Currently, one of the major trends in science education is to try to make science relevant to students. To this end, teachers, curriculum designers, and researchers have tried many techniques. Recently, Glen Aikenhead has published a review of the research on such attempts to make "a science education for everyday life" (Aikenhead, 2006).

This paper will focus on what are known as "context based" science courses, courses which focus on how science is applied (Bennett *et al.*, 2005). For younger students, this means showing how it matters in everyday life, while for more advanced ones, it means showing about how science professionals act (Bennett et al., 2005). An overview of several such courses can be found in the July 2006 issue of the *International Journal of Science Education*.

One claim about these courses is that they should increase understanding of the material because that will motivate students to learn it (Bennett & Holman, 2002). The goal of this paper will be to investigate the research and theoretical concepts needed understand what aspects of the courses should make them more motivational. It will begin with some qualitative research on typical science classrooms in order to demonstrate the motivational problems that these settings have. It will then use a recent review of motivational theories and constructivist science education (Palmer, 2005) to describe what could be some motivational issues being faced in these situations. Keller's model of motivation and instructional design (Keller, 1983) and research informed by it will also be examined, along with other important research in motivation. Lastly, the research on the context-based courses themselves will be considered.

This paper begins not in the context-based science classroom but in the typical one. This will help spotlight some of the motivational differences between traditional and context-

based classrooms that will be useful for understanding the latter. Two recent qualitative studies exist which examine typical secondary classrooms (Hanrahan, 1998; Osborne & Collins, 2001). There are motivational problems in these classrooms, and these problems will be examined using the motivational theories described by Palmer (2005.)

Osborne and Collins examine focus groups of GCSE students in the late 1990s in the UK. These groups had been created to find out what the science classroom is like from the vantage point of the students (Osborne & Collins, 2001). The results have a good deal to say about the motivation of the science student in typical classrooms in Britain, where the study of science is mandatory. The authors present a world where covering content has become so important because of testing that the only thing teachers feel they can do is give lectures and have students take notes. There are examples of students who are frustrated that there is no time for discussion of interesting (or in at least one case) socially relevant topics. Osborne and Collins state that this leads to decreases in the autonomy of the student as well as in his feelings of competence, as he can't justify what he has learned other than by saying that the teacher had said it (Osborne & Collins, 2001). One particularly upsetting passage is about students who have found science to be so hard and have had it be so for such long a time that they don't care about it any more. (Osborne & Collins, 2001)

The study also discusses things that the students like about science class. The authors claim that students like anything that discusses things about themselves, like about the biology of humans or Earth's place in the universe (Osborne & Collins, 2001). The authors suggest that the reasons for learning science and why this will be useful later

need to be stressed, and that science might have a "marketing problem" (Osborne & Collins, 2001).

In another qualitative study, Hanrahan (1998) researches a class of Australian biology students. In their classroom, where the author has been an observer, covering the content and getting the correct answer seems to dominate everything else. Discussion and group work are used, but in discussion only some students feel they can really play a role, and in addition no one wants to participate too much. Group work seems to be nothing more than the most knowledgeable student in the group answering the questions, followed by social discussion. Hanrahan cites Ames and Archer, claiming that they say self-regulation decreases where the goal is performance and not mastery. Another important finding is that students explicitly tell the author that they feel they don't have much control over their science classes as compared to other courses (Hanrahan, 1998).

Research in motivation can help explain why students in these high school science classrooms seem to have some complaints about them. Self-Determination Theory, which describes intrinsic motivation and the process of "internalizing" externally motivating things (Deci, 1992, using the work of Deci & Ryan, 1991.) Several environmental aspects are important for this, as the following quote shows:

> Earlier I said that there are three fundamental psychological needs that are intrinsic to the self- the needs for competence, autonomy, and relatedness. Social contexts that allow the satisfaction of these three basic needs will promote intrinsic motivation, internalization, and interest, whereas those that thwart one or more of these basic needs will inhibit or undermine these processes (Deci, 1992) .

This idea relates directly to several of the points made in the two studies of traditional classrooms. In Osborne and Collins's study, note that students' autonomy is lost because the teacher sometimes has to justify content as being true simply because the students need to know it for the exam (Osborne & Collins, 2001). They also make the point that

this threatens students' feelings of competence as well (Osborne & Collins, 2001). The students in Hanrahan's study are also affected by the needs described by Deci. This author notes that in the class she researches, only some students seem to participate in the discussion (Hanrahan, 1998). From an SDT perspective, this might undermine the other students' feelings of competence. (***) Students in this study said that science was the class that allowed them to be the least creative of any of their classes (Hanrahan, 1998), possibly undermining their feelings of control.

Other theories in motivation are also important when considering activities in science classrooms. A recent review of motivation and constructivist science education discusses several of these. In both studies discussed above, the classroom was driven by the need to perform well on tests (Hanrahan, 1998; Osborne & Collins, 2001). Based on the work of achievement goal theorists (Ames, Elliot, Maher, Pintrich, and their co-workers), it was claimed that such a performance goal would decrease student motivation because the students pay more attention to each other than to whatever is being taught (Palmer, 2005). Pintrich has also suggested that it is very important students have mastery goals in order to get them to be willing to replace old, scientifically inappropriate concepts with new ones (Pintrich *et al.*, 1993) Hanrahan explicitly cites a paper by Ames and Archer that claim that students' self-regulation decreases in performance oriented classrooms (Hanrahan, 1998).

Another motivational construct to consider will be attribution theory, which Keller and Palmer attribute to the work of Weiner (Keller, 1983; Palmer, 2005) (Keller discusses the various components of the model and cites other workers who helped contribute to it, as well.) The model consists of students deciding whether what happens in a given situation

is because of them or because of others, as well as whether that situation can change or not. “Learned helplessness” occurs when the students feel that they are failing because of their own, un-improvable ability, and according to Palmer, a study by Firman and co-workers has shown that students like this don’t try very much, and have an increased chance of failing (Palmer, 2005). One has to wonder if the students who no longer care about science in Osborn and Collins’s study are suffering from this condition.

The above discussion is meant to show what some high school science classrooms look like, and to discuss some of the motivational reasons for why they might not be very motivating to students. Now, the discussion must turn to improvement. The question is, can showing students the relevance of science concepts increase their motivation towards learning? Furthermore, is this something which is happening in the context-based courses? Are there possibly other aspects of the context based courses that might suggest that they would be more successful than a traditional course? It is suspected that if context-based approaches promote mastery goals (**), fulfill students’ needs for self-determination (Deci, 1992), and allow students to attribute success in positive ways will increase their motivation.

Keller (1983) describes four variables that teachers must be concerned with when designing instruction. They are “interest,” “relevance,” “expectancy,” and “satisfaction.” The first two categories seem to be the most pertinent to context based science education. An important part of interest is curiosity, and using the work of Berlyne, Keller sets out to describe this. Berlyne apparently made a number of distinctions about different types of curiosity. There is “perceptual curiosity,” which is caused by something that wasn’t expected, and “epistemic curiosity,” which is more related to “problem solving” (Keller,

1983). According to Keller, Berlyne also describes the difference between "state" and "trait" curiosity, which is the difference between curiosity about a situation versus general curiosity (Keller, 1983). An important point to be made about curiosity, (which comes from Berlyne and an earlier Keller paper) is people must feel safe about the risks of being curious before they will be such (Keller, 1983). This last caveat will be useful in explaining some of the later research. In order to increase people's curiosity, Keller recommends a number of things, including doing surprising things, make things personal, use a proper mix of old and new knowledge, use analogies, and teach students to do "inquiry" (Keller, 1983).

Keller admits that his work on relevance is not entirely separated from that on interest (Keller, 1983). He divides relevance into three factors- "personal," "instrumental," and "cultural" (Keller, 1983). Personal relevance means that you are meeting the needs of students(Keller, 1983), and he describes a good amount of research and theory on what students' needs are. It is not an equivalent construction to the needs described in Self-Determination Theory – but one can see how the advice Keller gives could fulfill those needs. It will be assumed in this paper that fulfilling the needs for competence, autonomy, and relatedness (Deci, 1992) will increase personal relevance. Following the advice of Raynor, Keller also states that showing why something is important will increase motivation (Keller, 1983). Lastly, it is stated that the other important people in a student's life can influence what he values and finds important (Keller, 1983). Using the experience of McConnell, Keller recommends giving students role models of people who do the activity you are teaching (Keller, 1983). Keller continued to develop the categories of relevance and interest, according to research articles read for this review, into

something called the ARCS model (R. Miller, personal communication, 4/19/07). According to the three studies examined that use the model, the new categories are "attention," "relevance," "confidence," and "satisfaction" (Frymeir & Shulman, 1995; Means *et al.*, 1997; Newby, 1991).

Means and co-workers do not attempt to create a course-level intervention, but rather investigate how changes in wording designed to make the material seem more relevant can affect motivation. The evidence that they collect shows that it can. Using a model of instruction developed by Keller, this group looked at the feelings of motivation and student performance after going through some readings about the heart. Two of the four treatment groups came from a statistics class, whereas the other two came from a physiology class. This difference was assumed to be a difference intrinsic motivation. In each class, half of the students had readings enhanced using the ARCS model, which included strategies for making the material relevant to the learners and trying to direct them towards the mastery goal of learning the material. Several motivational measures and an achievement test on the content were used, and a MANOVA carried out. It seemed that being in the class that needed the material was important, but that using the enhanced material had a larger effect on motivation. More specific information about the various effects and significance of individual variables can be found in the paper.

These authors interpret the larger effect size of the enhanced instruction as showing that being in a psychology course doesn't guarantee intrinsic motivation for it (Means et al., 1997) This paper also cites a number of papers which they claim shows "learners must understand the purpose and see the utility of the instruction."(Means et al., 1997).

In another study, the researchers focus on student perceptions of their teachers- specifically perceptions of if the teachers are trying to make course content relevant and how that affects the students' perceptions of motivation and immediacy (Frymeir & Shulman, 1995). Students in a communications class were asked to complete a questionnaire about how their teacher in another class they were in tried to make content relevant. They were also interested in how often the teachers did various things to try and increase their immediacy. These variables were considered independent variables and student motivation to study, the dependent variable, was measured using a scale developed by Richmond. The authors make the distinction similar to what Berlyne did above (Keller, 1983) between motivation for a particular task (state motivation) versus a more generalized relevancy (trait motivation) and cite work by Brophy and Keller to justify this (Frymeir & Shulman, 1995)

These authors found that attempts to make things relevant to the student resulted in higher motivation when it came to studying, and that it was correlated with attempts to be immediate. When they did multiple linear regression they found that the three postulated independent variables of immediacy (verbal and non verbal) and relevance shared quite a bit of variance in motivation, and that verbal immediacy and relevance each accounted for a small amount of unique variance (4% and 3% respectively.) The authors of the study were surprised at how much immediacy and relevance overlapped because they claim that they are defined differently (relevance by Keller and immediacy by Richmond 1987.) They state, based on work by Frymeir and by Kelley and Gorham that immediacy might have been needed to get the attention of the students in order to see that the teacher was trying to be relevant. This makes sense in terms of SDT. If the teacher doesn't do

anything to make the students feel relatedness during his or her teaching, one could expect a decrease in motivation because of this.

The idea of teachers relating things to real life is also apparent in a paper that the Frymeir and Shulman article cites. In a study by Newby, first year elementary school teachers were observed and the amount of time that they spent doing certain behaviors was recorded (Newby, 1991). Every once and a while, the number of students that were on task was noted. The author then used the ARCS model to break strategies the teachers used into categories: attention getting, relevance, confidence building, and satisfaction. Of these, relevance and confidence building were used significantly less than attention getting, which was used significantly less than satisfaction (Newby, 1991) Of the four categories, the only ones that correlated with students doing the task at hand were satisfaction strategies and relevance ones: students were on task more with relevance strategies and less with satisfaction ones (Newby, 1991)

Newby lists a number of reasons for why relevance and confidence are not used so often, and one of them is very interesting. He says that to do these things the teacher might have to make his or her instruction more individual, which these teachers might have been to inexperienced or had to little time to do. Newby specifically looked at statements that teachers used for motivation and points out that there may be more situations where one can use things like rewards than when one can relate things to outside experience (Newby, 1991)

Hynd and her collogues carried out a study that tested whether having a reason to learn a particular physics concept would influence future elementary school teachers' learning of the concept and the quality of their ability to teach it to a child (Hynd *et al.*, 1997) The

overall study included four treatment groups in a 2x2 design, with one variable being a way in which the concept was taught and the other being knowing that you would have to teach the lesson to a child. They used the work Posner, *et al* to say that a new idea has to be useful to make sure that a student will adopt it and also a precious study by their group that "relevance and usefulness were influences in conceptual change."(Hynd et al., 1997). There was no effect of knowing that one would have to teach the physics topic. They could only speculate at reasons for this, but suggested that it could be that both groups of teachers were motivated to learn the new topic. Other suggestions were that Posner's model was based on the ability to solve problems and not the ability to teach, or that perhaps this wasn't as important to future elementary school teachers as it was to their previous groups, who had reason to think physics would be a part of their careers (Hynd et al., 1997).

This last study is similar to some of the research that has been reviewed by Deci. Two pieces of information from those studies are very important. First, Deci, Eghrari, Patrick, and Leone (1991) apparently showed that you could help students internalize an unexciting task more if you did certain things:

> They were: providing a rationale for doing the dul task (viz., it can improve concentration); minimizing the use of pressure and providing a sense of choice about doing the activity; and acknowledging that the subjects might find the activity uninteresting (Deci, 1992)

Deci then goes on to state that making sure people know why something is worthwhile to them, along with being involved and not decreasing their autonomy can contribute to people's "willingness" to do an otherwise un-stimulating activity (Deci, 1992).

The second important piece of work comes from the work of Benware and Deci. Students who were told that they should read material to be tested on it learned it more poorly and were less interested in it than students who were told to learn it in order to teach it (Deci,

1992). Simmilarly, the work of Grolnick and Ryan showed that students who were told they were going to be tested on material understood it less, were less interested, forgot it quicker, and felt more "pressured" by it (Deci, 1992).

Recently, a group of Self-Determination theorists published a review on goals in that theory (Vansteenkiste *et al.*, 2006). In this paper, previous studies by the group are examined where students are given a task to do, with different reasons for doing it. For example, a reading about the environment was presented to students who were either told the knowledge was useful in making them a good citizen or that it could be used to save themselves some money (Vansteenkiste, et al 2006, citing the work of Vansteenkiste, 2004.) A similar strategy was chosen within a PE setting: students were told that an exercise could help them be physically fit or that it could help make them look better (Vansteenkiste et al., 2006). In both of these cases, the goal related to personal well being was considered an intrinsic goal, whereas the one done for an outside reason was considered extrinsic. Generally, higher performance was found for students who had been given intrinsic goals. Some of these studies examined whether persistence or conceptual versus wrote learning of the material were affected (wrote learning was not.) Generally, it seems that intrinsic goals and autonomous environments promoted learning, whereas extrinsic ones harmed it (Vansteenkiste et al., 2006). This was true even if *both* extrinsic and intrinsic goals were given (Vansteenkiste et al., 2006). Before giving that result, the authors pointed out that this would be what to expect with SDT, as the extrinsic goal would be distracting students from the learning(Vansteenkiste et al., 2006). This is an idea to bear in mind as one reads the literature about the current state of science classrooms and possible role of context within them.

The research cited above focuses on small interventions that seem to encompass a single lesson. Two papers (Frymeir & Shulman, 1995; Newby, 1991) suggested that teachers attempting to make things relevant to their students had an effect on those learners. Another paper (Means et al., 1997) showed that small changes in the presentation of material (in this case wording) could have an effect. The research presented in two reviews using SDT (Deci, 1992; Vansteenkiste et al., 2006) showed that variables related to why a task was being done (ie for intrinsic versus extrinsic goals, or being in an environment that fulfils the need to be self determined, or being in an environment that is pressure-free versus pressured) were important in determining motivational and other variables. The paper presented by Hynd (1997) did not show an effect of relevance, although it raised some good discussion points and cited previous work by the group that seemed to suggest that how relevant something was did have an affect on learning.

At first, the relationship between this literature and context based science courses may seem unclear. This research concerns relatively small interventions, whereas a context based course is a sustained curriculum change over time. However, as one reads the research on the context-based courses, it becomes clear that some of the lessons described above do explain success or problems in these courses.

It might be helpful in the following discussion to have a good idea about what a context-based course is. The *Salters* series of context-based courses, created at the University of York, have been very well described (Bennett et al., 2005; Bennett & Holman, 2002; Bennett & Lubben, 2006; Hughes, 2000; Ramsden, 1992, 1997), and therefore it is useful to understand the format of these courses. A unit in one such course, *Salters Advanced*

Chemistry, can be used as an example[1]. In one section about medicines, students begin by going through the history of medicines, and are later walked through a method of compound identification. This is done using salicylic acid, a traditional medicine (Burton *et al.*, 1994b). The discussion introduces some common identification techniques in chemistry. Later, there is a practical discussion about the economic feasibility of certain methods of making chemicals, and the chapter concludes with an interview with someone who works at an English chemistry company. Students are asked to consult a separate textbook that contains certain chemical concepts (Burton *et al.*, 1994a) or other references when they need to (Burton et al., 1994b).

Some of the research in context based courses has been reviewed (Bennett & Holman, 2002). Two of the studies in this review were examined further, those carried out by Judith Ramsden. The first of these (Ramsden, 1992) was admittedly "small-scale," and consisted of asking the early high school students to rate how much they enjoyed various aspects of the course, whether it helped them comprehend their current lives, whether they think it would be useful later, and whether it helped them more interested in science. Students were also asked to elaborate. There was some discussion about the gender differences that showed up, such as on specific units and on whether a particular gender valued laboratory work or non- lab more (Ramsden, 1992). The most interesting part of the study, though, was that the question "I enjoyed this unit" and the question "I felt this unit made me more interested in science" when looked at for all the units had significantly different scores (Ramsden, 1992). On the basis of two students comments, Ramsden suspects that this was because the students didn't see the activities as typical

[1] This description uses the original texts of *Salters Advanced Chemistry* (Burton *et al.*, 1994a, 1994b). A revised version was released in 2000.

science activities (Ramsden, 1992). Another study by Ramsden reported that some of the students in a Salters class (12 out of 124) wrote on a questionnaire that they enjoyed the usefulness of the course, wheres no students in the comparison group of 92 said this (Ramsden, 1997).

Recently, a group connected with the Salters materials surveyed A-level chemistry teachers in Great Britain over their opinions on their chosen courses (Bennett et al., 2005). Some of these teachers were using a more traditional course, and some were using *Salters Advanced Chemistry*. The researchers had three hypotheses, and the first two are pertinent. First, citing work by Burton and coworkers, Holman, and Holman and co-workers, they predicted that the contexts would make students more motivated and more willing to study more chemistry (Bennett et al., 2005). Secondly, citing work by Kyriacou, they predicted that the active learning would "also stimulate interest and motivation" (Bennett et al., 2005) Teachers in both courses seemed to think that the students' in the *Salters* course would be more motivated than the students in the traditional course (Bennett et al., 2005). In addition, there was indication that the Salters students were having to control their own efforts to learn (Bennett et al., 2005). Teachers of both courses felt that the Salters course had more different types of activities for students to do (Bennett et al., 2005). A concern was testing- teachers in both courses felt that the Salters courses were less straightforward, but that they might give students other than the best students some help (Bennett et al., 2005).

The research cited above shows one important thing: that the context-based material seems to be well-received. These types of research designs, though, do not give many

clues as to how motivation is being affected. Two other recent studies are more helpful in this respect.

A recent critique by Hughes (2000) of *Salters Advanced Chemistry* was based on her 1998 dissertation. The thesis of Hughes's paper is that even in a context-based course, the material relating to society can be "marginalized" as compared to the traditional science content (Hughes, 2000). This marginalization is then related to concepts of a gendered view of science. For her dissertation, Hughes did a case study of two Salters classes. She examined the syllabus for the course, sat in on classes, and interviewed students. What she found directly relates to some of the motivational concepts that have already been discussed. First, it doesn't appear that the performance goal environment seen in the Hanrahan and Osborn and Collins studies entirely disappeared environment in the Salters course. Hughes claims that there is a tension between "science education for all" and the culture of the United Kingdom that emphasizes exams (Hughes, 2000). This could be seen in how an activity that related to the role in society of chemistry was not taken seriously by students, as it was placed in an odd location in the term and wasn't graded. One student specifically told the researcher that she didn't think of the applications of the material, but rather simply experiments (Hughes, 2000). Nevertheless, another student (who had started in a more traditional course) said that she vastly preferred the Salters course as she could relate it to things (Hughes, 2000). It seems that there are several lessons to take out of Hughes's article. The first is that if there is still an extrinsic goal, (ie the test), that students won't be focusing on the content (Palmer, 2005). This is similar to the research summarized by Vansteenkiste and co-workers which found that having an external goal even if one also had an intrinsic one harmed learning (Vansteenkiste et al.,

2006). This could be because the students still did not feel the class was self-determined (**), which could explain the student in this study who was very positive about the course as she knew how much less self-determined it could be, having been in another chemistry course. Another lesson is also course goals. In a practitioners article, Wink has pointed out that for relevant material to be adopted by students, it must be a substantial part of the course and be assessed (Wink, 2005). Another lesson is that even with material designed to be relevant, students might not see it as such. The strategies recommended by Keller to arouse curiosity, instrumental relevance and cultural relevance could be very useful in facilitating this.

A final study examined a different, modular course at two colleges in the United States that claimed to be context based (Gutwill-Wise, 2001). One college was a small liberal arts college, whereas the other was a large university that had graduate students teaching lab sections. While students who took the modular course seemed to get chemistry content better (in fact, the students in the large university even did better on their first test in the semester following the treatment,) attitudinal changes were interesting. At the small college, students liked the modular course better than the normal course. In this case, the researchers had had some trouble filling the modular course because of scheduling problems, so they actually offered students free textbooks if they'd enroll in the modular section (Gutwill-Wise, 2001). At the university, students liked the modular course less than the traditional course. In this case, different sections of the course were assigned to different treatments, and some of the students in the experimental approach felt that they were being used. Graduate assistants teaching the course also had negative attitudes about it, which might have worn off on students. Finally, it appeared that

students had an idea of what the course would be like, and were not happy when it wasn't what they thought it would be (Gutwill-Wise, 2001).

It seems that SDT is a useful method for describing these results. Students at the small college, although in some cases rewarded for being in the experimental class, were there on their own volition. It was a self-determined choice. Students at the large university didn't have this feeling about autonomy, and their attitude decreased. Their sense of relatedness to their professors may also have been affected by this. If they had a sense of relatedness to their graduate assistants, that would explain why their negative attitudes were so important.

In summary, this paper has reviewed some of the literature on relevance and motivation. It was found that the literature contained examples of small-scale interventions that were found to increase students' motivation. Many of these investigations were carried out using the theoretical framework of the ARCS model (Keller, 1983) or Self-Determination Theory (Deci, 1992). Upon examination of the literature on context-based courses, it was found that they seemed to be well received, but that continuing to change the classroom climate from a performance goal oriented situation to a mastery goal situation was important. In addition, some of the small changes in tone and orientation suggested by the ARCS model, as well as a concerted effort to make students feel like changes in their science curricula are self determined, seem highly important.

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