

# VIRTUAL REALITY AS A TEACHING TOOL IN ENGINEERING & DESIGN

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## ABSTRACT

The paper discusses the use of virtual technology as a teaching aide as well as a communication tool for the new generation of students who not only have a passing interest but also will feel the benefits that the system will bring to new global designer/engineer.

The aim has been to immerse the designer into the world around him and let him/her learn about assembly and manufacturing in a very new way. This will enable us to tap into the group projects and allow a more virtual interactive process. A world full of possibilities where the academic and the student are truly interactive. New innovative teaching pedagogies and techniques are created which should help improve student experience and recruitment in the long run.

*Keywords: Virtual reality, innovative teaching, interactive, real-time learning, real-time feedback*

## 1 INTRODUCTION

Due to large gap between Advanced Levels studies at school and the university education large support mechanisms have to be implemented in order to achieve retention and progression. This is the perceived added value by the new post 1992 universities (ex. polytechnics). The retention topic has been studied greatly and many recommendations have been made. Meloni [1] states that the definitions of “teaching online” and “teaching with technology” vary, even from instructor to instructor. “Teaching with technology” can have many definitions. It could be using PowerPoint, or using email to distribute course materials, or blogs enabling or the flipped classroom. The instructor and student’s communication through online platforms, such as Blackboard, Moodle, Brightspace etc. is very convenient on the face of it since it frees both parties from the time constraints, however, unless there will be a few face-to-face sessions, the process will fall flat. It must be borne in mind that the lecturer still needs to deliver course material, enabling the students and assess their output. Students must interact with the course material and the associated resources in order to proceed to the next level. It is obvious that if the student does not interact with the course and the notes given, then the whole process will be in vain and failure will ensue. Gow & Kember [2] investigated the relationship between parallel teaching that can be identified and student learning outcomes. This was achieved through semi-structured interviews with lecturers through questionnaires. Previous teaching models in the learning theory community, according to Mathias [3] have been batch models. That is, in these models the teacher has generated a single set of helpful examples to present to the learner. The increase in the cost of higher education has been discussed by Hurson and Kavi [4] and linked to recent market demands for computer specialists as well as the lack of expertise in offering technology-oriented courses. They reiterate that there more and more of the new class of non-traditional adult students and the contradiction of the need to maintain small class sizes call for new teaching practices. It has been established that people's learning styles differ, but most students absorb and retain visual material more readily than other types of material. However, the world is full of ear learners and those who learn by physical practice. The average learner retains about 20% of what is heard, 40% of what is seen and heard, and 75% of what is seen, heard, and experienced. A feat that cannot be achieved in the traditional classroom settings with large numbers, cross disciplinary, and only hour long. A traditional lecture would have some video, slide presentation, chalk and talk problem solving as well as question and answers. Advances in computer technology allow information to be presented in many different ways (multimedia); hence, interactive computer courses offer all three modes of learning. They discuss their efforts and experiences in developing a computer course using multimedia technology. However, they also recognise that the student must embrace the

interactive nature of the lecture environment and the fluency of the data. The understanding of approaches to online teaching and the emergence of pedagogies that will ensure online teaching and learning materials are effective have been investigated by Stephenson [5]. Preparing students for a rapidly changing health care system and sustaining the teachers' interest in the students' thinking abilities within nursing education has been investigated by Ironside [6]. The paper explores the underlying assumptions embedded teaching and learning and whether these influence students' thinking. Using Heideggerian hermeneutics, how teachers and students experience enacting a new pedagogy has been explored. This article explains how enacting this pedagogy offers new possibilities for teaching and learning thinking. The paper identified two themes, Thinking as Questioning. The use of 3D immersive virtual worlds in higher education has been studied by Bronack et al [7]. The most likely pedagogical approaches were studied. Innovations linking the virtual worlds to social aspects of teaching and learning were investigated. The authors have coined the Presence Pedagogy (P2), which is a way of teaching and learning within the social constructivist theory. It relies on building a true community of practice, and constructing an online environment fostering collaboration. The is unlike the more traditional learning and teaching since students engaged in a P2 learning environment are part of a broader community of practice in which everyone is a potential instructor, peer, expert, and novice—and learn with and from one another. The behaviour and expectations of the fee-paying students are rapidly changing, making it difficult to map or cater for. After a very long time spent thinking and researching various methods of learning and teaching, it was concluded that nothing was as expected as the perfect solution. This may sound like dogmatic and cold-hearted response but nonetheless is true. Many researchers including the authors as well as psychologist have erred on the side of caution as well as the positive side of the teaching and engagement theory. It required thinking outside the box and a completely blank canvas. The solution to be devised was tailor made for our students, but the hope was that the final outcome could be implemented across the board. The approach needed to be bold. Starting with the fact or assumption that any lecture is a dynamic process. The lecture could be totally one sided, either very dry or have some the humour of the lecturer to seep through. The question was “what constitutes a successful lecture?” Is there a particular formula? Is it time, topic, content, location, personality, etc., dependant? Too many variables and no paper, which has looked at it in the way, which would have been useful. After all, this is the generation of digital age but only a fraction are heavy users, and many are really mildly technophobes. How do you make a bland and dry lecture into a fun and engaging one? This paper aims to describe the somewhat novel and successful processes used in order to facilitate this through modern interactive tools, multitasking, as well as nurturing creative and analytical approaches. The dimensions and consequences of college student attrition and features of institutional action to deal with attrition are discussed by Tinto [8]. The paper discusses the patterns of student departure from individual colleges as opposed to permanent college withdrawal. The work based on Emile Durkheim and Arnold Van Gennep proposed that student departure might depend on the social and intellectual health of college life as much as of the students' experiences at the college. The student attrition depends on the quality of faculty student interaction and the student's integration into the school. The effective retention lies in the college's commitment to students. Factors such as the structure, assessment of student retention and structure were considered. Cabrera and Nora and Castañeda [9] state several theories to explain the college persistence process but only two theories have provided a comprehensive framework on college departure decisions. These two are Tinto's [8, 10] Student Integration Model and Bean's [11, 12, 13, 14, 15, 16] Student Attrition Model. Tinto's model across different types of institutions with differing student populations have been validated by Cabrera et al [9]. Student Attrition Model has also been proven to be valid in explaining student persistence behaviour while modifications to the model have been used to explain the persistence process among non-traditional students. The two theories have attempted to explain the same phenomenon, but no attempt to examine the validity if the two models could be merged.

Cabrera, Castañeda, Nora, and Hengstler [17] have shown the overlap between the two theoretical frameworks. This study attempted to note the extent that two theories can be merged in explaining students' persistence decisions by simultaneously testing all non-overlapping propositions underlying both conceptual frameworks. According to Lau [18] institutional administrators, faculty and students play a vital role in improving student retention. They could use appropriate funding, provide academic support and physical facilities, as well as promoting multiculturalism and diversity. Techniques such as multimedia technology, cooperative and collaborative learning in the classroom have shown positive results. However, to a large extent, college retention depends on the students themselves. Various

concepts of retention and attrition within a unifying conceptual framework, Co synthesise the research on retention and attrition have been investigated by Lenning [19]. He examined the implications of the research for postsecondary administrators and researchers. Retention and attrition research pertain to both the percentages of students who complete programmes and the reasons for completion or attrition. Practical considerations concerning attrition and retention that administrators should consider were briefly addressed. How critical is student retention to the college environment has been studied by Wild and Ebbers [20]. According to them, it is necessary to identify the retention goal of the institution in order to understand student retention issues in colleges. It is then that a retention programme can be designed and implemented. Reasons [21] has studied college student retention, specifically student demographic characteristics. He concedes that due to the increasing diversity of undergraduate college students, a new and thorough examination is needed. The retention literature focuses on research conducted after 1990 and emphasises the changing demographics in higher education. Research related to a relatively new variable—the merit index—also was reviewed, revealing potentially promising, but currently mixed results. Here the aim was to wipe the slate clean and start with a fresh canvas. Tomiyama et al [22] have looked at the design theory and methodology in the industrial and education applications and discuss the gap between practical and educational usages. According to them design theories are not widely taught but methodologies are. They have identified many insufficiencies in the design methodologies. For product designers, according to Lutters et al [23] tools and techniques are essential in driving the design cycle. They present an overview of approaches in structuring and using tools/techniques, based on the effectuation of creativity and decision-making in the design environment. In elaborating on characteristics of tools/techniques and ensuing ways of selecting them, the designer's portfolio of tools/techniques is characterised. Representative problems of tool/technique usage are depicted and contextualised by illustrating their industrial application. Prospects for future developments are also reviewed. According to Abulrub et al [24] virtual reality has achieved an adequate level of development for it to be considered in innovative applications such as education, training, and research in higher education. Virtual reality offers both opportunities and challenges for the educational sector. One of the challenges of virtual reality technology is the costs associated which have been unaffordable for educational institutes. However, in recent years, computer hardware and software development has made it more feasible to incorporate virtual reality technology into future teaching strategies. Despite the cost challenges, educational benefits of implementing virtual reality remain compelling. Oh, et al [25] have reported on the Flat-pack Furniture Design Critic (FFDC). By analysing the literature of architecture education, they have identified critiquing methods: delivery types (interpretation, introduction, example, demonstration, and evaluation) and communication modalities (written comments, graphical annotations, and images). Their FFDC uses these methods to deliver feedback. They also presented how their FFDC system selects particular methods by considering a certain condition such as users knowledge level and the previously used methods.

## **2 CASE STUDY**

It was decided that the best way to teach assembly and design was to use the concept of flat pack but in the sense that it was applied to the assembly of a component within the virtual environment. The following undergraduate Mechanical Engineering project was chosen for the proof of concept. A simple oscillating engine (Figure 1) consisting of 38 components including fasteners is manufactured by the students and assembled as part of a current workshop module. This methodology illustrates the process of taking the existing CAD model and preparing it for viewing in VR with the intent of using it as a visual aid for the student prior to the assembly of the product.

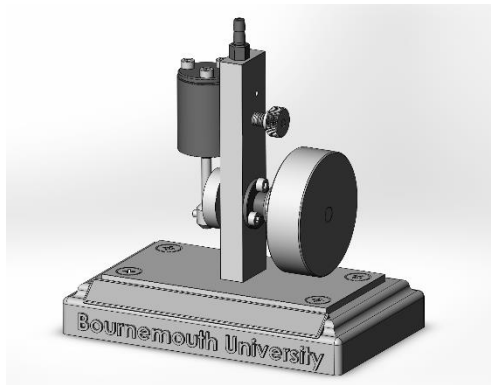


Figure 1. Simple Oscillating Engine (SolidWorks)

The key steps in the process are shown in Figure 2, it should be noted that due to the unrestricted viewing possibilities of the VR space the CAD model quality had to be improved to make it believable to the viewer, this involved the removal of sharp edges and cutting of geometrically correct threads. Model updates and additions can be a time-consuming process but necessary for the creation of a believable VR environment.

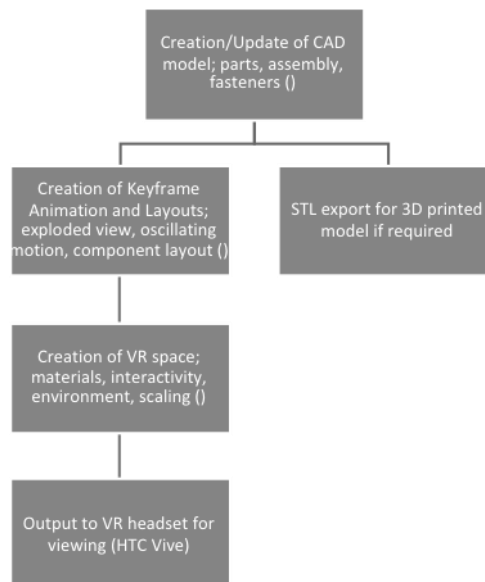


Figure 2. Methodology Flow Chart

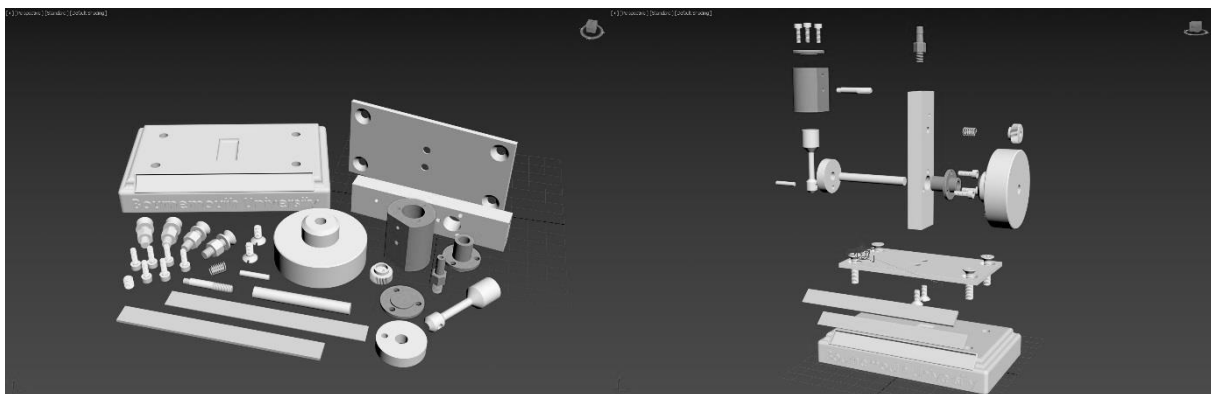


Figure 3. Component Layout & Animated Exploded View (Autodesk 3ds Max)

To make the assembly process easier to understand three separate models were created to illustrate; the parts required to be manufactured, function of the product by showing the oscillating piston and method of assembly using an animated exploded view (Figure 4). The viewer can freely navigate the VR environment and view the models from any angle as well as control the exploded view and piston motion.



Figure 4. VR Space (Autodesk VRED)

Due to the unrestricted nature of the digital workspace, it is possible to scale the CAD models to whatever size is required to make the VR model clear to the viewer. In Figure 4 the human figures (rendered for scale only) allow for an appreciation of the size of the models in VR environment, which is much larger than the desk-based model the students manufacture. Being able to view small detailed components in a VR workspace at increased scale is one of several benefits in using the VR system.

### 3 CONCLUSIONS

It is too early to gauge how successful the project has been as a teaching aide. The initial feedbacks were all positive. The students enjoyed the interaction and wanted more examples. It is almost the case of not being able to keep up with the demand, mainly due to the shortfall in equipment but also for fear of diluting the actual physical elements of the manufacturing. The cohorts such as the BA (Hons) Industrial Design who do not have a formal workshop element are very much in the driving seat, wanting more time on and it be tailor made for them. The authors, as part of the, Quinquennial review process of the courses in the Faculty, are attempting to embed the VR Assembly into the Design & Engineering Framework units for both Design Visualisation and Manufacturing units.

### REFERENCES

- [1] Meloni J. Technologies for Teaching: Strategies and Pitfalls, *Education Digest*, April 2011, Vol. 76, No. 8, pp 23-27.
- [2] Gow L. and Kember D. Conceptions of teaching and their relationship to student learning. *British Journal of Educational Psychology*, 1993 (Online 2011), Volume 63, Issue 1, pp. 20–23.
- [3] Mathias D.H. A Model of Interactive Teaching. *Journal of Computer and System Sciences*, 1997, Volume 54, Issue 3, pp. 487–501.
- [4] Hurson A.R. and Kavi K.M. Interactive Teaching Practices in Small Class Sizes while Cutting into the High Cost of Education. <http://mcs.open.ac.uk/bp5/papers/1997-EdMedia/ed-media-tutorials.pdf> [Accessed 2013, 15, 01].

- [5] Stephenson J. Teaching & Learning Online: Pedagogies for New Technologies. *Stylus Publishing, Inc.*, 2002, ISBN-0-7494-3511-9.
- [6] Ironside P.M. New Pedagogies for Teaching- Thinking: The Lived Experiences of Students and Teachers Enacting Narrative Pedagogy. *Journal of Nursing Education*, 2003, Vol. 42, No. 11.
- [7] Bronack S. Sanders R. Cheney A. Riedl R. Tashner J. and Matzen N. Presence Pedagogy: Teaching and Learning in a 3D Virtual Immersive World. *International Journal of Teaching and Learning in Higher Education*, 2008, Volume 20, Number 1, pp. 59-69.
- [8] Tinto V. Leaving College: Rethinking the Causes and Cures of Student Attrition. *University of Chicago Press*, 1987, ISBN-0-226-80446-1.
- [9] Cabrera A.F, Nora A. and Castañeda M.B. College Persistence: Structural Equations Modelling Test of an Integrated Model of Student Retention. *The Journal of Higher Education*, 1993 Vol. 64, No. 2, pp. 123-139.
- [10] Tinto V. Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational Research*, 1975, 45, pp. 89-125.
- [11] Bean J.P. Dropouts and Turnover. The Synthesis and Test of a Causal Model of Student Attrition. *Research in Higher Education*, 1980, 12, pp.155-87.
- [12] Bean J.P. Student Attrition, Intentions, and Confidence: Interactions Effects in a Path Model. *Research in Higher Education*, 1982, 17, pp. 291-319.
- [13] Bean J.P. Conceptual Models of Student Attrition: How Theory Can Help the Institutional Researcher. *In Studying Student Attrition, edited by E. T. Pascarella*, 1982, pp. 17-33. San Francisco: Jossey-Bass.
- [14] Bean J.P. The Application of a Model of Turnover in Work Organisations to the Student Attrition Process. *Review of Higher Education*, 1983, 6, pp.129-48.
- [15] Bean J.P. Interaction Effects Based on Class Level in an Exploratory Model of College Student Dropout Syndrome. *American Educational Research Journal*, 1985, pp. 2235-64.
- [16] Bean J.P. Why Students Leave: Insights from Research. *In the Strategic Management of College Enrolments, edited by D. Hossler and associates*, 1990, pp. 147-69. San Francisco: Jossey Bass.
- [17] Cabrera, A.F. Castañeda M.B., Nora. A and Hengstler D.S. The Convergence between Two Theories of College Persistence. *Journal of Higher Education*, 1992, 63, pp.143-64.
- [18] Lau L.K. Institutional Factors Affecting Student Retention. *Journal of Education*, 2003, Vol. 124, No. 1, pp. 126-136.
- [19] Lenning O.T. Retention and Attrition: Evidence for Action and Research. *National Centre for Higher Education Management Systems, P.O. Drawer P, Boulder, CO 80302*, 1980.
- [20] Wild L. and Ebbers L. Rethinking Student Retention in Community Colleges. *Community College Journal of Research and Practice*, 2002, 26, pp. 503- 519.
- [21] Reasons R.D. Student Variables that Predict Retention: Recent Research and New Developments. *NASPA Journal*, 2009, Vol. 46, No. 3. pp. 482-501.
- [22] Tomiyama T., Gu P., Jin Y., Lutters D., Kind C. and Kimura F. Design methodologies: Industrial and educational applications, *CIRP Annals-Manufacturing Technology*, 2009, Vol. 58, pp. 543-565.
- [23] Lutters E., Van Houten F.J.A.M., Bernard A., Mermoz E. and Shutte C.S.L.C. Tools and techniques for product design, *CIRP Annals-Manufacturing Technology*, 2014, Vol. 63, pp. 607-630.
- [24] Abulrub A.H.G., Attridge A.N. and Williams M.A. Virtual Reality in Engineering Education, *IEEE Global Engineering Education Conference*, 4-6 April 2010.
- [25] Oh Y., Gross M.D., Ishizaki S. and Do E.Y.-L. Constrain-Based Design Critic for Flat-pack Furniture Design, *Proceedings of the 17<sup>th</sup> International Conference on Computers in Education*, 2009, Hong Kong, Asia-Pacific Society for Computers in Education.