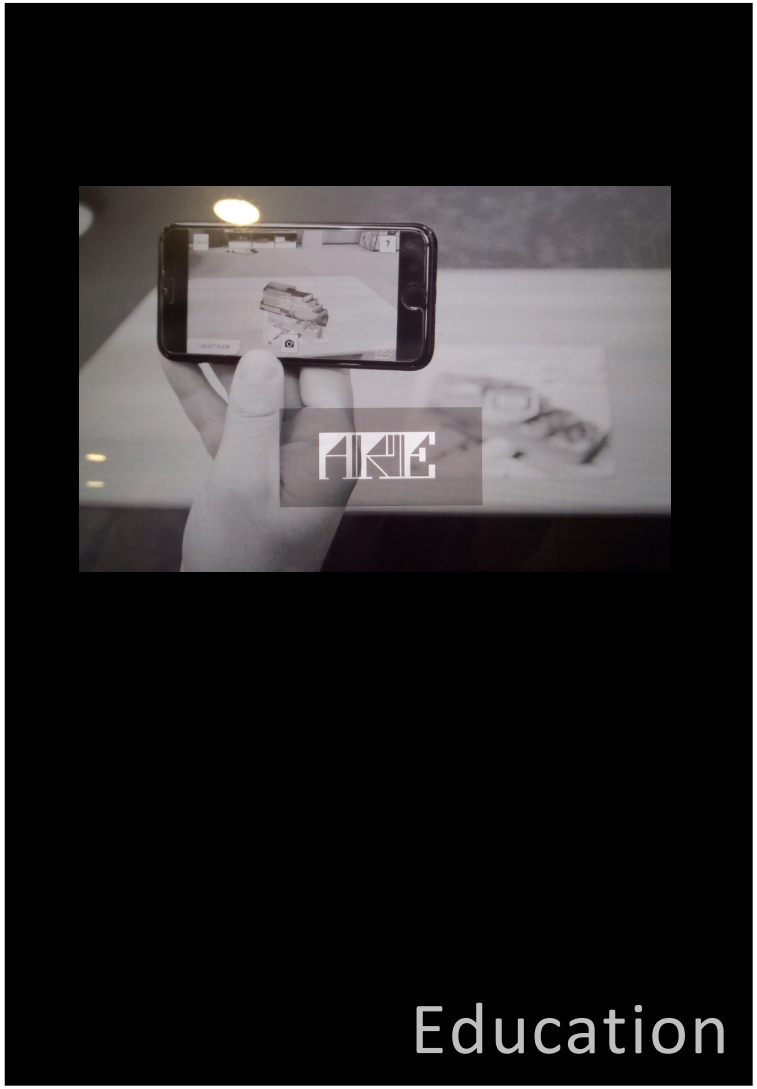

Case Study

Augmented Reality in Education

By

AUGMENTED REALITY EXPERTS

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Scope of the Case Study

This case study introduces readers to augmented reality (AR) and its application in the education sector. After briefly exploring the concept of AR, the case study details the how and why of its use in different educational contexts by drawing on practical examples and research findings. Snapshots about its relevance in the contexts of the early years, middle and senior schooling and higher education are also provided. Lastly, information about how our team at Augmented Reality Experts can help you achieve you AR objectives is provided along with a template designed to help you shape your own AR application and list of example applications to review.

Introducing Augmented Reality

What is Augmented Reality?

With the advancement of technology and changing demands of an increasingly digitally literate population [1], augmented reality (AR) continues to enter more and more facets of our lives. One of the earliest widespread examples of this was in sports coverage where additional information such as touchdown lines or 3-point markers have been superimposed over the live playing area – augmenting the viewer's experience. Similarly, gamers engage in an AR experience as supplementary information about health, targeting systems, location, weapons etc. that responds to their surrounds is superimposed over what

they see. AR is defined by this bringing together of the real and the virtual to enhance our knowledge and understanding and help us do things better and more efficiently [2].

"*With augmented reality we harness the affordances of technology to provide users with an enhanced experience by adding a layer of digital information to our experience of the world around us. This experience can be delivered in many ways using different technologies across different locations for various purposes and industries*"

Alec, Augmented Reality Experts

AR can be conceptualised as forming part of a continuum that ranges from virtual reality (completely synthetic) to telepresence (completely real)[3], which is the end AR is typically closer towards [4, 5]. Unlike virtual reality which takes the user to a new world, AR does not seek to replace reality, but rather use it as a background [6]. AR is not limited to certain tools or technologies, and has been understood as a technique comprising three key characteristics; that it combines real and virtual, is interactive in real time and registers in 3D (although 2D options are possible) [7]. Regardless of how one defines AR, when we use it we are no longer a "detached observer", but rather enter the digital environment and interact with it [2].

Why use Augmented Reality?

It is the blending of the real and digital that grants AR such widespread potential, yet has simultaneously posed technological challenges. For AR to function well objects need to be tracked in space and time so that the virtual and real visually align and coincide in real time. While these serious resourcing needs may have held the industry back, digital natives are now demanding more innovative and interactive opportunities. Coupled with the widespread adoption of smartphones and other personal devices, these drivers have spurred interest from developers and companies in recent times [8]. As a result, AR is becoming more widely known and better understood, especially since the successful release of PokemonGo in July 2016 which bough AR into the lives of millions across the globe [9]. However, AR should not be thought of only in relation to gaming, in fact the characteristics of AR mean it has countless applications, especially in the field of education.

Augmented Reality in Education

Applicability of Augmented Reality in Education

The increasing prevalence of smartphones and mobile devices [10] and students' familiarity with them has facilitated the inclusion of AR into mainstream education [11]. With AR use having steadily increased since 2007 and AR research having intensified in recent years [11], it appears to validate predictions in 2010 that AR use would soon become mainstream [12] and suggests that interest will continue to increase [11].

"Augmented reality has strong potential to provide both powerful contextual, in-situ learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world."

Johnson, L. F. p. 22 [13]

The augmentation of the user's experience by overlaying additional information in the forms of text, images, video etc. provides great potential for AR in the field of education. The accepted importance of learning context, interaction and real world applicability on the quality of learning [14, 15] further illustrates the potential for AR in this field.

"[AR's] unique ability to create immersive hybrid learning environments that combine digital and physical objects, thereby facilitating the development of processing skills such as critical thinking, problem solving, and communicating through interdependent collaborative exercises" [16]

For example, AR can help students to engage in authentic explorations of the real world [17]. Therefore situated, cognitive and experiential learning practices have found strong links with AR [15, 18-21], especially because of the level of immersion and interactivity possible [22]. AR is also able to assist with learning and memory processes because we tend to "remember things better when they are spatially associated with locations in 3D spaces rather than as abstract ideas" [2]. This process of remembering things by relating them to spatial locations can be used effectively to recall information by walking back through certain places or 'loki' [23].

What the Research Says

While research into the use of AR in education is expanding, they remain limited and typically report on single cases of technology use. Despite the limited research on how the use of mobile context-aware AR can be used to enhance learning and teaching [20], the following findings have been reported.

Key benefits of AR discussed in the literature:

- AR can enhance learning achievement [11, 24-26]
- AR can engage students & motivate them to learn [24, 25, 27-34]
- AR can specifically benefit remedial learners [35, 36]
- Educators, parents & students tend to exhibit positive attitudes towards the use of AR tools [16, 28, 37-39]
- Students value the provision of instantaneous results / feedback made available to them [25]
- AR can redefine learning spaces
- The use of AR can promote a more enjoyable learning experience [27, 28]
- AR can help improve teaching effectiveness especially when teaching abstract concepts [38]
- AR can influence children's confidence & imagination [38]
- AR can encourage informal & self-directed learning [38, 40, 41]
- AR enables children to play & interact in different ways [37]
- AR can support positive emotional attachment with the environment [25]
- AR can foster skill development [39]

Six key considerations from the literature:

1. **The role of the educator remains critical** to the success of AR use. If educators have positive experiences with the new technologies they are increasingly likely to use it again and encourage fellow colleagues to use AR in their classrooms [28, 42]. Therefore, adequate PD in the use of AR and ICT is critical to long-term success [38].
2. **Adequate resourcing** is important to the success of an AR intervention with a lack of resources often cited as a key limitation. This includes technical support, internet capabilities, hardware capabilities and device to student ratios.
3. **Accounting for the context of use**. AR can extend and introduce new learning spaces [27], however, Wi-Fi connectivity, safety, student supervision, weather etc. need to be considered. Moreover, some AR applications may not be feasible in the crowded classroom setting while others are.
4. **Cognitive overload and usability** issues for students need to be addressed as they are some of the most frequently reported challenges to AR [11, 20, 43, 44]. To help with this, especially when students are being introduced to new AR applications, adequate time needs to be allocated.
5. **Managing stakeholder concerns** about addiction and the need for human interaction is critical. Understanding and addressing parental concerns is particularly important in the school and early years contexts [29].
6. **Maintaining learner interest** in using AR tools once the novelty factor wears off needs to be considered. While students are typically excited by the new tool and interactive activities, the literature has raised questions about how long this interest will last [38].

Different uses of Augmented Reality in Education

AR is an effective learning and teaching tool [28] that offers many potential advantages when used effectively in educational settings [45]. The range of different possible applications of AR in education is diverse and there is no clear or generally accepted way of breaking them down. For example, AR can be used to provide extension opportunities and interactive classroom aids, revolutionise assessment, facilitate life-like simulations, provide reference information and address specific educational needs or niches. Moreover, at a functional level the forms of AR available to educators can be categorised according to whether they are location-aware or vision-based [20]. Location-based applications typically rely on GPS positioning as the trigger for the provision of additional information as students move around a physical location. Meanwhile, vision-based applications rely on students pointing the camera at an object to receive the augmented experience

In categorising the different uses of AR Diegman et al. (2015)[46] chose to focus on implementation and identified the following five ways in which AR can be implemented in education: 1. Discovery-based learning, 2. Objects modelling, 3. AR Books, 4. Skills training, and 5. AR Gaming. Here we use these five categories to briefly outline how AR is currently used in education. We have adopted this approach to provide a simple and inclusive way of communicating what is possible across different educational settings, disciplines and levels. These categories are not intended to be exhaustive and we recognise that overlap exists. However, the information provided aims to highlight some of the possibilities available and stimulate you to think about how AR could be used in your own context.

Discovery-based learning

"Students learn best what they have to figure out for themselves"
[47]

AR's ability to provide an interactive and exploratory experience naturally supports discovery-based learning. By overlaying and linking digital information with real-world experiences, AR helps students create connections. This access to additional information enables them to easily explore topics and ideas further, even in their own time as they take responsibility for on their own learning journeys. Such applications may provide students with additional information relating to specific exhibits, buildings, animals, books etc. that they encounter. For example, the American Museum of Natural History launched and AR app to accompany their Beyond Planet Earth exhibition that enabled viewers to collect 11 AR elements, giving them access to additional information including 3D animations. Other apps enable students to point their cameras to the sky and find out what constellations they are looking at and then dig deeper to learn more about topics that interest them.

Objects modelling

AR can provide interactive 3D renderings of almost anything to assist students in grasping new and different content. This modelling enables students to get full 360-degree views of objects, be they stationary or active. Interactive colouring pages and worksheets combine the real and virtual while children and students learn and explore new concepts for all ages. Other apps draw on different props such blocks, flashcards, globes and posters to provide students with more engaging and visual learning approaches. Capture the imagination of children with apps that overlay moving and 3D images such as dinosaurs or butterflies onto the world they see or get students to use design apps that use the camera to digitally capture the layout of rooms or buildings and enhance their learning experience.

AR Books

AR books can come in many forms with different levels of interactivity and personalisation. Some children's storybooks can be scanned using the camera to reveal active 3D visuals, sounds and information that give a whole new meaning to story time. The same technology can be used to enhance the traditional textbook experience for students and encourage independent learning as they explore concepts further. These types of books typically rely on you downloading an app and the camera picking up on visual triggers on the page to augment your experience. AR books and storytelling developing further and some now combine aspects of AR gaming to offer even more interactive options where you can take part and shape the story line.

Skills training

The immersive yet augmented nature of AR makes it highly suited to skills development. The use of AR in skills training is typically facilitated by being able to show students how it is done, enabling them to practice those skills in a life-like setting using simulations and lastly provide supplementary guidance, information and support in real time as they perform the task or skill. This has great potential in the sciences, creative arts, physical and applied disciplines and in situations where real-life skills training is hindered by resourcing, location or safety issues. Other apps can use AR technology to verify the layout or set-up of skills challenges or tasks so that they are replicable and comparable.

AR Gaming

A range of educational AR games exist that motivate students to learn by providing fun, interactive and personalised environments and reward structures. Ideal for all ages depending on the complexity of the game, the application of AR gaming in education is just getting a foothold. You can already play many traditional games using AR such as soccer or pool that typically required equipment or playing surfaces, so the sky is the limit when it comes to gaming in education.

Different Educational Contexts

The Early Years of Care and Education (ECEC)

While regulating technology use among young children is important [38], we live in an increasingly digital world and becoming familiar with AR at an early age has been shown to facilitate the future development of technology skills [28]. AR aligns well with many key elements of Australia's Early Years Learning Framework such as its ability to facilitate diverse learning outcomes, include indoor and outdoor experiences and promote the exploration of ideas and theories using imagination, creativity and play [48]. While the critical importance of play in child development is well established [49] and the nature of 'toys' may have changed in recent times [50], facilitating play through combining the virtual and physical worlds has proven to be greatly beneficial for children [49].Despite this potential and early uses of AR in ECEC dating back over fifteen years [51], the application of AR in ECEC remains an underexploited opportunity.

Augmented Reality and the School Experience

With the Australian Curriculum promoting ICT skills and critical and creative thinking, the validity of AR in this sector is clear [52]. Moreover, the majority of studies focusing on the use of AR in education tend to focus on the K – 12 sector [11]. This prevalence in schools has been put down to two possible causes. Firstly, AR's ability to foster visual and sensory learning aligns well with the learning needs and stage of cognitive development of elementary students and early adolescents [53]. Secondly, the familiarity of students with gaming makes them predisposed to the use of AR gaming techniques in their learning [54].

Augmented Reality and Higher Education

In a time where traditional higher education techniques and institutions are under threat from new open, flexible and online options, educators need to remain up-to-date and provide students with quality value for money experiences if they are to remain competitive. In fact, AR's ability to provide learner centred, interactive and immersive learning opportunities that combine the physical with the virtual makes it highly suited to an increasingly blended learning environment. AR has also been successful in improving university students' skill development and attitude towards learning [39].

Future of Augmented Reality in Education

As mentioned, while the possible benefits of using AR across all fields of education is widely recognised, it remains underutilised in the classroom.

Studies also suggest that its potential to support special needs students remains a specific area that warranting further exploration [11, 34, 55]. For those of us already using AR, we cannot rest on our laurels, as students attitudes towards AR may change over time [56] we must remember that the tool itself cannot guarantee successful learning outcomes. Pedagogical and practical issues such as the possible need for more class time, unsuitability in crowded classrooms, and instructors' experience with technology still present challenges, but should not be used as excuses to rule out its use. Rather, they should be used as points of reflection that help us engage in best practice. In the coming years technological issues will continue to decrease as mobile device use, wireless internet connectivity and computing power improve. These conditions will only further support the use of AR and make it an even more necessary component of quality education [39].

How ARE Can Work with You

The use of AR in Education in Australia is an exciting and developing opportunity. At ARE we are a team of specialised individuals that combine skills across business, education, architecture and engineering, software development, animation and 3D rendering to create applications that integrate AR with practical and creative innovations. We are passionate about AR and work closely with our clients to find new and creative ways to leverage the affordances of AR to meet their objectives. We are based in Melbourne with representation in Sydney and Adelaide and look forward to realising your AR ideas with you.

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AR App Design Considerations

Project Title:

Key Objectives

☐ Increase learner engagement
☐ Improve assessment practices
Improve awareness & understanding of course offerings
Improve student evaluations
Improve or enhance the campus experience
Improve professional development & in-house training
Maximise use of classroom / other spaces
☐ Expand scope of learning activities & enhance delivery
Reduce skills training times & costs for students
Other (specify)

Learning Considerations

- What are the specific learning objectives?
- How do these learning objectives align with your curriculum focus / plan?
- How are assessment & feedback incorporated?
- How does AR help you achieve these objectives?

Specific Uses

Provide extension learning opportunities
Provide interactive classroom aids
Provide more authentic assessment options
Provide life-like & immersive simulations
Address specific educational needs or niches
Support skill development
Provide real-time instructions & information
Provide 3D visualisations & model rendering
Facilitate personalised & self-directed learning
Provide location-based information & interaction
Engage students through interactive gaming
Provide interactive checklists & review tools
Facilitate campus, lab or other site inductions & navigation
Enable remote assistance with tasks & activities
Other functions (specify)

Data Collection and Learning Analytics

Which, if any, key data metrics or learning analytics would you like to capture?

Context of App Use*

Intended location/s of use (classroom, laboratory, campus, cafes, home etc.) and activities being performed (experiments, bushwalks, map reading etc.)

*Note: Context of use will have implications on hardware choices and safety considerations

Safety and Security Considerations

What potential security risks need to be considered?
☐ Access to student/ child information
☐ Access to organisational data and intellectual property
☐ Other (specify)
What potential safety risks need to be considered?
User distraction

Hardware obstruction / interference with actions
Provision of inaccurate information
Other safety & security risks (specify)

Hardware

☐ Smartphones	Laptops
Tablets	Desktops
Smart glasses	Other (specify)
HoloLens	

Software Considerations

Licensing	Integration with existing platforms
Updatability & modifiability	Intended audience (public, internal)
Ability to work offline	Individual or group use
Data exporting formats	Intended duration of availability

Which platforms do you want it supported on?
Android
iOS
Other (Specify)

Relevant Policies and Frameworks

What policies or frameworks are pertinent? E.g. Early Years Learning Framework, Australian Curriculum, Graduate Learning Outcomes, Communications/ Technology policies, other.

Readiness

- How does AR fit with existing organisational & classroom practices?
- Are staff members & tech support familiar with AR technologies?
- Do the organisation and/or students have appropriate hardware?
- Do educators understand the potential of AR to enhance learning?
- Will using AR influence or potentially challenge current norms?

Content, Design and Messages

- Design priorities - ease of use, practicality, enjoyment, look, feel
- Key topics and/or processes to be included
- Information layering
- Legibility, flexibility, interactivity
- Visual clues - images, graphics and video
- Key phrases and messages
- Relevant teaching and training approaches and pedagogies
- Examples of themes or storylines from similar applications
- Colour schemes, fonts, branding
- Specific characters, products, animals or objects
- Information delivery (visually, aurally or both)

Notes

Example Applications

Discovery Based Learning

- **Zoo-AR / Taronga Zoo** - A different Zoo experience
- **LayAR/ Wikitude** - A deeper look at the world around you
- **Bayan Tales AR Discovery** - Children's favourite jungle actors
- **Star Walk 2 / SkyView** - Explore the night sky
- **Field Trip** - GPS tracking provides key local information
- **Sun Seeker** - solar paths, solstices, rise & set times
- **Google Translate –** instantaneous text translation using camera

Objects Modelling

- **Augment** - Visualize nearly any 3D model in AR
- **Quiver/ 3D Coloring/ Spectacular/ Chromeville/ Chromeville Science** - Fun educational twist on traditional colouring in
- **Spacecraft 3D** - Interact with a variety of NASA space crafts
- **Elements 4D by DAQRI** - Learn about real life chemistry
- **AR Flash Cards/ OOBEDU AR Kids App** - Interactive flashcards
- **Orboot: AR Globe** - A new take on geography for kids
- **AR-3D science** - Interactive physics, biology & chemistry learning
- **AR Human anatomy/ Anatomy 4D –** Immersive anatomy
- **Dinosaurs Everywhere / AR Butterfly Burst** - Dinosaurs and butterflies are roaming the streets with you
- **MagicPlan** - Capture interactive digital plans on your smart device
- **ZooKazam** - Learn about animals in a completely different way

AR Books

- **Magic Book** - Interactive children's colouring book
- **Tagme3D** - Educational series of AR books for children
- **Pearson BouncePages** - Augment the textbook experience
- **Peronio Pop-up Book** - Ultra-imaginative pop-up AR/VR book

Skills Training

- **Bosch Toolbox App** - Everything for those learning construction
- **Aurasma** - Create and share your own AR experiences
- **SkillCity from Manchester City FC** - Compare your skills
- **SketchAR – Drawing easily using AR** - Enhance your drawing skills
- **Park AR** - Practice your parking skills with this game

AR Gaming

- **Prepare for Impact** - 3D aviation safety game
- **Popar Dinosaurs** - Educational interactive smart toys
- **CyberChase Shape Quest!** - 3D AR puzzle game for kids
- **Play Shifu: Fun games for kids** - Immersive & engaging learning
- **Kick Ball** - Kick a virtual soccer ball solo or against a friend
- **Euclidean Flick Lands** - Brain teasers
- **PhyscisPlayground** - Immersive, 3D physics learning

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