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RESEARCHED BASED REPORT OF PRACTICE

THERMAL IMAGING CAMERAS AS "CATCH FACTORS" FOR STUDENTS' CURRENT INTEREST

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ABSTRACT
Generating interest in different school subjects is one educational goal. Interest has an impact on learning processes and learning outcomes. Teachers can only trigger the situational interest of students e.g. by using attractive devices and media, or designing an interesting environment. With the advancing technological developments of recent years, the use of Thermal Imaging Cameras in school has become possible. These make phenomena and processes visible which are normally invisible. The cameras show a two-dimensional temperature profile of an observed region. Temperature changes due to certain processes like friction can been observed, so that students' understanding of these processes is supported. The goal of this study is to examine for how far experimenting with Thermal Imaging Cameras increases the three aspects of students' current interest – emotional, value-related, epistemic –, and which characteristics of the camera functions as a catch factor. Additionally, we wanted to identify if students prefer experimenting for itself or if they prefer experimenting with digital media. Therefore, 53 students from the 7th grade were asked, regarding the three aspects of the current interest, and attractive features of Thermal Imaging Cameras, in part in a pre-post-design. Additionally, the students were asked about their preference for experimentation (by itself or with digital media). Data analysis included paired t-test respectively one-sample t-test and an ANCOVA in order to clarify the factor gender. The results indicate that the camera did appeal to the students. They were particularly interested in the fact that the invisible was made visible. However, it did not succeed in increasing their current interest. It also turned out that the students appreciated doing experiments independently of the different media. The factor gender does not provide additional clarification.

Background: Generating interest in school subjects is an educational goal, because interest has an impact on learning processes and outcomes. In this regard, situational interest of students is important in classroom situations. It is provoked by so-called catch factors, e.g. digital media like a Thermal Imaging Camera (TIC). A TIC offers students a new way to experience thermal phenomena: it shows a two-dimensional temperature profile of an observed region. They are able to make visible thermal phenomena and processes that are normally invisible, due to the wavelength of infrared radiation.

Purpose: One aim of this study is to investigate the way in which experimenting with TICs affects the three aspects of current interest (emotional, epistemic, value-related), and which characteristics of the camera functions act as a catch factor. Another aim is to identify if students prefer experimenting for their own value or with digital media (iPads or TICs).

Sample/Setting: The sample consists of 53 students, grade 7 at a German secondary school in Lower Saxony. All the students carried out experiments with TICs for three school hours. In order to check if the students were comparable with other students and not primed by their teacher's educational approach, a pre-test directly before experimenting was conducted with a reference group of 50 students in the same grade at another secondary school in Lower Saxony.

Design Methods: In a quasi-experimental pre-post design, a questionnaire of the three sub-scales of the current interest was used. For comparison between groups and respectively within them, we used a paired t-test and one-sample t-test. We ran an ANCOVA to investigate possible differences between gender with respect to the post-test interest scores. In order to examine students' preference for experimentation (with digital media or for their own value), we let them rank the options. For possible catch-factors, six possible catch factors describing camera characteristics were derived inductively.

Results: The camera appealed to the students. They appreciate conducting experiments for their own value, but are emotionally engaged by working with the camera. The analysis of the catch factors indicates that the function of TICs is the center of interest: to see phenomena that are normally invisible (catch factor: *physical view*). However, the cameras did not succeed in increasing students' current interest. No gender differences could be identified in the development of interest.

Conclusions/Implications for classroom practice and future research: Experimenting is still of great importance in school science classes. However, the devices used must serve a real purpose, such as making the invisible visible. For TICs, it may be necessary to ask students more complex questions when they do experiments with the cameras, ones that can only be answered with the TIC and that are relevant to the students. The connection to the interesting phenomena of everyday life may be more fruitful as well.

Keywords: *Thermal Imaging Camera, interest, catch factor*

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1 INTRODUCTION

Thermal imaging makes processes visible that are invisible to humans, due to a radiation wavelength outside the spectrum of the human eye. Enhanced perception, technically extended by a Thermal Imaging Camera (TIC), can support teaching-learning processes (Greinert & Weßnigk, 2019). They offer access to thermal processes, and finally to a deeper understanding of energy dissipation (Nordine & Weßnigk, 2016; Weßnigk & Nordine, 2017; Greinert & Weßnigk, 2019).

TICs belong to digital media, which gain differentiated learning experiences (Weidenmann, 2009), and affect students' interest (Conradty, 2009; Schaumburg 2015). Students seem to develop interest in experimenting with TICs (Greinert & Weßnigk, 2019), though physics is not a subject favored (Hoffmann, Häussler, & Lehrke, 1998; Merzyn, 2008). TICs might have an impact on student fascination for physics (Vollmer & Möllmann, 2010). However, it is currently unclear whether learning environments, particular adapted to experiments with TICs, affect student interest.

2 RESEARCH BACKGROUND

2.1 Interest

Interest is a core concept in educational psychology. Interest influences learning processes and performance (Pekrun & Schiefele, 1996; Rounds & Su, 2014; Schiefele, 2009; Schiefele, Krapp, & Schreyer, 1993). Therefore, it seems plausible that science teaching aims to promote student interest (Baumert et al., 1997; Krapp, 2002). The study presented here is based on the person-object theory of interest development (Krapp, 1999; Renninger, Hidi, & Krapp, 1992).

2.2 Individual and situational interest

Corresponding to the person-object theory of interest development, four components are important (Fig. 1): the individual interest of a person as a disposition, the interestingness found in a learning environment or context, actualized individual interest, and situational interest.

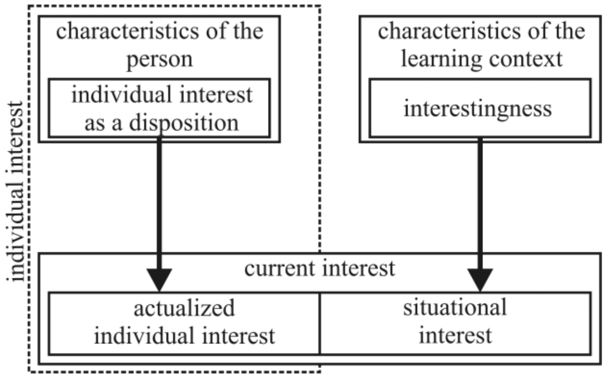

Fig. 1. Model of interest (Krapp, Hidi, & Renninger, 1992, adapted).

Actualized individual interest is influenced by personal characteristics, whereas situational interest is solely influenced by the characteristics of the learning context and its interestingness (Daniels, 2008). Both aspects are classified as current interest. They cannot be measured independently (Renninger & Hidi, 2015). Individual interest depends on personal preferences and develops slowly. Because teachers have little-to-no influence over it, situational interest is quite important in classroom situations (Mitchel, 1993). Teachers can create an attractive learning environment and may have an explicit impact on students' situational interest and an implicit impact on students' individual interest.

Three different levels of interest development (Krapp, 2002) indicate a possible change of individual interest when situational interest is affected (Hidi & Renninger, 2006) (Fig. 2): At the *first level*, the situational interest is triggered by catch factors (Hidi & Baird, 1986, 1988) like digital media. To reach the *second level*, so-called hold factors are necessary for stabilizing attention (Hidi & Renninger, 2006). This can be attained if students see the relevance of the content (Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000; Mitchel, 1993). At the *third level*, situational interest is converted into individual interest.

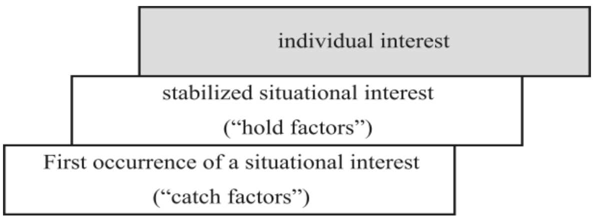

Fig. 2. Levels of interest development (Krapp, 2002).

2.3 Aspects of current interest

Schiefele (1978) distinguishes between three parts of current interest: *emotional*, *value-related, epistemic.*

The *emotional aspect* is described as participation, happiness and stimulation (Schiefele & Krapp, 1996). It addresses the extent to which the realization of an interest-based action is connected, such as to feelings (Krapp, 2018).

The *epistemic aspect* is characterized by the intention to gain more knowledge of the object of interest (Prenzel, Lankes & Minsel, 2000).

The *value-related* aspect describes high subjective importance attached to the object of interest. If this is seen as personally important, interest will increase (Krapp, 2018).

In this article, we focus on the impact of experimenting with TICs on the three interest aspects, as well as on the identification of catch factors that trigger current interest.

2.4 Thermal Imaging Cameras to enrich physics education

There is no real object with the temperature absolute zero, as every object emits electromagnetic radiation. The object's frequency spectrum depends mainly on its temperature. The higher the temperature, the higher the frequency of the maximum radiation emitted. Objects at room temperature will radiate mainly in the infrared part of the spectrum, with a frequency too low to be detected by our eyes. Thermal processes, usually invisible, can be observed in real time using TICs (Haglund, Jeppsson, Hedberg, & Schönborn, 2015). This expands human perception into the infrared range (Karstädt, Möllmann, Pinno, & Vollmer, 1998). A TIC determines the frequency spectrum of the radiation that hits its sensor, and constructs a color plot of the surface temperature of the region observed (Vollmer & Möllmann, 2010). The decrease in TIC prices has brought them into schools, for example in science classes.

A change in surface temperature distribution during a running process is displayed almost simultaneously on the camera screen. Often, a so-called false color image is chosen, scaling areas and objects with different temperatures with different colors. The handling of TICs is intuitive, permitting a qualitative-natural approach to thermodynamics (Haglund et al., 2015; Nordmeier et al., 2008).

The camera used is the FLIR ONE, attached to an iPad Mini (Flir Systems, 2020). The related app allows detailed infrared imaging (Greinert & Weßnigk, 2020).

In summary, TICs offer extended perception to be used in contexts where the visualization of thermal processes can contribute to a growth in knowledge.

2.5 Research Questions

Matching the increasing use of TICs in classrooms (Kleefeld & Bohrmann-Linde, 2019), the aim of this article is to capture the influence of TICs on students' current interest and analyze it more precisely:

1) Which aspects of students' current interest (emotional, value-related, epistemic) are influenced by experimenting with TICs?
2) Do students like doing experiments for their own value, or do they prefer experimenting with digital media (iPads and TICs)?
3) To what extent is it possible to identify catch factors when working with TICs?

3 METHODS AND DESIGN

3.1 Intervention

In order to answer the research questions, an intervention was carried out in two school classes as part of a regular physics lesson. At the beginning of the course of three roughly 45-minute periods, students had a short introduction to the TIC. Students then passed several experimental stations exploring different thermal processes, using TICs for the first time. Students carried out an experiment in which a friction process led to an increase in temperature of the object observed and the environment. The students were able to reason an increase in thermal energy that was transferred in the environment (for detailed description, see Greinert & Weßnigk, 2019).

3.2 Description of the sample

The intervention group consists of 53 students from two seventh grade classes in a secondary school in Germany (25 female, 26 male students, average age: 12,3 years).

3.3 Design

In order to control the influence of special features of previous education on the intervention group's interest in experimenting, and to ensure that our intervention group is not biased by the particular effects of its physics class, we additionally examined a reference group (n = 50) from another secondary school, same grade, regarding the aspects of current interest (pre-survey). The school has comparable socio-economic background, and the teaching follows the current pedagogical approach.

In order to answer research question 1, we asked the students for their current interest in a pre-post-design (T_0, T_1) in a questionnaire (Engeln, 2004), with the sub-scales *emotional*, *value-related* and *epistemic aspect* (Tab. 1). T_0 took place right before the intervention, T_1 at the end. All items were single choice, with the response options "not at all", "not really", "quite" and "definitely yes", labelled with numbers 1 to 4 (see appendix). The pre-test reflects students' current interest regarding doing experiments in their physics class. Example: *emotional: "Doing experiments was boring".*

Research question 2 focusses on whether students like doing experiments for their own value, or if they prefer experimenting with digital media, especially iPads and TICs. We added the following statement to the items of the *epistemic* and *value-related* scales: "*It is especially important/interesting for me to do experiments…*".
The students had to rank the options "with TICs", "with iPads" and "for their own value" in positions 1 to 3. We

differentiated TIC and iPad, although the TIC only works with an iPad that functions as the TIC's screen. We did this because the students know about the iPads from school classes and may prefer working with the iPad, disregarding a connection to the TIC.

In order to answer research question 3, six possible catch factors were derived inductively from results of science education research: i) *creative-artistic*, ii) *medial-technical*, iii) *physical view*, iv) *reference-to-reality*, *societal* v), and vi) *working self-dependently*.

The catch factor *creative-artistic* focusses on the particular appeal of the false-color images. They can be interesting from an aesthetic point of view: aesthetic and creativity contribute to an engagement in science (Goodman et al., 2020).

Medial-technical addresses the unique effect of using new media and technologies. Students' interest is primarily influenced by activity types that are for example allowed for engagement with technology (Swarat et al., 2012; Hochberg et al., 2018).

Physical view targets the expanded perception and to see normally invisible phenomena (Haglund et al., 2015).

Bennett, Lubben, and Hogarth (2006) showed that students prefer the science-technology-society approach in science class that brings science to life. This is represented by the catch factor *reference-to-reality*.

Societal focusses on the value of TICs in society. It emphasizes professional usage of technical devices and is connected to the importance of science in society (ibid.; Laumann, Fischer, Weßnigk, & Neumann, in press; Hoffmann et al., 1998).

Students' interest can be substantially aroused through inquiry skills lessons (Palmer, 2009). *Working self-dependently* refers to the fact that the students themselves are responsible for the results they generate with the TICs.

All the items start with the phrase "*I like working with the TIC because…*" and have response options "not at all", "not really", "quite" and "definitely yes", and were labelled with numbers 1 to 4.
Example: "*I like working with TICs because...*"
… I can see things which are usually invisible. (physical view)

Tab. 1. Overview of the instruments.

Instruments	Number of Items	Test dates
emotional	4	T_0, T_1
epistemic	3	T_0, T_1
value-related	3	T_0, T_1
Catch factors	10	T_1

3.4 Data Analysis

Our research questions are multivariate questions, which are normally solved by analyses of variance (Bortz & Döring, 2006). In our explorative analyses we use t-tests and focus on the most pronounced differences. In order to avoid alpha error accumulation a Bonferroni adjustment was performed (Bühner, 2006).

For a comparison between and within respective groups, we used one-sample t-test, a paired t-test, and Cohen's *d* as effect size. As psychometric indices, we have presented Cronbach's Alpha for reliability and item-test correlation (Bortz & Döring, 2006, see appendix).

As gender has an effect on interest development, an ANCOVA was run. We used the pre-test scores of each interest aspect and gender as covariates, and are interested in any differences between gender with respect to the post-test interest scores. In order to check the assumption, we created a scatter plot and checked the linearity, used the Levene's Test for proofing homogeneity of variance, and the Shapiro Wilk test for testing normality of residuals (Kassambara, 2019).

For all the interest aspects, there is linearity and homogeneity in residual variances ($p > 0.05$: no significant interactions between gender and pre-test scores). The Shapiro Wilk test was not significant for emotional and epistemic aspects ($p > 0.05$), and only the residuals of the value-based aspect were not normally distributed ($p < 0.05$). We suspect that the cause lies in the sample size, since the *p*-value is only about significance.

In order to answer research question 2, we reduced the answers from three dimensions (*doing experiments for their own value, experimenting with iPads, experimenting with TICS*) to the two dimensions *experimenting for its own value* and *experimenting with digital media*. Whenever a student ranked *doing experiments for their own value* on rank 1, it was coded with 1 (*experimenting with digital media* was coded with 2). Whenever a student placed *doing experiments for their own value* on rank 2 or 3, we coded it with 2 (and *experimenting with digital media* with 1). In this way, we were able to make sure that experimenting with digital media is one dimension. We then inverted the rank scores and normalized them to 1.

Regarding research question 3, a correlation was calculated (Pearson) in order to investigate for how far the individual catch factors are interdependent.

4 RESULTS

The results of the pre-survey for the current interest of the intervention and reference group are shown in Figure 3.

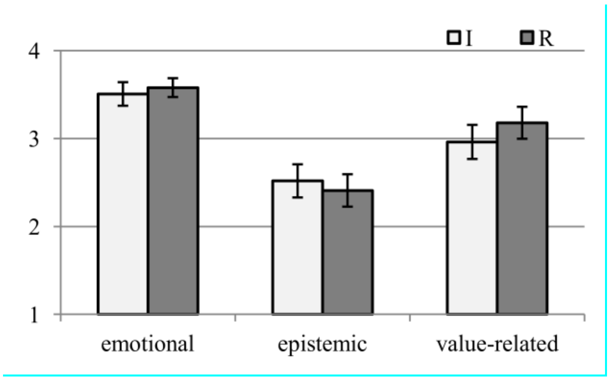

Fig. 3. Current interest for intervention (I) and reference group (R), T_0.

Tab. 2. Mean value and standard deviation, intervention (I) and reference group (R), T_0 (Fig. 3).

Interest aspect	Mean value	Standard deviation
emotional I	3.51	0.50
emotional R	3.58	0.39
epistemic I	2.52	0.70
epistemic R	2.41	0.67
value-related I	2.96	0.72
value-related R	3.18	0.66

There are no observable differences between the intervention and the reference group for each interest aspect (emotional: $t = 0.88$, $p = 0.38$; epistemic: $t = 0.85$, $p = 0.40$; value-related: $t = 1.61$, $p = 0.11$). The intervention group can be seen as "a fairly normal class of 7th graders".

The sub-scales of the current interest have an acceptable Cronbach's α that lies between 0.66 and 0.82 (see appendix). The values of the item-test correlation lie between 0.33 and 0.76, which is rated adequate (Bortz & Döring, 2006).

Research Question 1: Which aspect of the students' current interest are influenced by experimenting with TICs?

The mean values of all the current interest aspects had not changed significantly (Fig. 4).

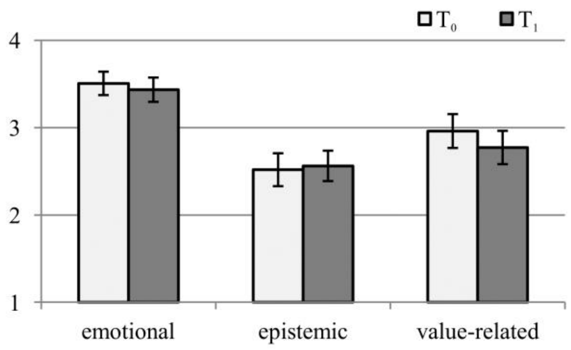

Fig. 4. Current interest, intervention group, T_0 and T_1.

Tab. 3. Mean value and standard deviation of interest aspects, T_0 and T_1 (Fig. 4).

Interest aspect	Mean value	Standard deviation
emotional T0	3.51	0.50
emotional T1	3.44	0.52
epistemic T0	2.52	0.70
epistemic T1	2.56	0.65
value-related T0	2.96	0.72
value-related T1	2.77	0.66

An ANOCOVA was run to determine the effect of gender on the interest aspects after controlling the pre-scores. After adjustment for T_0 scores, there was no statistically significant difference in post-test interest aspects between the groups, $p > 0.05$ for emotional, epistemic and value-related.

Research Question 2: Do students like experimenting for their own value, or do they prefer experimenting with digital media (iPads and/or TICs)?

Students like *doing experiments for their own value* (experimenting) significantly more than *experimenting with digital media* (digital media), for the epistemic and the value-related aspects, both with small effects: value-related: experimenting-digital media: $t = 37.36$, $p < 0.05$; $d = 0.31$, epistemic: experimenting-digital media: $t = 64.92$, $p < 0.05$; $d = 0.26$. (Fig. 5).

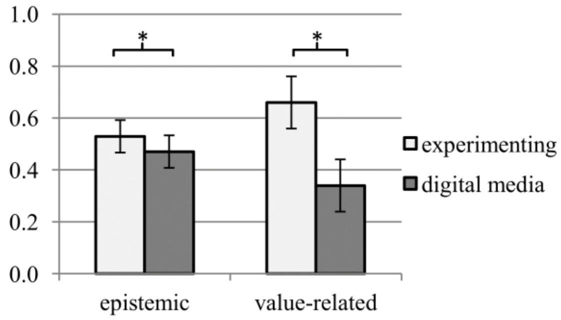

Fig. 5. Epistemic and value-related aspects, experimenting and digital media, T_1.

Tab. 4. Inverted and normalized scores of mean value and standard deviation, epistemic and value related aspects, experimenting and digital media, T_1 (Fig. 5).

Interest aspect	Mean value	Standard deviation
epistemic – experimenting	0.53	0.23
epistemic – digital media	0.47	0.23
value-related – experimenting	0.66	0.37
value-related – digital media	0.34	0.37

Research Question 3: To what extent is it possible to identify catch factors when working with TICs?

The high level of the catch factor *physical view* of the TIC (Fig. 6) is remarkable. To see phenomena that are normally invisible works significantly higher as a catch factor than *creative-artistic* and *societal*, both with a large effect. *Physical view* is significantly higher than *medial-technical* with a medium effect: *Creative-artistic – physical view*: $t = 12.92$; $p < 0.001$; $d = 1.78$, *societal – physical view*: $t = 7.05$; $p < 0.001$; $d = 0.97$, *medial-technical – physical view*: $t = 5.33$; $p < 0.001$; $d = 0.73$.

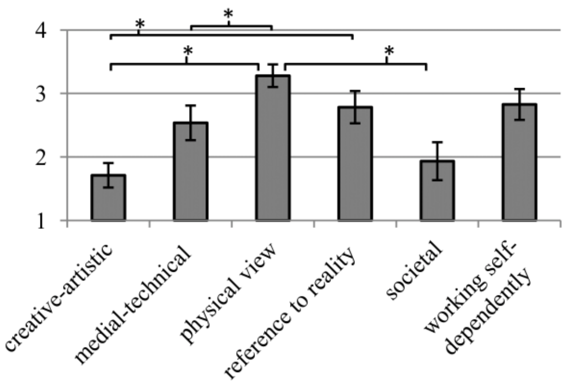

Fig. 6. TIC catch factors, T_1.

Tab. 5. Mean value and standard deviation, catch factors, T_1 (Fig. 6).

Interest aspect	Mean value	Standard deviation
creative-artistic	1.71	0.72
medial-technical	2.54	1.01
physical view	3.28	0.66
reference-to-reality	2.78	0.95
societal	1.93	1.11
working self-dependently	2.83	0.90

The analysis shows moderate significant correlation between *physical view* and *working self-dependently* ($r = 0.67$). All other correlations are low.

5. DISCUSSION AND CONCLUSIONS

No effect can be detected on any aspect of current interest after experimenting with TICs. Interest in performing experiments with TICs might therefore be of individual and not only situational interest: a significant change in current interest after a short period of time is not expected. The high rates for the emotional aspect are noteworthy. The reason for this could be a novelty effect which influences learner motivation (Kerres, 2001).

The significantly higher value-related and epistemic interest in doing experiments for their own value underline the enormous importance of classroom experiments (Hopf, 2004). This underlines the results of Swarat et al. (2012): interest is often tied to a specific content, but to specific activities (see also Azevedo, 2013).

Besides the poor impact on students' current interest, the TIC seems to work as a catch factor: students appreciate conducting experiments and seeing normally invisible phenomena: *physical view* is of top priority for possible catch factors. The moderate correlation between *physical view* and *working self-dependently* shows that seeing something that is usually invisible and the feeling of being responsible for the results are correlated. Students seem to be interested in "looking behind the perception wall".

Looking at the catch factor *medial-technical*, it seems unnecessary to use high-tech devices in the classroom, unless the measurement generates new information. Students want to generate new knowledge, but are less interested in the technical device.

However, the TIC experiments do not seem to suffice as a hold factor. One reason might be a lack of linking points to future applications and to more complex questions requiring the TIC technology. The relevance of everyday practice and examinations in a realistic context is underlined by the factor *reference-to-reality* and confirms the results of Bennett et al. (2006).

In sum, this study cannot show a general change in current interest based on the use of TICs, but high scores in the emotional interest aspect indicates that experimenting with TICs is associated with positive emotional experiences. The strong value-related and epistemic interest in doing experiments for their own value emphasizes the importance of doing experiments in science classes, independently of gender.

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