Development of a Simulation Board Game Based on the Physical Principles of Superconductivity and Magnetism for use as a Teaching Aid

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We have designed a tactical simulation board game based on the physical principles of superconductivity and magnetism. This could be used as a teaching aid to engage the interest of students, and help them gain a qualitative understanding of physical concepts. Preliminary play testing with undergraduate students indicates that the game achieves this result.

1. Introduction

Students generally learn material better when they engage actively with the subject matter and if their interest is stimulated [1,2]. This can be especially useful in helping students gain an intuitive understanding of many physics concepts [3]. To assist in developing this qualitative comprehension, a tactical simulation board game based on the principles of superconductivity and magnetism has been developed. This could be used as a teaching aid to help motivate students and assist in their understanding of these physics concepts. The Vortex! Game was developed as an assignment submission for the 3rd year condensed matter physics course, PHYS3032, at the ANU in 2006.

2. Game Mechanics

The game was designed in a science fiction setting, where the players control futuristic spaceships trying to destroy each other. The setting and goal were designed to appeal to physics students, thus adding an extra element of motivation. Elements of magnetism and superconductivity are incorporated in the way the ships move. The spaceships are made of magnets so that they interact with the magnetic terrain. The terrain over which the ships move consists of a hexagonal grid of different types of material: ferromagnetic, superconducting (type II) and non-magnetic (Fig. 1). For example, ferromagnetic terrain is represented by orange hexes with a domain arrow that indicates the direction of the horizontal component of the local magnetic field. Hence if ships move in the same direction as the field vector they will move further (lower energy cost) than if they are moving in the opposite direction.

Players are also able to modify the terrain by firing missiles at the terrain. For example, heating a superconducting or ferromagnetic hex above the critical or Curie temperatures respectively, will cause them to lose their magnetic properties for some time. The direction of the ferromagnetic domain in a hex can also be changed, which affects the domains in the neighbouring hexes. Another major terrain modification occurs when a strong magnetic field is introduced into one of the type II superconductor hexes. As the superconductor works to exclude the magnetic field, it undergoes a transition from the Meissner state to a vortex state, characterised by circular vortices of large currents. The vortex lattice is hexagonal, which fits very well with the hex map used to represent terrain in the game, which is partially why the hex map was used.

The game rules are deliberately designed to be simple and accessible, while still incorporating a substantial amount of correct physical modeling of magnetic behaviour.

It should also be noted that similar games designed around numerous other physical theories are also possible. In this respect, Vortex! can be seen as an example of how the abstracting of a physical theory into qualitatively accurate game mechanics can be achieved. The platform on which such a game is designed may also vary. The obvious alternative format is a computer. The main advantage of a computer application over a board game is that the relevant physics may be expressed quantitatively and in real-time due to the available processing power. The board game format, however, has a number of other advantages as discussed below.

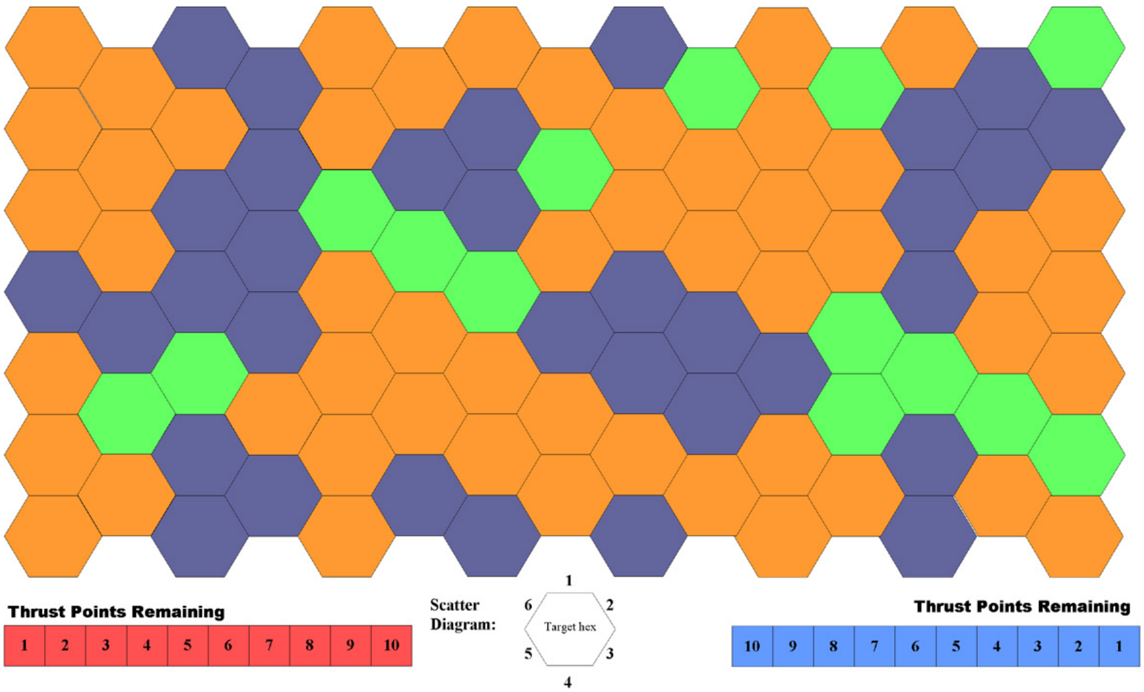

Fig. 1. The board used in the game showing the hex grid.

3. Educational Rationale

In order to aid in the development of an intuitive understanding of a physical theory, which due to its nature is usually a type of abstract mathematical construction, a tool is often beneficial that allows the student to directly manipulate the important properties of the theory while avoiding any lengthy calculations.

The Vortex! board game is such a tool that allows players to develop their ideas of magnetism and energy conservation. This is achieved by abstracting the involved physical principles into game mechanics such that they are qualitatively but not completely quantitatively accurate. The format for such a tool may vary as well – in this case a board game was chosen, but other platforms, such as computer applications, may also be used. An advantage of a computer game implementation is that the relevant physics may be expressed quantitatively and in real-time due to the available processing power. A board game implementation, however, has a number of other advantages. These include appealing to a broader group of students, including those who are not computer game players, as well as it being more social and consequently requiring personal interaction, thus encouraging co-operative learning. In addition, unlike a computer game, a board game requires no additional software or hardware other than what comes in the game box, thus making it more manageable in a classroom environment. The social aspect of the game is of particular interest and is one of its major advantages over the computer game format. In testing the game, it drew the interest and participation of students and academics, some of who would not have participated in a computer game.

As a second educational benefit, as well as providing the players with a basic insight into the physical principles, it is hoped that it will do so in a manner that is substantially more engaging then a list of textbook questions. By providing students with this prospect of interacting with familiar subject matter from such a different perspective they will be motivated to engage with the material - even if it is only out of a sense of curiosity rather then a genuine interest in the game itself [2].

The game is not intended to replace traditional problem sets that provide quantitative understanding of the physics, but is instead designed to supplement them by providing an engaging and interactive introduction to magnetism. Initial class testing in 2006 indicates that students do find the game engaging. Further class testing in 2007 will investigate student learning outcomes from use of the game in a third year CMP course at the ANU.

4. Conclusion

The game successfully abstracts the relevant physical principles of magnetism such that they were playable in a game format while remaining qualitatively accurate.

Students were intrigued by the prospect of interacting with physical principles from a new perspective and were thus enthusiastic to play the game.

As a teaching aid, the game complements traditional quantitative learning tools in that it allows for students to become familiar with the central concepts of the theory while avoiding lengthy calculations.

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