Design of a prototype for teaching general relativity to upper secondary students

Citation for published version (APA):

Document status and date:
Published: 11/02/2019

Document Version:
Other version

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at: openaccess@tue.nl
providing details and we will investigate your claim.

Download date: 29. Dec. 2019
Design of a prototype for teaching general relativity to upper secondary students

Dr S. Delhaye\textsuperscript{1,2}, Dr L.G.A. de Putter - Smits\textsuperscript{2} and Prof. B.E.U. Pepin\textsuperscript{2}

\textsuperscript{1} Jan van Brabant College, Helmond, The Netherlands
\textsuperscript{2} Eindhoven School of Education, Eindhoven, The Netherlands

Together with quantum physics, general relativity is one of the major modern theories in contemporary physics. General relativity is not part of the standard upper secondary school physics curriculum in the Netherlands. The goal of our design based research project, is to develop and evaluate curriculum materials on general relativity for upper secondary physics classes, with the research question: What does a design of a prototype for teaching general relativity to upper secondary students in the Netherlands look like?

The design of the materials is based on a set of design principles. These design principles in turn, are based on a literature study, a cursory textbook analysis and three expert rounds with didactical and content knowledge experts. From the literature study and textbook analysis it became apparent that it is possible to teach general relativity at secondary or even primary level \cite{Pitts_2014}. The explanations have to be specifically aimed at the students’ skill and comprehension levels \cite{Haddad_1972}. The use of visuals, like graphics, images and animations, increases student engagement and can lead to enhanced learning results. The use of models and visualization techniques can further aid in helping students wrap their heads around the various abstract concepts. Four key concepts of general relativity were proposed based on similar key concepts identified by other authors \cite{Hartle_2005}. These are 1) The principle of equivalence; 2) The principle of relativity; 3) Geodesics and 4) Spacetime and curvature. During two expert rounds, the design principles and the ultimate design itself have been improved and validated. Based on the literature review and the expert rounds, the following design principles have been formulated: The module 1) contains appealing contexts, 2) is close to the level of mathematics that can be expected of an upper secondary student, 3) is presented in an age appropriate way, 4) is visually supported, 5) contains hands-on experiences, 6) enables students to study the materials independently from the teacher, 7) is embedded within the current physics curriculum, 8) is appealing and encourages students to read and study the curriculum materials and 9) is structured in a consistent and coherent way.

References
\begin{itemize}
  \item \cite{Pitts_2014} Pitts, M., Venville, G., Blair, D., & Zadnik, M., Research in Science Education \textbf{44} (3), 363-388 (2014)
  \item \cite{Haddad_1972} Haddad, W. D., & Pella, M. O., The Journal of Experimental Education \textbf{41} (1), 22-32 (1972)
  \item \cite{Hartle_2005} Hartle, J. B., American Journal of Physics \textbf{74} (1), 14-21 (2005)
\end{itemize}