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Student Primary School Teachers' Attitude towards Virtual Reality in Primary School Education

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Abstract. As the general interest in several fields of application for virtual reality (VR) technologies rises, we see efforts to establish VR as a medium for teaching in our early education system. In order to investigate the current attitudes of becoming primary school teachers towards the integration of VR in different primary school education topics, we conducted a survey among 277 student primary school teachers with different specializations. We assumed that the students' interest would be connected to the experiences they made with VR. In addition, we hypothesized that the students' interest would be positively correlated to the overall perceived benefit of the different subjects through the use of VR due to motivational reasons. We also assumed a connection between the previous experiences and the perceived benefit so that a participant who made previous experiences knows more about the applications and possibilities of VR. Furthermore, we hypothesized that the studied main subject influences the perceived benefit of particular primary school subjects so that a student with a certain main subject was more likely to see the possibilities of the application of a new medium in the corresponding primary school subject. This paper depicts the findings from the study, together with a discussion of possible effects on teacher training for primary school education. Furthermore, we discuss the given qualitative answers in terms of possible factors that influence learning processes and indicators that determine learning outcomes using the medium VR.

Keywords: Virtual Reality · Primary School · Learning Environment · Media Learning · Teachers' Attitudes

1 Introduction

Right from the start of serious development progress in terms of virtual reality (VR) in the early 90s, many researchers thought of the educational possibilities of immersive virtual environments. Bricken named VR as "the next step in the evolutionary path" [1] right after the computer revolution. Thinking of VR as a paradigm shift, reality generation as a replacement for symbol processing, participants replacing observers and the interface being replaced by an overall inclusion of the user are just some of the changes brought by VR [1]. Considering programmable participation, natural semantics, constructivism, cognitive

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presence and multiple participants as some of the main issues posed by VR in educational terms, Bricken states: "Just substitute the virtual for the actual, then get rid of the constraints of the actual" [1].

Furthermore, the possibilities of accurate, schematized, substantiated and metaphorical representations in VRs expand the world of possible applications in educational use, especially through the two principles of visualization: spatialization and multi-sensory input [2]. Following Milgram et al., we see VR as a digital environment that is completely synthetic with the purpose to immerse the participant-observer with enabled interaction [3]. The application of a VR in the educational domain is called an educational virtual environment (EVE) [4]. Until now, there are many research fields in terms of EVEs [5–7]. In a ten year review of empirical research on the educational applications of VR, which is based on 53 research studies, Mikropoulos stated in 2009 that VR seems to be a mature technology appropriate for pedagogical use [8].

But empirical research and technological developments may not be sufficient to bring VR into our educational system: Without a pedagogical and didactical fundamentum and the teachers' support of the use of this immersive teaching and learning medium, VR cannot go far in the educational context. In order to investigate the attitude of becoming teachers towards the application of VR in early education, we conducted a survey among 277 student primary school teachers, asking them, in addition to general question about gender, studied subjects and their main subject, about their attitude towards their experiences with VR, interest in experimenting with VR and their perceived benefit of the use of VR technologies in primary school education.

2 Do we need VR in Primary School Education?

2.1 Application of VR in Primary School Education

Virtual and augmented realities (ARs) have already been used in pilot projects in primary schools [9]. Different studies show potential benefits in teaching and learning with VR and AR. In a project from Kerawalla et al. 133 children aged 9-10 years participated in an AR for understanding how the earth and sun interact in 3D space to give rise to day and night [10]. Other formal learning aspects like improving imaginative writing [11], the construction of three-dimensional shapes [12] and the comprehension of planetary phenomena [13] have been investigated recently. Roussou, Oliver and Slater developed a virtual playground for primary school students between the ages of 8 and 12 in order to investigate how learning improves through interacting in an immersive virtual environment [7]. In addition, research in encountering social issues like school phobia [14] and bullying [15] is on its way to enhance pedagogical action in primary schools.

2.2 Proposed research model and research hypotheses

We assumed that the students' interest (INT, consisting of I1, I2, and I3) would be connected to the experiences (EXP) they made so that a student who is

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generally more interested in working and experimenting with VR would be more likely to have already experienced VR in one way or another (H1).

Furthermore, we hypothesized that the students' interest would be positively correlated to the overall perceived benefit of the different subjects (PEBE, consisting of S1, ..., S9) through the use of VR due to motivational reasons (H2).

At this, we also assumed a connection between the previous experiences and the perceived benefit so that a participant who made previous experiences knows more about the applications and possibilities of VR (H3).

We hypothesized that the studied main subject influences the perceived benefit of particular primary school subjects so that a student with a certain main subject was more likely to see the possibilities of the application of a new medium in the corresponding primary school subject (H4). To check H4, we were making up pairs among the different studied main subjects and the subjects of the primary school curriculum (table 1subject pairstable.1.1) and hypothesized their connection (H4.1- H4.9). In summary, we examined the hypotheses presented below.

- **H1** There will be a positive relationship between overall interest and previous experiences.
- **H2** There will be a positive relationship between overall interest and overall perceived benefit.
- **H3** There will be a positive relationship between previous experiences and overall perceived benefit.
- **H4.x** There will be a positive relationship between the studied main subject and the perceived benefit of the corresponding primary school subject.

Table 1. subject pairs

hypothesis	studied main subject	primary school subject
H4.1	Geography	Local History and Geography
H4.2	Mathematics	Mathematics
H4.3	German	German
H4.4	English	English
H4.5	Religion	Religion
H4.6	History	Local History and Geography
H4.7	Physical Education	Physical Education
H4.8	Arts	Arts
H4.9	Arts	Handicrafts

3 Research Method

3.1 Sample

All 277 participants of the survey were student primary school teachers from the University of — in Germany, of which 237 were female, 42 were male. The rep-

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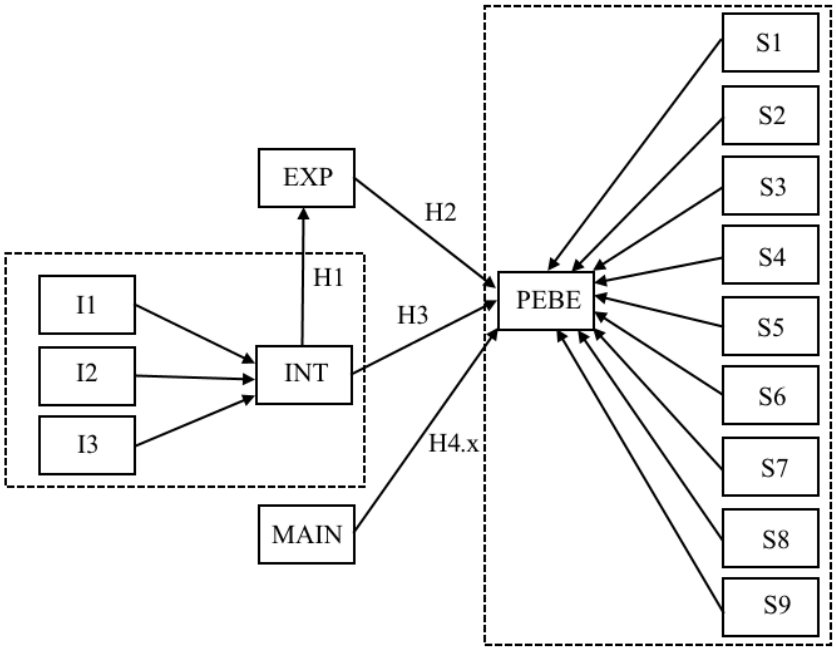

Fig. 1. research model

resented main subjects were Social Studies (17), Geography (50), Mathematics (21), German (71), English (40), Religion (46), History (20), Physical Education (7) and Arts (4).

3.2 Questionnaire

To investigate the attitude of student primary school teachers towards the application of VR in primary school education, we first asked them general questions about their gender, their envisaged school type in their teaching studies (in order to sort out students with a different background than primary school education), their main subject and their minor subjects.

The next part containing questions about experiences and attitudes towards VR started with a brief description of VR (translated from German): *Virtual Realities (VRs) are completely synthetic digital worlds which are fully generated by a computer. Usually VRs are experienced through head mounted displays - these are displays which are attached to the head of the user and trace the users head motions in order to change the picture on the display according to the head orientation and head tilt.* We know that this definition does not cover all aspects of a technologically independent description of VRs. The decision to focus on

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the technical aspect of the currently dominant technology of the head-mounted display (HMD) was made on the basis of simplicity.

The first subsection asked about the previous experiences of the participants with the medium VR using a VR headset with an adaptable smartphone or with a professional HMD.

The next subsection contained three questions about the students interest in working and experimenting with VR in general, covering the interest fields *personal interest in experimenting with VR*, *exploring the didactical possibilities of VR in primary school education in the course of their studies* and *application of VR in their later professional life as a primary school teacher*.

The third subsection asked for nine school subjects about whether the use of VR as a teaching and learning medium would bring a benefit for pupils or not. The items of the third subsection (German, Mathematics, Local History and Geography, Arts, Music, Physical Education, Religion, English, and Handicrafts) were orientated on the german primary school curriculum.

A fourth section gave the participants the possibility for a brief description of a specific application for the VR technology in one or more particular subjects in primary school education.

3.3 Procedure

Before the participants filled out the questionnaire, they were shown a promotional video from the HTC Vive [16]. The medium of the promotional video was chosen because it is intended to show the wide range of possibilities of the advertised product. The choice in favor of the particular video from HTC was made through a pretest where five students were shown four promotional videos from HTC and Oculus and were later asked what video would show best the operating principle and the possibilities of the VR technology.

Afterward, the participants were given 10 minutes to complete the questionnaire. The students were encouraged to fill out the survey on their own and thinking about their individual experiences, interests, and attitudes.

3.4 Findings

Experiences Of all participants, 275 answered the single choice question *What have been your previous experiences in terms of virtual reality systems or applications?* with the five possible items *I have already used a VR headset with an adaptable smartphone (Google Cardboard, Daydream View, Gear VR, ...) before.*, *I have already used a professional VR head-mounted display (HTC Vive, Oculus Rift, ...) before.*, *I own a VR headset with an adaptable smartphone (Google Cardboard, Daydream View, Gear VR, ...) and use it sometimes.*, *I own a professional VR head-mounted display (HTC Vive, Oculus Rift, Microsoft HoloLens, ...) and use it sometimes.* and *I do not have any experience with VR.*. The findings show that 1.1 % of the participants own a VR headset with an adaptable smartphone or a professional HMD, 19.7% have already used a VR headset with

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Table 2. interest in VR

interest area	personal experimenting	in the course of their studies	in later professional life	overall interest
personal experimenting	1.000	**.243****	**.245****	**.677****
in the course of their studies	-	1.000	**.593****	**.768****
in their later professional life	-	-	1.000	**.795****
overall interest	-	-	-	1.000

**. The coefficient is statistically significant at the 1% level (both sides).

adaptable smartphone or HMD once and 79.2% do not have any experience with VR by the time of the survey.

Interest To survey the students interest in VR, we asked three questions about different fields (personal experimenting with VR, exploring the didactical possibilities of VR in primary school education in the course of their studies, application of VR in their later professional life as a primary school teacher) of application of VR which were to be answered on a 4 point Likert scale (*not interested*, *rather not interested*, *slightly interested*, *very interested*). Summarizing the items *not interested* and *rather not interested* to *rather not interested* and the items *slightly interested* and *very interested* to *rather interested*, the following results were found: 36.4% of the students are rather not interested in personal experimenting with VR, while 63.6% are rather interested. 22.7% of the students are rather not interested in exploring the didactical possibilities of VR in primary school education in the course of their studies while 77.3% are interested. 37.2% of the students are rather not interested in the application of VR in their later professional life as a primary school teacher, while 62.8% are interested. The items were highly significantly correlated (Spearman-Rho correlation) among each other (table 2interest in VRtable.1.2). We then summarized them to an *overall interest* as the average value of the three interest items.

Fields of Application We then asked the participants *In what subjects in primary school can you, from the perspective of a becoming primary school teacher, think of a possible benefit from the use of VR as a teaching and learning medium for pupils? Note that it is not important what software is currently available, but rather think of the general possibilities of VR with the right software.*. The

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Table 3. VR applications in different subjects in primary school

subject	no benefit	rather no benefit	recognizable benefit	great benefit	**sum**
German	93	148	29	5	**275**
Mathematics	63	82	97	33	**275**
Local History and Geography	4	28	110	133	**275**
Arts	31	58	122	65	**276**
Music	51	127	80	15	**273**
Physical Education	98	59	78	40	**275**
Religion	94	126	45	7	**272**
English	59	129	70	15	**273**
Handicrafts	63	82	97	33	**276**

four-point Likert scale consists of the items *no benefit*, *rather no benefit*, *recognizable benefit* and *great benefit*. Table 3VR applications in different subjects in primary schooltable.1.3 shows the results of the study. The most prominent answer which shows recognizable or great benefit through the use of VR was the subject *Local History and Geography* with 88.36 % in favor for VR, followed by Arts (68%), Handicrafts (47%) and Mathematics (47%). The answers with the strongest rejection of a possible benefit through VR are German (87.63%), Religion (80%), English (68.36%) and Music (64.72%).

Table 4correlations between perceived benefit between subjectstable.1.4 shows that most of the perceived benefits of the use of VR in different subjects are significantly correlated (Spearman-Rho) with each other. The answers of the subjects were summarized and the *overall perception* was calculated as the average value.

Influence of Experiences on Interest There was no statistical significant connection (Chi-Square) neither between the previous experiences (Yes or No) of the students and their interest shown in the study nor between the experiences and the calculated overall interest.

Influence of Interest on Perceived Benefit We found a highly significant correlation (.000) between the calculated overall interest and the calculated overall perception (r=.454) using the Spearman-Rho correlation.

Influence of Experiences on Perceived Benefit There was no statistically significant connection found between the previous experiences of the partici-

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Table 4. correlations between perceived benefit between subjects

subject	German	Mathematics	Local History and Geography	Arts	Music	Physical Education	Religion	English	Handicrafts	Overall Perception
German	1.000	**.344****	**.180****	**.225****	**.280****	**.147***	**.372****	**.467****	**.136***	**.571****
Mathematics	-	1.000	**.172****	**.212****	.005	.090	.117	**.189****	**.209****	**.469****
Local History and Geography	-	-	1.000	**.303****	**.269****	**.153***	**.271****	**.411****	**.188****	**.529****
Arts	-	-	-	1.000	**.350****	**.224****	**.254****	**.303****	**.406****	**.618****
Music	-	-	-	-	1.000	**.302****	**.235****	**.312****	**.211****	**.545****
Physical Education	-	-	-	-	-	1.000	**.129***	.107	**.274****	**.523****
Religion	-	-	-	-	-	-	1.000	**.454****	.083	**.514****
English	-	-	-	-	-	-	-	1.000	**.211****	**.629****
Handicrafts	-	-	-	-	-	-	-	-	1.000	**.561****
Overall Perception	-	-	-	-	-	-	-	-	-	1.000

*. The coefficient is statistically significant at the 5% level (both sides).
**. The coefficient is statistically significant at the 1% level (both sides).

pants and their overall perception about the benefits of the application of VR in primary school subjects.

Influence of Studied Main Subject on Perceived Benefit of Particular Subjects In addition to possible influences from the variables interest and experience, we investigated how the studied main subject influences the perception of the possible benefit in a specific subject in the primary school curriculum. Therefore we summarized the items for the perceived benefit from the use of VR in particular school subjects in primary school to *Yes* (recognizable benefit and great benefit) and *No* (no benefit and rather no benefit) and took a look at the different main subjects from the students.

Here, as shown in the table 5correlations between perceived benefit and studied main subjecttable.1.5, we found significant correlations between the studied main subject *Social Studies* and the primary school subject *Physical Education*.

The studied main subject *German* was highly significantly correlated to the primary school subject *Local History and Geography* and significantly correlated to *Physical Education*.

The studied main subject *English* was significantly correlated to the primary school subject *English*.

Furthermore, we found significant correlations between the studied main subject *Religion* and the primary school subject *Religion*, between the studied main subject *History* and the primary school subject *Handicrafts* as well as between

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Table 5. correlations between perceived benefit and studied main subject

main subject	German	Mathematics	Local History and Geography	Arts	Music	Physical Education	Religion	English	Handicrafts
Social Studies	.703	.970	.583	1.767	.002	**4.631***	.228	.321	1.645
Geography	2.144	.070	1.763	1.162	.099	.897	1.482	1.230	.776
Mathematics	1.213	1.772	2.840	.741	.109	1.908	.344	.514	.512
German	1.819	.001	**8.384****	.837	.471	**5.554***	1.423	.1.290	.234
English	.383	1.964	.034	1.124	1.922	2.070	.079	**4.202***	.538
Religion	.114	.058	.106	1.197	.464	1.936	**5.016***	.502	1.812
History	.138	1.303	.924	.518	3.728	.443	.011	.013	**5.236***
Physical Education	**6.164***	.056	.049	.044	1.581	.594	2.619	2.266	.132
Arts	.573	.012	.535	1.932	.413	1.706	.091	.071	.000

*. The coefficient is statistically significant at the 5% level (both sides).
**. The coefficient is statistically significant at the 1% level (both sides).

the studied main subject *Physical Education* and the primary school subject *German*.

4 Discussion

The results show that the attitudes towards the application of VR as a teaching and learning medium in primary school education vary significantly among student primary school teachers. The most prominent answers for a recognizable or great benefit through the use of VR, Local History and Geography, Arts, Handicrafts and Mathematics may have been chosen due to their spatial or constructive orientation. The assumption that the primary school subjects German, Religion, English, and Music would have no or rather no benefit may have been made due to the apparent lack of possible visualization or spatialization.

In our first hypothesis, we assumed that there would be a positive relationship between overall interest and previous experiences. This hypothesis could not be verified. In fact, only a fifth of all participants did ever experience a VR so by now, the general visibility of this new technology is very low so many users that may be interested in VR technology simply do not have access to VR systems.

The second hypothesis assumed that there would be a positive relationship between the students' overall interest and their overall perceived benefit. This

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hypothesis could be verified, we found a highly significant positive correlation between the two variables which was moderate in strength. This implies that general interest in VR is connected to the perceived benefit of the application of VR in learning and teaching settings in general. In addition to that, we found out that almost all of the perceived benefits from different subjects were connected to each other what may also result from a risen interest or confidence in the VR technology in general.

The third hypothesis predicted a positive relationship between the previous experiences and the overall perceived benefit. We could not verify this hypothesis what may have the same reasons as the rejection of H1, in particular, the lack of visibility of VR technology in public. In addition, just because one uses a specific software in VR, may not ensure that the user understands the full range of possibilities of the VR technology.

The fourth hypothesis claimed a positive relationship between the studied main subject and the perceived benefit of the corresponding primary school subject. For the verification of this hypothesis, we generated nine separate hypothesis concerning the different corresponding subjects (studied main subject and primary school subject). In this study, we could only verify the hypotheses H4.4 and H4.5, representing the corresponding subjects English/English and Religion/Religion. We found out that student primary school teachers with these main subjects were more likely to rate the possible benefit through the application of VR in their English/Religion classes in primary school higher than students with other main subjects. Considering these results, we had to drop the assumption of a general validity of H4 so that this hypothesis was only true for the subjects English and Religion.

We assume that the participants of the survey may not have had enough experience in their main subjects because the chosen courses to carry out the survey were undergraduate classes with students who had less experience than student primary school teachers right before their final exams or professional primary school teachers. Besides that, the choice of the main subjects English and Religion may come with a high personal interest of the participants in the topic already before commencing their studies. This could explain the found connection between the main subject and the corresponding subject in primary school, English and Religion.

It is quite interesting that we found the unexpected connections between the main subject Social Studies and the primary school subject Physical Education, the main subject German and the primary school subjects Local History and Geography and Physical Education, the main subject History and the primary school subject Handicrafts as well as between the main subject Physical Education and the primary school subject German. An investigation about these would be interesting for further research. By now, we assume a connection between the major and minor subjects, where for example Geography, Social Studies, and Physical Education are often paired with German.

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5 Conclusions

In this study, we found some interesting connections between different variables. As the main result, we can say that there is a moderately strong relationship between the personal interest in VR technology (in different areas) and the perception of a possible benefit from teaching and learning with VR technology in primary school. Following these perceptions and attitudes of future primary school teachers it would be interesting to investigate, how interest and perceived possible benefit actually influence the learning outcomes of the pupils.

Even though there is existing research in terms of factors influencing learning processes and outcomes in VRs [5, 17], it would be interesting to investigate the factors mentioned by student teachers that cause the perceived benefit. In the free text answer in the fourth section of the questionnaire, many students described topics, where either visualization and spatialization would help to enhance the childrens' understanding of particular (sometimes abstract) concepts. Other answers described topics which already have spatial or visual representations in the real world (for example plants, animals, countries, cultures) but are not easily accessible for teachers and their classes. Another aspect was the motivational factor: Just by using and experimenting with the new medium, children can easily be motivated for the topics represented through the VR technology, for example in Physical Education (virtual parcours). The exploration of the impact of these factors on learning outcomes may be a further research desideratum.

In terms of cognitive benefits over for example television or normal displays, the participants named the possibility to learn through activities, experimenting and making experiences in the VR. That can be related to the concept of presence. Even though there has been researching about if and how presence in VR influences learning processes and learning outcomes [18–21], there is still a lack of a substantiated investigation of how presence influences the learning processes on different age groups, cognitive levels and in particular topics.

We are convinced that VR enables new possibilities in teaching and learning. But to bring VR into schools, we do not only have to prove the effectiveness of VR settings in terms of teaching and learning. We rather have to convince professional teachers and becoming teachers of the utility of VR in their classrooms and develop VR software for teaching and learning together, combining technical know-how with didactical and pedagogical demands. Therefore, high-quality supply of immersive education has to be designed, implemented and tested jointly by teachers, immersive education, and virtual technology experts. We see immersive education as a highly interdisciplinary research area which has to combine know-how from pedagogical, technological and content viewpoints.

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