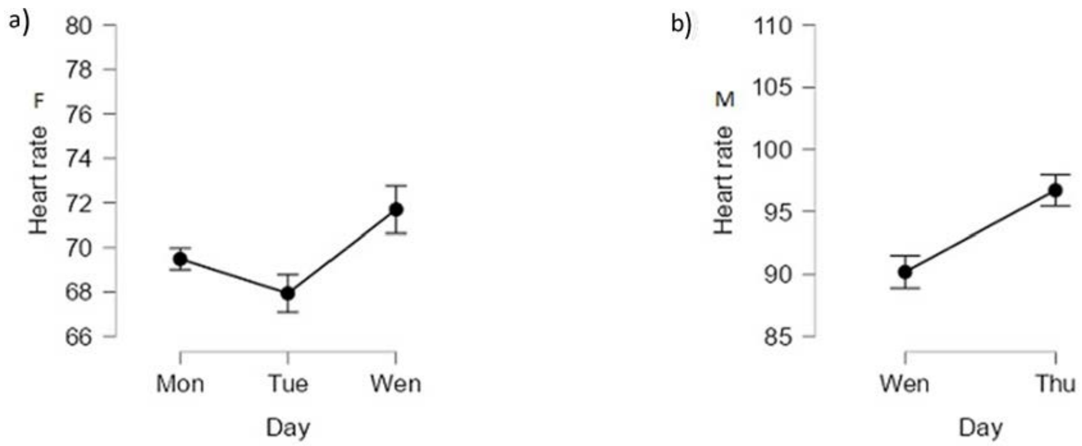

Figure 4. a) HR comparison among teacher F. b)HR comparison among teacher M

The Kruskal-Wallis test indicates that teacher F showed significant differences in HR according to the day of the week (H=44.790, p<.001). According to Dunn's post hoc test, there are variations between pairs of days: between Monday (M=69.491) and Tuesday (M=67.941), between Monday (M=69.491) and Wednesday (M=71.692) and between Tuesday (M=67.941) and Wednesday (M=71.692), at a significance level of p< .001). Similarly, for teacher M, the Mann-Whitney test showed significant differences between the two days he taught (W=2304.500, p<0.001), with the HR being higher on Thursday (M=96.704) than on Wednesday (M=90.188).

Female teacher gets a lower HR than male teacher. This is contrary to scientific evidence indicating that the average for adult women is between 78 and 82 beats while the average adult male HR is between 70 and 72 beats per minute, while (Prabhavathi, Tamarai-Selvi, Poornima & Sarvanan, 2014). Considering that this result comes from the fact that there are other variables that could influence the HR of individuals, such as physical condition.

HR and student group size. According to the Kruskal-Wallis test there is no significant variation in HR according to the number of students in teacher F (H=1.488, p=0.223). For teacher M cannot evaluate this aspect because he only taught one group size.

About class size, although no differences were found, it is a step forward to have studied this variable in an objective way because the gap in the field could be attributed to the fact that previous qualitative investigations on class size and teachers' stress reactions were not obtained directly from the act of teaching, but from teachers' subjective and retrospective impressions (Harfitt, 2012).

HR and time of the day. Differences in HR during the school day were shown for the two teachers (Figure 5).

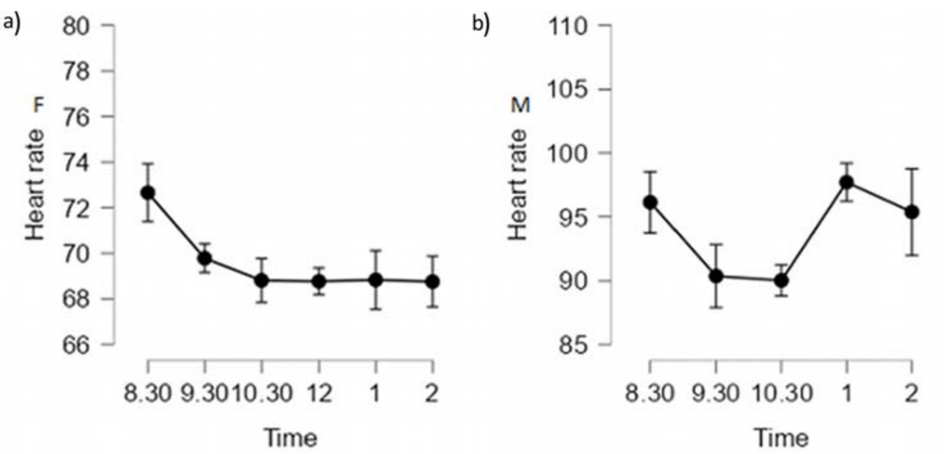

Figure 5. a) HR during the day for teacher F. b) HR during the day for teacher M

The Kruskal-Wallis test showed significant differences in HR during the day for both teachers. Teacher F obtained H=57.710 (p<0.001). The Dunn post hoc returned differences between 8:30am and 9:30am (p=0.003), 10:30am, 12pm and 1pm (all at p< .001); between 9:30am and 10:30am (p=0.003), and between 9:30am and 1pm (p< .001). The HR was at 8:30 am (M=72.660), followed by 9:30 am (M=69.785) (Table 1).

Comparison	Z	W_i	W_j	P	p_{bonf}	p_{holm}
8.30am - 9.30am	3.407	436.060	353.487	< .001 ***	0.005 **	0.003 **
8.30am - 10.30am	6.291	436.060	267.505	< .001 ***	< .001 ***	< .001 ***
8.30am - 12pm	4.840	436.060	315.561	< .001 ***	< .001 ***	< .001 ***
8.30am - 1pm	6.364	436.060	275.098	< .001 ***	< .001 ***	< .001 ***
8.30am - 2pm	4.401	436.060	296.694	< .001 ***	< .001 ***	< .001 ***
9.30am - 10.30am	3.504	353.487	267.505	< .001 ***	0.003 **	0.003 **
9.30am - 12pm	1.689	353.487	315.561	0.046 *	0.684	0.259
9.30am - 1pm	3.424	353.487	275.098	< .001 ***	0.005 **	0.003 **
9.30am - 2pm	1.907	353.487	296.694	0.028 *	0.424	0.226
10.30am - 12pm	-1.908	267.505	315.561	0.028 *	0.423	0.226
10.30am - 1pm	-0.297	267.505	275.098	0.383	1.000	0.722
10.30am - 2pm	-0.915	267.505	296.694	0.180	1.000	0.720
12pm - 1pm	1.715	315.561	275.098	0.043 *	0.647	0.259
12pm - 2pm	0.622	315.561	296.694	0.267	1.000	0.722
1pm - 2pm	-0.705	275.098	296.694	0.241	1.000	0.722

* p < .05, ** p < .01, *** p < .001

Table 1. Dunn's Post Hoc Comparisons – Time Teacher F

Meanwhile, teacher M obtained H=51.629, p<0.001. Dunn's post hoc test showed differences between several pairs of times: between 8:30 am and 9:30 am and 10:30 am (both p<0.001); between 9:30 am and 1 pm (p<0.001), 2 pm (p=0.026), between 10:30 am and 1 pm (p<0.001) and 2 pm (p=0.002). The HR occurred at 1 pm (M=97.709), followed by 8:30 am (M=96.143), with the lowest at 10:30 am (M=90.023) (Table 2).

Comparison	Z	W_i	W_j	p	p_{bonf}	p_{holm}
8.30 - 9.30	3.715	124.806	77.098	< .001 ***	0.001 **	< .001 ***
8.30 - 10.30	4.857	124.806	63.602	< .001 ***	< .001 ***	< .001 ***
8.30 - 1	-1.100	124.806	137.918	0.136	1.000	0.438
8.30 - 2	0.380	124.806	118.786	0.352	1.000	0.438
9.30 - 10.30	1.025	77.098	63.602	0.153	1.000	0.438
9.30 - 1	-4.858	77.098	137.918	< .001 ***	< .001 ***	< .001 ***
9.30 - 2	-2.560	77.098	118.786	0.005 **	0.052	0.026 *
10.30 - 1	-6.055	63.602	137.918	< .001 ***	< .001 ***	< .001 ***
10.30 - 2	-3.429	63.602	118.786	< .001 ***	0.003 **	0.002 **
1 - 2	1.229	137.918	118.786	0.109	1.000	0.438

* p < .05, ** p < .01, *** p < .001

Table 2. Dunn's Post Hoc Comparisons – Time Teacher M

Regarding differences in the day of the week, no scientific studies have been found that refer to this but found differences with respect to the time of day. In the present study, teacher M reports this tendency, but must consider that the last class is at 2pm, so it is difficult to perceive her response to stress in the last hours of the day. There appears to be no significant differences in HR according to the time of day, although the hypothalamic system responds more to psychological stress in the morning rather than in the evening, whereas the sympathoadrenal medullary system in terms of increase of HR did not show a significant time of day difference between the two groups of the experiment (Yamanaka, Motoshima & Uchida, 2019).

HR and educational activity. The HR according to the type of educational activity varied significantly in the two teachers (teacher F: H=66.660, p<0.001; teacher M: 46.733, p<0.001) as shown in the Figure 6 according to the Kruskal-Wallis test.

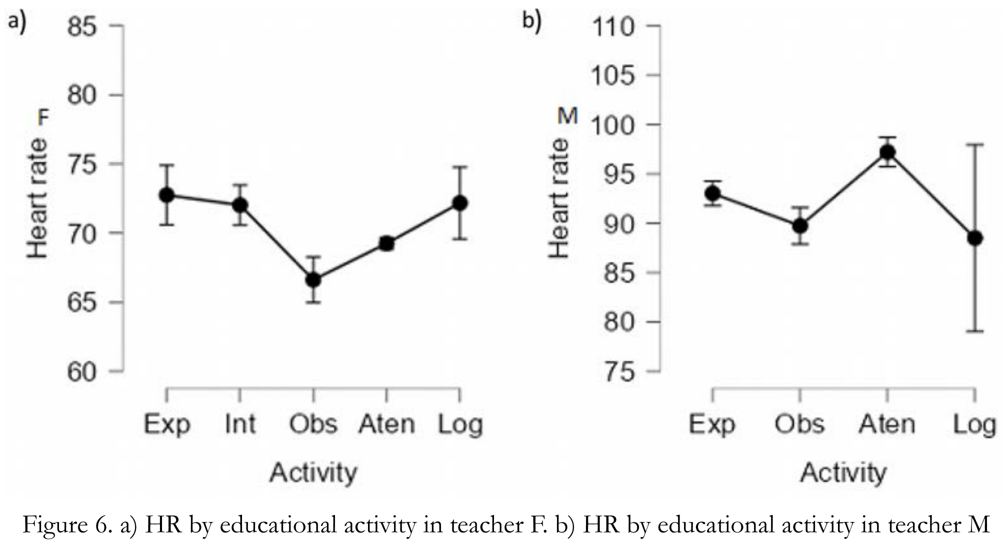

Figure 6. a) HR by educational activity in teacher F. b) HR by educational activity in teacher M

For teacher F, Dunn's post hoc test indicated the following differences: between Explanation and Observation and Attention (both at a level of p<0.001); between Interaction/discussion and Observation and Attention (both at a level of $p<0.001$); finally, between Observation and Attention and logistic activity (both at a level of $p<0.001$). The highest HR occurred during Explanation (M=72.745) and the lowest is Observation of students (M=66.621) (Table 3).

Comparison	Z	W_i	W_j	p	p_{bonf}	p_{holm}
Exp - Int	-0.039	398.273	399.636	0.484	1.000	0.535
Exp - Obs	6.692	398.273	182.379	< .001 ***	< .001 ***	< .001 ***
Exp - Aten	4.553	398.273	286.198	< .001 ***	< .001 ***	< .001 ***
Exp - Log	0.922	398.273	362.000	0.178	1.000	0.535
Int - Obs	6.340	399.636	182.379	< .001 ***	< .001 ***	< .001 ***
Int - Aten	4.172	399.636	286.198	< .001 ***	< .001 ***	< .001 ***
Int - Log	0.918	399.636	362.000	0.179	1.000	0.535
Obs - Aten	-4.317	182.379	286.198	< .001 ***	< .001 ***	< .001 ***
Obs - Log	-4.608	182.379	362.000	< .001 ***	< .001 ***	< .001 ***
Aten - Log	-2.301	286.198	362.000	0.011 *	0.107	0.043 *

* p < .05, *** p < .001

Table 3. Dunn's Post Hoc Comparisons - Activity Teacher F

For teacher M, Dunn's post hoc test showed differences in HR according to the educational activities: between Explanation and Attention to students (<0.001), between Observation and Attention ($p<0.001$) and between Attention and logistic activity ($p=0.012$). In their case, the highest HR was in Attention to the students (M=97.202) and the lowest in logistic activities (M=88.500) (Table 4).

Comparison	Z	W_i	W_j	p	p_{bonf}	p_{holm}
Exp - Obs	1.687	84.477	64.683	0.046 *	0.275	0.137
Exp - Aten	-4.068	84.477	127.117	< .001 ***	< .001 ***	< .001 ***
Exp - Log	0.672	84.477	69.750	0.251	1.000	0.502
Obs - Aten	-6.345	64.683	127.117	< .001 ***	< .001 ***	< .001 ***
Obs - Log	-0.234	64.683	69.750	0.407	1.000	0.502
Aten - Log	2.736	127.117	69.750	0.003 **	0.019 *	0.012*

* p < .05, ** p < .01, *** p < .001

Table 4. Dunn's Post Hoc Comparisons - Activity Teacher M

In the literature is difficult to find that one educational activity can generate more stress than another finds. Regarding class activity and HR, it is expected that observation would be the most relaxed educational activity, due to what it is to wait, and so it is with both teachers. However, with the rest of the categories there is no general result: for the teacher F the explanation is more demanding and for the teacher M, the attention to the students. Considering that there will be individual variability according to the preferences and abilities of each one.

Correlations HR and environmental conditions. The analysis between HR and environmental conditions in teacher F, showed small negative correlations between RH and Mean Temperature ($r=-0.207$, $p<0.001$), and RH with Sun irradiance ($r=-0.142$, $p<0.001$) (Table 5).

In Professor M, positive correlations were also expressed between RH and Mean Temperature ($r=0.326$, $p<0.001$), Humidity ($r=0.395$, $p<0.001$) and Sun irradiance (0.252, $p<0.001$) (Table 6).

Another difference found is in the correlations between HR and environmental conditions. In teacher F, HR is influenced with a negative correlation between temperature and sun irradiance, while teacher M maintains a positive correlation between HR and the 3 environmental variables. In relation to temperature, the low temperatures reported are out of thermal comfort (21.66 degrees Celsius), which would negatively affect the well-being of teachers. It should be borne in mind that the study was carried out in winter and the windows were open according to COVID protocol. In general, the temperature-HR relationship was observed to be V-shaped in most groups of participants (Madaniyazi, Zhou, Li, Williams, Jaakkola, Liang et al., 2016), which would more closely resemble the pattern of teacher F.

Variable		HR	Temp Mean	Humidity	Sun irradiance
1. Heart rate	Spearman's rho	-			
	p-value	-			
2. Temp Mean	Spearman's rho	-0.207 ***	-		
	p-value	< .001	-		
3. Humidity	Spearman's rho	0.062	-0.783 ***	-	
	p-value	0.115	< .001	-	
4. Sun irradiance	Spearman's rho	-0.142 ***	0.894 ***	-0.843 ***	-
	p-value	< .001	< .001	< .001	-

* p < .05, ** p < .01, *** p < .001

Table 5. Spearman's Correlations HR- environmental conditions Teacher F

Variable		HR	Temp Mean	Humidity	Sun irradiance
1. Heart rate	Spearman's rho	-			
	p-value	-			
2. Temp Mean	Spearman's rho	0.326 ***	-		
	p-value	< .001	-		
3. Humidity	Spearman's rho	0.395 ***	0.256 ***	-	
	p-value	< .001	< .001	-	
4. Sun irradiance	Spearman's rho	0.252 ***	0.899 ***	0.153 *	-
	p-value	< .001	< .001	0.027	-

* p < .05, ** p < .01, *** p < .001

Table 6. Spearman's Correlations HR- environmental conditions Teacher M

4. Conclusions

The present study provides the assessment of indirect stress through HR with a commercial device such as a smartwatch, which allows for real-time and continuous measurement. This makes it a novelty in the field of education.

In relation to the main objective of exploring the use of the smartwatch as a tool for monitoring the teacher's stress through the measure of HR, it has been fulfilled in a positive way. We obtained data to monitor the conditions of high activation for a teacher, as well as critical moments, which will serve for prevention.

The fact of having systematic information on the teacher's own variables and those of the environment which relatively affordable devices, is evidence of integrating the technologies of the Fourth Industrial Revolution into the educational environment and brings us closer to the concept of the Smart Classroom (Palau & Mogas, 2019).

In relation to the specific objectives, it has been able to observe the differences in HR between the participants depending on the day, time of day, activities carried out, and the influence of environmental variables (temperature, humidity, and sun irradiance). There are observed marked differences between the two participants. There are also observed differences in HR according to the day of the week, the time of the day and the activity performed in class, but they do not share a pattern. In this way, the results obtained from the data analysis are not conclusive due to the limited sample but do indicate trends in each of the individuals analysed.

Although no theoretical conclusions can be drawn, it is a first step to establish practical implications of the use of smartwatch or for teachers.

5. Limitations and Future Research

The limitations of the study are mainly that it is an exploratory and correlational study with a tiny sample, so it cannot draw generalisable conclusions from the analyses developed. Also, the control of the activities carried out in class was self-reported by the teacher, so there may be some inaccuracies.

Future research will investigate how smart bracelets and smartwatches can assist teachers in analyzing heart rate data with real-time camera footage and relating it to classroom activities. Indoor environmental factors, including noise levels, will be considered. A qualitative approach to evaluate teachers' perception of these devices' use and usefulness is another option.

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