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Introducing bystander resuscitation as part of subject-matter teaching in secondary schools: Do we overestimate interest and skill acquisition?

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Abstract

Cardiac health is a major health issue in modern societies. To improve bystander response to cardiac arrests, it has been recommended to introduce instruction in basic life support (BLS) into health-related subject-matter education (e.g., biology). This study aims to explore perceived specific interest, knowledge and recorded BLS performance before and after a BLS intervention, as well as possible effects of gender. Data of N = 365 secondary school students in Germany was analysed. They answered a questionnaire dealing with subject-related interest and a knowledge-test, before and after at least two lessons about BLS. A subgroup of students (n = 186) attended a simulation-based assessment. We found that students performed better chest compressions, but that initial interest was not sustained during intervention, particularly in the case of male students. The quality of chest compressions and knowledge growth can be improved for some aspects and future classroom interventions should aim towards a better understanding of students' interest motives for learning these skills. The role of more problem- and health-oriented, reflective, and modular learning opportunities in BLS education should be investigated to better address these issues compared to common instruction-centred trainings.

1 Introduction

> *And it would make sense, if we really manage to get people used to resuscitation from childhood on […]. Then they [i.e., children] will come home and say, 'I learned it today in school. And Dad, can I show you how to do resuscitation?' And then they bluntly affront their parents in a way that none of us would dare. […]*
>
> *– Interview from a local emergency paramedic (translated)*

The lifesaving importance of immediate basic medical support after cardiac arrests by informed and trained citizens has been outlined in multiple statements and publications (Dumcke et al., 2019; Gräsner et al., 2020; Hasselqvist-Ax et al., 2015; Perkins et al., 2015). Only 40.2% of cardiac arrest received bystander resuscitation in Germany 2019 (Fischer et al., 2020).

In recent years, efforts have been intensified to improve survival after cardiac arrest in Europe. Besides improving emergency medical service structures, it has been suggested to implement emergency telephone assistance and create public campaigns to foster and support teaching basic measures to bystanders (Chen et al., 2019; Wissenberg et al., 2013). Medical recommendations emphasize providing resuscitation lessons for secondary school students (e.g., Böttiger, Semeraro & Wingen, 2017). As the introductory quote illustrates, early experienced familiarity and open-minded children are promising learners. This is also supported by the German Ministers of Education and Cultural Affairs (KMK) since 2014. They recommend annually teaching basic life support starting at the age of 12. In Germany, these programs are available, but the level of implementation differs in each German state as it is not mandatory. The distribution is moderate to low (Schroeder et al., 2017). This could reflect difficulties in teaching health issues and basic life support measures, such as missing funding for materials or teacher training, outstanding legislation status and uncertainty regarding instructor competencies (Dumcke et al., 2019).

Circulatory diseases are a leading cause of death in Germany and other industrialized nations. Along with medical board and research recommendations for basic life support (BLS) education (Böttiger et al., 2017), the enhancement of an interdisciplinary teaching concept on "perspectives in cardiac health" may foster students' health-knowledge and first aid skills. To support this approach, we started our project "Leben retten macht Schule"[1], following an interdisciplinary concept to be addressed in biology or physical education subject-matter teaching and including questions from medicine, human biology, physiology, and social psychology. Within the interventions, the effectiveness of setting, methods and materials is evaluated, indicating practicability for later implementation. Although many investigations on BLS training success have been conducted (see review of Plant & Taylor, 2013), evidence on self-reported attitudes or beliefs is poor. While BLS approaching self-efficacy was presented and investigated by Dumcke, Rahe-Meyer, and Wegner (2021), situational interest (i.e., interestedness) was not yet on focus when researching BLS educational settings. There is a need to close this gap, as the learners' interest is a variable of learning motivation (Krapp, 2007) and therefore meaningful for learning achievements. Finally, gender disparities are known for BLS education regarding performance or engagement (e.g., Finke et al., 2018), which is why studies regarding interest or learning outcomes with respect to gender issues should be carried on.

As part of a broader designed mixed-methods study[2], this article contributes general findings on secondary school students' (1) initial interest and endorses (2) knowledge (by questionnaire), as well as (3) performance outcomes (by a practical test) regarding BLS which is the standard cardiopulmonary resuscitation (CPR) algorithm.

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[1] Translated as: "schools start saving lives. This initiative is part of the funded project "The heart in school", see acknowledgements.

[2] The survey contained more than the scales and variables reported in this article.

Interventional effects over time and potential gender issues in interest and performance results are discussed in the context of teaching and interdisciplinary concepts.

2 Background

To describe the theoretical and empirical basis of this mixed-design-approach, a broader interdisciplinary description is necessary. It involves interest research, European resuscitation guidelines and research on education involving the issue of first aid and BLS.

2.1 Situational interest

Interest can be described as a motivational variable that "refers to the psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas (i.e., content) over time". (Hidi & Renninger, 2006, p. 112). Despite different conceptualizations (Renninger & Hidi, 2011), interest is always referred to person-object/environment interaction (Krapp, Hidi & Renninger, 1992, p. 5). Krapp (1998, 2007) developed an ontogenetic perspective of interest, differentiating interest into individual and situational interest. General characteristics of interest are cognitive activation (e.g., readiness to acquire new information), emotional stimulation (involvement of enjoyment, autonomy and social relatedness) and value-relation, connecting interest to one's attitudes and aspects of a self-system (Krapp, 2007, pp. 10-11). Whereas individual interest results from a multi-stage internalization process, situational interest is conceptually similar but different from curiosity (Krapp et al., 1992, p. 9): Both share "collative variables" (novelty, uncertainty, conflicts) – as it is the case when confronted with a CPR situation – but situational interest or interestedness is driven by content-specific (cognitive) characteristics. It also may develop into persisting interest. In the first instance of interaction, situational interest is usually generated by external objects or tasks (e.g., pictures, quotes, or presented problems) and instructional conditions (group work, media, etc.) but is known as the "catch facet" or the predisposition to reengage with particular content ("triggered situational interest", Hidi & Renninger, 2006, p. 114). For example, this can be the excitement to learn about circulation or CPR or doing new hands-on activities.

With respect to interest in classrooms, interest is a medium predictor for learning achievements (Schiefele, Krapp & Winteler, 1992). However, for STEM subjects, a general decline in interest is empirically evident as school progresses (Potvin & Hasni, 2014) and could be a result of an increase in abstract content in science education. With respect to gender issues, scientific interest differs between males and females according to ROSE results (Schreiner, 2006): German girls' are particularly interested in human biology. Diseases, pandemics, functions of the body and sexuality are of higher interest, when compared to boys ($p < .001$; Holstermann & Bögeholz, 2007, p. 75). For instance, how to administer first aid and the use of medical equipment is ranked fourth

(Mean 3.4; scale from 1 to 4) of the girls' 10 most interesting science issues (vs. rank 9 for boys; Mean 3.1) (Elster, 2007, p. 6).

2.2 Resuscitation quality and guidelines

BLS training is derived from the 2015 European Resuscitation Council Guidelines for adult resuscitation and early defibrillation based on the International Liaison Committee in Resuscitation Consensus on Science and Treatment Recommendations (Perkins et al., 2015, pp. 84-86)*: (1) Recognition of cardiac arrest, (2) Calling Help/Emergency call, (3) Provide minimum circulation (chest compressions), (4) Apply a defibrillation with an Automatic External Defibrillator (AED) [if available].* Rescue breaths are recommended for trained and able persons (Perkins et al., 2015, pp. 82;84). However, for training secondary school students, chest-compression only CPR can be favored to ease initial learning of effective chest compressions as the most crucial task during BLS – with comparable outcome to conventional BLS (Hüpfl, Selig & Nagele, 2010). By postponing more difficult actions (e.g., ventilations, AED usage, effective communication and coordination in a team), educators can prevent cognitive overload and restraints.

2.3 Evidence overview on student CPR training

In recent years, multiple studies have led to a growing body of evidence regarding teaching CPR to students. In 2013, Plant and Taylor reviewed 49 studies regarding a variety of teaching methods for CPR training of schoolchildren and concluded an overall improved performance (e.g., knowledge, skills, perceived competence/efficacy) after training within a short time scale (Plant & Taylor, 2013, p. 419, see also Lukas et al., 2016; Meissner, Kloppe & Hanefeld, 2012). Students younger than 10 years old were able to perform a consciousness assessment, call for help and operate an AED, which makes age-appropriate teaching concepts favourable (Plant & Taylor, 2013, p. 419). A longitudinal 4-year investigation reported that students starting to learn practical CPR at the age of 10 finally performed better than those starting at 13 years of age (Bohn et al., 2012).

Chest compressions (and mouth-to-mouth resuscitation) are performed more effectively as age and body mass index (BMI) increases (Fleischhackl et al., 2009; Jones et al., 2007), in line with studies later than Plant and Taylor's review (e.g., Abelairas-Gómez et al., 2014). However, only 26% to 45% of 13-year-old students reached the recommended depth, stressing the importance of considering this physical limitation in lessons. In general, practical lessons and hands-on activities were preferable to video-only or simulation methods (Reder, Cummings & Quan, 2006), particularly for CPR outcome. However, more recent investigations indicate that theoretical knowledge and cardiac arrest responsiveness is adequately supplemented by brief video interventions (Beskind et al., 2016; Cerezo Espinosa et al., 2018).

The effect of previous experience with live-saving measures depends on a variation of social background and gender (Plant & Taylor, 2013, p. 417). With respect to gender, a

review from Finke et al. (n = 24 studies) observed higher encouragement and interest to pass on knowledge in females, when equipped with portable manikins to show CPR to relatives (Finke et al., 2018, pp. 71-74). Males were more confident with their proficiency in CPR (Kanstad, Nilsen & Fredriksen, 2011) and predominantly perform deeper chest compressions (Finke et al., 2018, p. 73). No gender-related differences were found for the correct rate of chest compressions (Abelairas-Gómez et al., 2014; Fleischhackl et al., 2009), as well as for the level of knowledge (Finke et al., 2018, p. 74).

With respect to the instructor's profession, investigations had shown that lessons conducted by trained schoolteachers did not result in negative training results. Older and trained students ('peers') seem to be qualified to train younger classes: their learning achievements were comparable to lessons led by medical professionals (e.g., Lukas et al., 2016).

3 Research interest and hypotheses

The results of this work are presented as an interim analysis in the context of a broader project-based assessment. For this analysis, all available data were pooled independent from two differing teaching approaches (basic versus extended) to compare the extensive sample to the body of evidence[3]. The general question to be answered was what levels of situational interest (i.e., interestedness), theoretical knowledge and practical skills, as learning outcomes, secondary students have in relation to the BLS teaching intervention.

Applying study findings on resuscitation training (Finke et al., 2018) that there are gender differences regarding motivational attitudes of students (and also skill performance), this study provides new information about initial interest, also taking reported higher interest in females regarding health issues in science education into account (Elster, 2007; e.g., Holstermann & Bögeholz, 2007).

H1   Perceived subject-related interest increases from baseline (t_0) to t_1.

H2   Female students show a higher interest for human circulatory functions and CPR than male counterparts.

A second aim is to confirm prior research with respect to positive outcomes in CPR quality and knowledge that is achieved by interventions dealing with cardiac arrest and CPR, especially after action-oriented lessons (Lukas *et al*., 2016). For CPR performance quality (i.e mean values and percentage of correct appliance) we hypothesize that we will find a positive intervention effect for all assessed variables (baseline vs. final assessment), which is observed for both genders. However we assume gender differences in performance quality between male and female participants to also verify

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[3]   Note: According to COVID-19 pandemic, the intervention formats or group datasets are incomplete, causing baseline inequality (age, type of school, etc.). Therefore, intervention groups were *not* compared regarding effectiveness here.

previous review reports (cf. Finke et al., 2018). However, these findings are conflicting so that we cannot specify which differences are to be expected.

H3   Average compression quality increases after the intervention (t_1) compared to baseline (t_0).

        a.   The compression depth and rate increase to t_1.

        b.   Compressions have a higher percentage of correct depth, rate and chest recoil at t_1.

H4   Differences in absolute performance (mean depth and rate) and correct percentages) of male and female students (at t_0 and t_1) are significant.

Regarding knowledge development, we analysed the mean score and the proportions of correct answers (see Appendix 2) before and after the intervention, to confirm a knowledge growth effect as described by literature (Lukas et al., 2016, p. 37; cf. background). Since gender does not play a role (Finke et al., 2018), we assume that both genders have similar opportunities to improve their knowledge.

H5   Mean knowledge is significantly different at t_1 compared to t_0.

H6   No gender differences in knowledge acquisition apply.

4 Methodology

4.1 Design

A mixed-methods design was used for data collection. The students' self-perceptions and knowledge were assessed with a paper-pencil questionnaire before the intervention followed by a CPR practical simulation test, which was completed by a subgroup of students due to limited class time. The same tests were completed after the intervention (see Figure 1).

Questionnaire and practical test data were collected between 5 and 10 days before and after the intervention. The intervention lasted a minimum of 90 minutes for the education of basic information on cardiac arrest and the process of BLS including 60 min. hands-on practice (basic). Additionally to this, a part of participants (extended) received 6-10 teaching units to frame or consolidate specific interdisciplinary content (e.g., circulatory and heart conduction system, related first aid measures, defibrillation, or medical aspects).[4]

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[4]   These differences were not considered or investigated in this article, which accesses pooled data of all interventions (cf. footnote 3, above).

Fig. 1: Study design overview. The flow-chart indicates time-points (left), procedure and test instruments (middle) and exclusion criteria (right column). * See for example Wegner, Peperkorn, and Dumcke (2020).
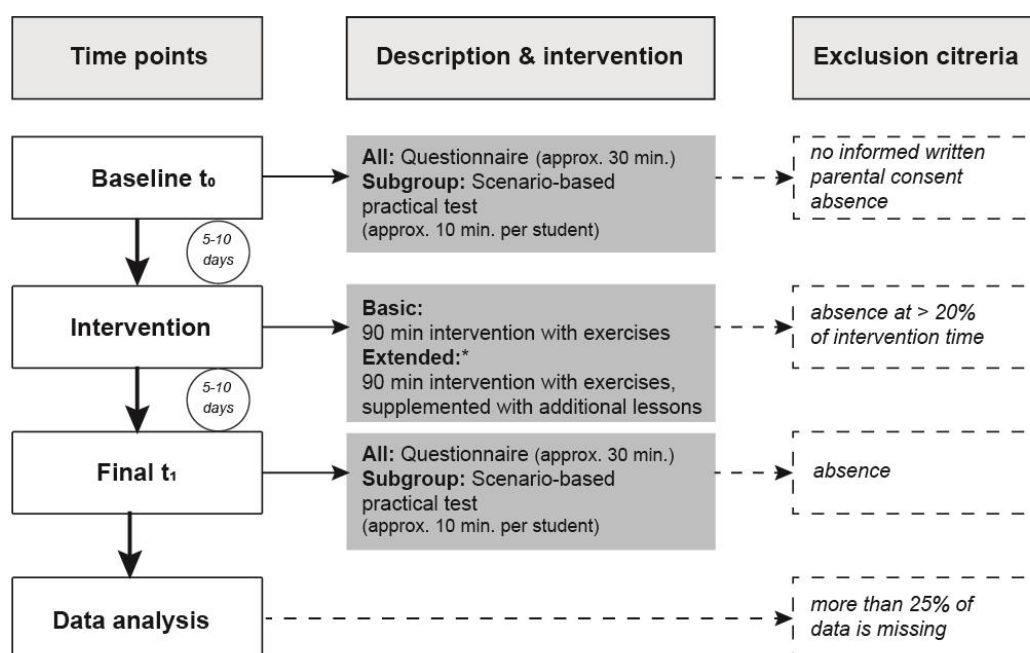
4.2 Paper-pencil questionnaire

The questionnaire was developed for the project in which this study was conducted, as no established instrument was available. Only students with a signed informed written consent could participate. Anonymization was realized by using an individual code (characters and numbers) created by the participants out of personal information. The questionnaire covers (a) demographics and general information, (b) self-reported situational interest (6 items; besides a broader number of other scales, which is not dealt with here), (c) a knowledge test (8 single-choice questions) and (d) a teaching quality assessment at t_1 (also not part of this article).

Students' class, age, biology and physical education grades, prior first aid activities and prior experience with cardiac arrest/CPR were assessed. Items were randomly arranged for every scale at baseline and final testing.

4.2.1 Subject-related interest

Subject-related interest was captured using a modified scale for 'triggered interest in Biology' from Wegner (2009). To relate the original items to this specific issue, the phrases "Heart & Circulation" (human biology aspect) and "CPR" (resuscitation specific skills) were inserted, dividing this scale into two domains (Table 1, Appendix 1). Due to insufficient item psychometrics (low discriminatory power and inter-item-correlation), the original subscales were shortened to three items each (for reliability values, see Table 1 and for a full item list, see Appendix 1).

Table 1: Psychometric data of the subject-related interest scale.

Scale[a]	Items Example	No.	N t_0	t_1	Cronbach's α t_0	t_1
General (combined) subject-related interest (INT) (Wegner, 2009, modified)		6	356	352	.932	.915
Domain: Circulatory Issues (CIRC)	I am very interested in the issue of 'heart & circulation'.	3	360	355	.901	.887
Domain: BLS Issues (CPR)	I think the issue 'resuscitation' is exciting, so I would like to know more about it.	3	361	361	.905	.887

[a] 6-point rating scales: 0=fully disagree; 5=fully agree (translated from German language)

Abbreviations: CPR: cardiopulmonary resuscitation; BLS: basic life support

4.2.2 Knowledge single-choice test

To assess domain specific knowledge, we conducted a single-choice test with eight items equally split between a) theoretical, human biological knowledge regarding mechanisms and characteristics of the circulatory system/heart and b) technicalities of resuscitation (recognition and measures). Single choice questions were composed out of one correct answer and two non-matching distractors. The questions were deliberately chosen to cover a wide range of difficulty levels (for a list of items, see Appendix 2).

4.3 Scenario-based test (manikin recordings)

The practical test was completed in small groups (4-8 students), but students cannot see each other. The quality of chest compressions was recorded. Each group was registered using the identifier code from the questionnaire to correctly assign the datasets. After registration, a documented, standardized instruction with a scenario description (e.g., "Imagine you are at the local bus station, a person is lying on the floor […]) was given to the participants. The test lasted one minute, starting with the initial chest compression. The students were briefly interviewed afterwards about how they felt about this task and received a short outlook (further procedure at t_0; individual outcome at t_1).

Student performance was recorded with the CPR manikin Little Anne™ QCPR (Laerdal Medical, Puchheim) via Bluetooth using the Laerdal Instructor App, v. 3.13.1 (see

Figure 2). The following records were defined as variables according to (Perkins et al., 2015, pp. 88-90): compression rate (required: 50-60 mm), compression depth (required: 100-120 min^{-1}) and chest recoil (required: complete release).

Fig. 2: Setting of the practical test and data storage. Students were arranged not to face each other. Credit: R. Dumcke.

4.4 Sample

In total, the data of N = 365 participants (mean age = 13.67 years, SD = 1.46; 47.1% female; see Table 2) fit the inclusion criteria. Participants were recruited from five schools in the region of Ostwestfalen-Lippe in Germany, with n = 213 (51.8%) at a grammar school ("Gymnasium") and the remaining participants from other secondary school types[5]. Half of the participants (48.2%) received the 90 minutes basic training in combination with additional, framing and interdisciplinary lessons (cf. design).

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[5]   In Germany, secondary schools have different types. "Realschule" provides a lower secondary education from grades 5 to 10 (10-16 years). "Gesamtschule" offers lower and upper secondary level, with different education paths. "Gymnasium" is focused on an in-depth general education (qualification for higher education access).

Table 2: Sample characteristics, N = 365.

Groups	Gender[a]		Grade				Prior first aid course	Witness of a cardiac arrest situation
	m	*f*	*06*	*08*	*09*	*10*	*yes*	*yes*
Age			11-12	13-14	14-15	15-16		
n	193	172	84	112	125	44	77	84
%	**52.9**	**47.1**	**23.0**	**30.7**	**34.2**	**12.1**	**21.1**	**23.0**

[a] No other gender than female/male was stated.

4.5 Statistics

Data was analysed with the Statistical package for the Social Sciences v.26 (SPSS 26). Demographics are given in percentages. The interest scale was checked for reliability (Cronbach's alpha; cf. Table 1), for knowledge test items difficulty indices were provided (Appendix 2). Differences between baseline assessment (t_0) and the final test (t_1) were calculated with paired t-test procedures. Differences between groups (e.g., gender) were assessed by calculating independent t-tests. Normal distribution was assumed in compliance with the central limit theorem (sample size per group n > 50) and proofed visually (Q-Q-diagrams, histograms). All independent comparisons were interpreted using the Welch output independent from Levene statistics (cf. Rasch, Kubinger & Moder, 2011). According to the hypotheses, in the case of multiple comparisons of dependent variables, Bonferroni-Holm corrections were applied. P-values ≤ .05 were considered statistically significant and effect size according to Cohen (1992) was estimated to be small (d ≥ 0.2), medium (d ≥ 0.5) and high (d ≥ 0.8).

5 Results

5.1 Situational interest

With hypothesis H1 an increase of subject-related, situational interest according to the intervention was assumed, which resulted in non-significant one-sided t-test comparisons for general interest (subscales combined) as well as for the interest subscales (circulatory system and resuscitation/CPR; p > 0.99 for all tests). Accordingly, all comparisons separated for females and males were non-significant (p = 1.00 for all tests).

However, mean values in interest decreased (Figure 3), which is why two-sided tests were conducted to review significance of decreasing interest after the BLS intervention. Subject-related interest in general (t(364) = 4.16; p < .001; d = .178), for the human circulatory system (t(364) = 4.49; p < .001; d = .198) and resuscitation/CPR

(t(364) = 3.10; p = .002; d = .136) were significantly lower at t_1 (indicated in Figure 3). Comparing situational interest separately related to gender in two-sided tests, a significant negative time effect was found for male and female participants as well. Both showed decreased self-reported interest in the circulatory system and resuscitation/CPR subscales as well as in the combined overall interest (Figure 3, all comparisons: p < .05).

When comparing interest between the gender groups, females showed significantly higher values for overall interest before (t (358.75) = 3,97; p < .001; d = .416) and after intervention (t(360.18) = 4,58; p < .001; d = .481) (see also Figure 3). This group effect was also given at both time points for each interest subscale: regarding the circulatory system (t_0: p < .001; d = .332; t_1: p < .001; d = .445) and resuscitation/CPR (t_0: p < .001; d = .448; t_1: p < .001; d = .440), respectively (Figure 3).

Notably, interest in resuscitation/CPR remains higher than in the circulatory system at the final test (M = 3.26 vs. M = 2.82, scale from 0 to 5), which was similar at baseline assessment.

Fig. 3: Differences in self-reported subject-related interest over time, in total and separated by gender at both time-points. <u>Gender differences at all time points are significant (p ≤ 0.001).</u> Asterisks (*) indicate the time effect (two-sided); *** p ≤ .001; ** p ≤ .01; * p ≤ .05. N = 365; n_{female} = 172; n_{male} = 193. Bonferroni-Holm correction was applied.
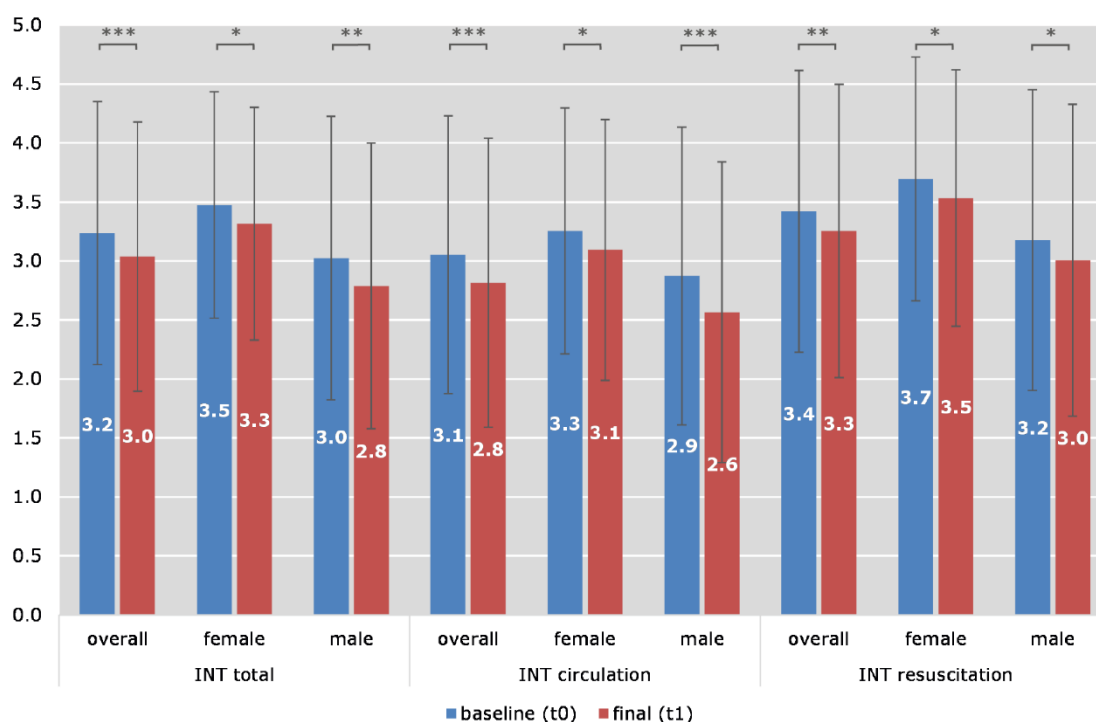

5.2 Knowledge assessment

Considering all participating students, average knowledge differs at t_1, and was higher compared to baseline (t(364) = -9,938; p < .001; d = .580; M = 3.97 vs. 4.79 of 8.00).

Females and males equally improved their total score from t_0 to t_1 (Figure 4). However, the time effect was not significant for questions about the circulatory system and heart function (t(364) = 0.409; p = .683; M = 2.22 vs. 2.19), only for those relating to managing and administering resuscitation and CPR (t(364) = -13.157; p = .001; d = .839; M = 1.75 vs. 2,59). Similar findings were also observed for each gender group (Figure 4).

There were no gender differences in knowledge level at any time point, except for the circulatory system, where it was higher for girls (p = .042; d = .260) at t_1 with a low effect. On average, participants answered 13% (danger of cardiac arrest) to 79% (human heart characteristics) of the questions incorrectly at final assessment (t_1). An overview of correct percentages for each item is provided in Appendix 2.

Fig. 4: Mean knowledge scores for the entire test circulation and CPR item sections, separated by overall results and by gender. Time effect significance is indicated by asterisks. Significant gender effects are indicated by crosses, non-indicated comparisons are non-significant. N = 365; n_{female} = 172; n_{male} = 193. *** p ≤ .001; * p ≤ .05; † p ≤ .05. Bonferroni-Holm correction was applied.
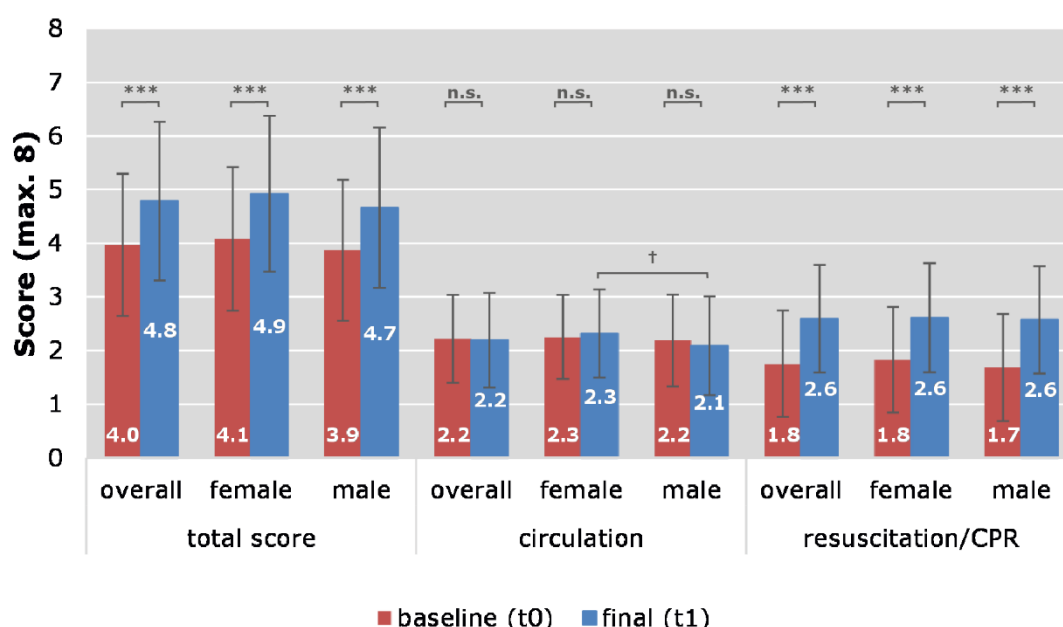
5.3 Chest-compression quality

Comparing the general quality outcome at t_1 with t_0, we found significant improvements for mean compression depth and rate after the intervention (p < .001; d = 1.20 and p < .001; d = 0.60, respectively; see Table 3). After the intervention, the mean depth of 60 mm and mean rate of 110 min^{-1} met the guideline requirements whereas at baseline, they did not. For the fraction of guideline-compliant performed compressions (to all compressions), results revealed that students at final testing achieved adequate depth in 79% (vs. 33% at t_0; p < .001, Table 3), but recommended rates in only 38% (vs. 17% at t_0), which was nonetheless a significant increase (p < .001,

Table 3). At t_1 chest recoil outcomes equalled the percentages at t_0 (92.5% vs. 91.9%; p = .622).

Table 3: Time-effect-comparisons for practical quality markers.

Variable	Group	Mean (SD)		Comparisons			
				Time		Groups	
		baseline (t_0)	final (t_1)	p (1-sided)	effect[d]	p (2-sided)[e]	
						(t_0)	(t_1)
Mean compression depth [mm][f]	total	40.94 (17.52)	59.59 (12.14)	< .001[a]	1.20		
	female	37.86 (16.35)	57.28 (11,47)	< .001[b]	1.33	.185	.120
	male	43.21 (18.07)	61.30 (12.39)	< .001[c]	1.14		
Mean compression rate [min^{-1}][g]	total	89.71 (39.37)	109.52 (19.27)	< .001[a]	0.60		
	female	88.05 (36.59)	106.28 (17.78)	< .001[b]	0.47	1.00	.176
	male	90.94 (41.43)	111.92 (20.05)	< .001[c]	0.61		
ompressions in correct depth (%)	total	32.70 (42.18)	78.59 (32.64)	< .001[a]	1.20		
	female	25.51 (38.93)	75.82 (35.34)	< .001[b]	1.35	.185	.666
	male	38.02 (43.86)	80.63 (30.50)	< .001[c]	1.10		
Compressions with correct frequency (%)	total	16.93 (26.70)	37.73 (34.53)	< .001[a]	0.67		
	female	20.09 (28.15)	41.96 (34.02)	< .001[b]	0.70	.519	.450
	male	14.60 (25.45)	34.60 (34.73)	< .001[c]	0.66		
Compressions with full pressure release (recoil) (%)	total	92.45 (22.13)	91.85 (19.59)	.622[a]			
	female	91.98 (23.78)	92.33 (19.15)	.546[b]		1.00	.774
	male	92.79 (20.94)	91.50 (19.98)	.701[c]			

n_{total} = 186; n_{female} = 79; n_{male} = 107

^a   Bonferroni-Holm corrected: complete data
^b   Bonferroni-Holm corrected: females
^c   Bonferroni-Holm corrected: males
^d   Effect size: Cohens d
^e   Bonferroni-Holm corrected: time point
^f   Recommended range: 50-60 mm
^g   Recommended range: 100-120 beats per minute

No gender disparity took effect ($p > .05$; cf. Table 3) in quality outcome: Mean values for compression depth and rate were guideline-compliant at t_1, while they were not at t_0 (43 vs. 38 mm and 91 vs. 88 bpm, for boys and girls, respectively). Remarkably, boys do *not* perform significantly better than girls when analysing the correct depth, rate and chest release percentages either before or after intervention (for all measurements $p > .05$, cf. Table 3). However, absolute values indicated a tendency toward gender-related differences in the quality of chest compressions, whereas females tended to maintain the correct rate more often than boys (42% vs. 35% at t_1, Table 3) and males compress more often in recommended depth (differences not significant; Table 3).

6 Discussion

Our results confirm recent empirical insight on student CPR training and performance and contribute new information about potential issues regarding critical interest development and necessary learning enhancements.

Situational interest on human circulation and BLS

Since interest, even "triggered situational interest", is a 'catch component' for intrinsic interest development and motivation (Hidi & Renninger, 2006, p. 114), our decreasing values are not favourable (rejecting H1). Novelty effects of the issue itself may have led to overestimated interest statements before the intervention, which were revised after the lessons' experience. Another argument for low interest may be that young students interpret cardiac diseases as a problem of "old people" resulting in a limited attribution of personal relevance (as known for approaches using risk communication; Schwarzer, 1997, p. 108). This perspective may be hard to change. Secondly, BLS training is generally said to be "easy for everyone" (Bohn et al., 2014, p. 323). Misleadingly, students may develop the opinion to know and master everything what is necessary after one (single) intervention. As a consequence, they again become less interested and motivated to learn to mastery and how to expand their competences. Concluding, an interdisciplinary strategy to hold interest may be feasible which provides the opportunity to learn about cardiac risks and pathology or to receive more

individual training time according to one's abilities. "Traditional" models in BLS teaching (strictly instructed exercises) should be enriched or replaced by action-oriented and problem-solving designs with self-regulated phases for students. Those principles are known to foster interest and motivation (Ryan & Deci, 2000). Finally, learning BLS is a process of bringing one's competences to a level of quality. Teachers may communicate a step stepwise path of learning from the beginning onwards proactively to the learners, accompanied with persuasion and viable feedback (e.g., which steps are done, which are to follow, etc.). The students should understand the progress as a motivating chance to build up optimism and empower self-efficacy toward competency in the whole complex of health and BLS literacy.

We found higher situational interest in girls compared to boys before and after participating in the intervention (confirming H2). Females were more engaged and motivated to not only participate, but also to relay what they learned about CPR or first aid (Finke et al., 2018). The stable interest of girls in medical tools and first aid (Holstermann & Bögeholz, 2007, cf. Chapter 2.1) is also covered by our intervention. Anyway, the findings suggest scheduling more course time also for considering gender stereotypes (cf. Perman et al., 2019) and support students (especially males) in discovering the relevance of BLS and how their progress may be lifesaving for someone else.

6.2 Knowledge achievement

Knowledge increased over time (confirming H5, but without gender effects, rejecting H6). These findings echo prior results that CPR training is effective for short-term retention (e.g., Lukas et al., 2016). Unfortunately, knowledge did not effectively change, particularly for the theoretical part regarding physiology-mechanisms. It is most likely that these issues were not properly addressed within the lessons or in not enough detail due to time restrictions. For a holistic comprehension of cardiac emergencies, we should aim to improve the link between physiology and health prevention (cf. "health education-concept", e.g., in the USA, Reder & Quan, 2003).

6.3 Qualitative outcome of compression-only CPR

Practical outcomes correspond to prior investigations (Lukas et al., 2016, p. 74; Meissner et al., 2012). However, the proportion of correctly performed compressions is not fully satisfactory according to guidelines (Abelairas-Gómez et al., 2014; Jones et al., 2007). Compared to preceding studies, compression depth values in this study are closer to compliant values, suggesting promising results for live-saving outcomes. On the other hand, the moderate performance for rate accuracy may underline the importance of these exercises (confirming H3 in parts). As an implication for teaching practical skills, hands-on lessons, scenario-based roleplay, and repeated training should be clearly considered when equipping schools for a broader implementation.

Gender disparities were not discovered for compression rate yet but reported for compression depth (Abelairas-Gómez et al., 2014, p. 815; Jones et al., 2007). Still, differences in depth due to gender-related physical strength are likely, even though

this effect was statistically not observed in this investigation (rejecting H4). This may be the case because students were older (14 years and over) and generally achieved higher proportions of in-range depth. Co-educated CPR lessons did not have disadvantages for one of the gender groups regarding practical achievements. Everyone is capable to learn BLS measures (Bohn et al., 2015); however, even while using 100 bpm music as a source of rhythm assistance during the exercise, adequacy was still low. Instructors should explore methods to better support the students' sense of rhythm. A reinforcement of recommended annually (or biannually) repeated CPR teaching (German Resuscitation Council [GRC], 2014) and the use of electronic or peer feedback devices (apps, observation sheets) should be launched.

7 Conclusion

When teaching basic resuscitation and circulatory issues to secondary school students we observed an initial interest and eagerness to learn, but this declined after the intervention. Future lessons must ensure that interest and at least reproductive knowledge remain stable over time. Further investigations should aim to understand students' cognition-, emotion- and value-oriented motives for learning in interdisciplinary health and first aid contexts. Regarding the practical section, our results confirmed that action-oriented simulations are important to ensure quality. However, medical and biological content knowledge should be understood as the basis for health literacy, competence perception and its communication. To improve knowledge gain, teaching concepts may be feasible, which include and link biological processes and problem-based, interactive, and communicative strategies when learning BLS practice. However, conditions and methods of competence and knowledge acquisition need further research so far.

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Supplementary Appendix

Appendix 1

Table A 1: Subject-related, situational interest: List of items (translated by authors) for circulatory issues (CIRC) and basic life support issues (CPR).

	Instruction: You will first be asked how you value the issues "human circulation" and "resuscitation". Do you agree with the statement, or not?	
Domains	CIRC_1 [1]	I am very interested in the issue of 'heart & circulation'.
	CIRC_4 [2]	I think the issue 'heart & circulation' is exciting, so I would like to know more about it.
	CIRC_5 [3]	The issue 'heart & circulation' makes me very curious.
	CPR_2 [1]	I am very interested in the issue 'resuscitation'.
	CPR_4 [2]	I think the issue 'resuscitation' is exciting, so I would like to know more about it.
	CPR_5 [3]	The issue 'resuscitation' makes me very curious.

Appendix 2

Table A 2: Proportion of correct answers of knowledge items and item difficulty. N = 365. CA: cardiac arrest.

Sub-scale	Question/Item	Time-point assessment	Correct answer (%)	False/no answer (%)	Difficulty s_i
Heart and Circulation	**danger during CA** What is the reason for serious danger to life during a cardiac arrest?	baseline	80.3	19.7	0.80
		final	86.6	13.4	0.87
	pathology CA Which malfunction is the most common reason for cardiac arrest?	baseline	32.3	67.7	0.32
		final	38.1	61.9	0.38
	risk group for CA Who is at risk to have a cardiac arrest?	baseline	85.8	14.2	0.85
		final	73.4	26.6	0.73
	human heart characteristics What is correct in terms of the human heart?	baseline	23.3	76.7	0.23
		final	21.4	78.6	0.21
Cardiopulmonary resuscitation (cc-only)	**check unconscious person** You see a person on the ground. He or she lies on the belly and does not react to your questions or when you shake their shoulders. What is the right next step?	baseline	66.0	34.0	0.66
		final	84.1	15.9	0.84
	check breathing How can you reliably check if someone has a functioning circulatory system?	baseline	17.8	82.2	0.18
		final	60.5	39.5	0.61
	chest compression quality I (depth and rate) How do you perform the chest compressions correctly?	baseline	52.3	47.7	0.52
		final	81.6	18.4	0.82
	chest compression quality II (flow-time) What do you have to consider when doing chest compressions?	baseline	39.2	60.8	0.39
		final	33.2	66.8	0.33

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