

IDENTIFYING BARRIERS TO INFUSION OF AQUACULTURE INTO SECONDARY AGRISCIENCE: ADOPTION OF A CURRICULUM INNOVATION

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Abstract

The large numbers of workers needed for jobs in technical agriculture, including those in aquaculture must understand basic biology and chemistry concepts and processes. Aquaculture education, when infused into the secondary agriscience curriculum, can help meet these needs. It provides an experiential learning experience that motivates students to learn science and mathematics, as well as reinforcing other academic disciplines. Not all teachers, however, may believe aquaculture to be a viable curricular choice for their individual programs. This article is based on a larger study commissioned by The National Council for Agricultural Education to examine implementation of aquaculture education in the United States. Specifically, this article addresses perceptions of secondary agriculture teachers regarding the barriers to offering aquaculture as part of an established agriculture program. Results of this multiple methods study indicate that if teachers believe that offering aquaculture as part of their curriculum will result in benefits to students they will find the means to overcome most perceived barriers, including cost.

Theoretical Framework

Several factors relate to the way that individuals adopt (or do not adopt) an innovation (Rogers, 1971; 1983; 1995; Russell, 1971). These factors include individual characteristics, an individual's attitude towards the innovation, and knowledge of the innovation. A great deal of research has been done to investigate factors that influence adoption of innovations (Fullan, 1987; 1991; Lionberger, 1960; Rogers, 1971, 1983, 1995; Russell, 1971). This section of the literature review will identify relevant research that deals with the adoption process as well as specific research that examined factors related to adoption of curriculum innovations.

Lionberger (1960) proposed a theory of the adoption process that contained five stages: 1) awareness, 2) interest, 3) evaluation, 4) trial, and 5) adoption. Rogers (1995) conceptualized these stages within the context of the innovation-decision making process. He proposed five stages, as well, but he focused on the processes utilized by an individual to accept or reject an

innovation-knowledge, persuasion, decision, implementation, and confirmation.

While these models were similar to those favored by many researchers in the past, there are several inconsistencies: 1) the models assume that adoption always occurs (rejection may occur), 2) the steps do not always occur in the specified order, and 3) the process seldom ends in adoption alone, rather the result is often further information seeking (Rogers, 1995).

Lionberger (1960) reported factors related to the adoption of an innovation. Practices that are compatible with existing beliefs of individuals are most likely to be adopted quickly. Also, the user must believe that a need exists for the new practice that must also be perceived to have cost benefits. Several factors that are external to the adopter are also important. Social groups and neighbors of an individual may influence adoption and adoption rates. In addition, an innovation which is easily demonstrated will be more quickly adopted (Lionberger, 1960). It must also be noted that some individuals are simply more prone to

make changes than others.

Factors Related to Curricular Innovation and Change

Fullan (1987) found that both organizational structural change and new materials are important to proposed curricular changes. The knowledge level and understanding of the prospective user as well as attitudes and value system also influence the adoption. Fullan (1991) further identified two types of observable behaviors in connection with curricular change: 1) direct classroom behavior and 2) planning and preparation of work for teaching. Both of these behaviors relate to the role of the user of the innovation and their attitudes towards it in that the attitudes of the users affect the way that they internalize their commitment to the specific curriculum elements. Fullan (1991) stated that this commitment is often one of the biggest determinants of success or failure of the adoption of the curricular innovation.

Darrow and Henderson (1987) identified the human acceptance of ideas and innovation as the real carrier of change, and human resistance to these ideas as the real barrier to change--important factors when considering curriculum adoption. They also identified factors related to reducing the resistance to curriculum change and innovation that included teachers' beliefs that the proposed change came from themselves as opposed to outsiders, there is administrative support for the change, teachers' autonomy and security will not be threatened, and teachers' workloads will not be increased (p. 47). Serious problems can arise if supervisors or others promoting a particular curriculum for adoption do not understand the very real potential for rejection of the innovation (Fullan, 1991; Rogers, 1995). This rejection may be explicit in that there may be stated refusals to adopt, or it may be more implicit, especially for innovations that are mandated from external agencies or others, in that the teacher may not fully utilize the curriculum in the manner in which

it was originally intended.

Darrow and Henderson (1987) summarized four steps that can lead to curricular innovation. The first is the identification of the need for change. Unless the need for change can be clearly justified and specific problems can be recognized, curricular revision will be delayed. The second step is analyzing the environment in which the curricular change will occur. This involves identifying principal groups that need to be involved in the development of the curriculum, identifying potential barriers to curricular change, and any institutional structures that need to be considered. Thirdly, alternative plans of action should be discussed. Sufficient time must be allocated to allow faculty and administrators an opportunity to consider the implications of proposed modifications. Creating and assessing various curricular options and models are important steps in the curriculum change and implementation process (p. 49).

Christiansen and Taylor (1966) summarized that the curriculum implementation process can be made to work most effectively when individual characteristics of teachers, teachers' value systems, and their awareness of the processes are considered by the implementers. Clearly, the literature reveals that teacher attitudes, characteristics, and knowledge levels are important factors in the adoption of a curriculum.

Statement of the Problem

The attitudes of curriculum users affect the way that they internalize commitments to specific curriculum elements themselves. Darrow and Henderson (1987) identified the human acceptance of ideas and innovation as the real carrier of change. They also identified human resistance to these ideas as the real barrier. These are important factors when considering curriculum adoption. Teachers must see a need for change, believe that change is justified, and be able to recognize problems that can be addressed by adoption of the

curriculum innovation. If these steps are not operationalized, formally or informally, curricular revisions will be delayed. As part of this process, the identification of barriers to adoption of the change is also necessary.

Purpose and Objectives

This study was part of a larger study commissioned by The National Council for Agricultural Education designed to assess aquaculture education in the U. S. This article is based on a portion of the study that examined barriers to implementation of aquaculture education as a component of the secondary agriculture curriculum. Objectives were to 1) Identify the barriers to offering aquaculture education as a component of secondary agriculture programs, 2) Determine if barriers differ in regard to degree of perceived seriousness by those teaching aquaculture vs. those who do not, 3) Describe barriers in more detail and how they may have affected adoption, and 4) Describe implications for teacher education in agriculture.

Methods of the Study

This study utilized a multiple methods approach to allow for a more holistic understanding of perceived barriers to implementation of aquaculture education. Methods included use of a survey, interviews, and focus group discussions.

Survey Methods and Procedures

The population for the study was the set of all United States vocational agriculture teachers, with an accessible population of 9,747 members of the National Association of Agricultural Educators (NAAE). A random sample of 750 teachers was drawn (Krejcie & Morgan, 1970) for use with a survey focused on aquaculture education and its implementation. Dr. Gary Wingenbach, West Virginia University, authorized adaptations of one of his surveys for the fixed-

response portion of this study (Wingenbach & Gartin, 1997). A panel of experts determined content and face validity; a pilot test was conducted and suggestions incorporated into the final document. Calculated reliability for the Likert-scaled items used in this portion of the study yielded an alpha of 0.86.

Copies of the revised instrument were mailed to participants with follow-up mailings sent to nonrespondents. The post office returned 19 surveys as "undeliverable" reducing the accessible sample to 731. A total of 406 surveys were returned for a response rate of 55.8%. Follow-up phone calls to 25 randomly selected nonrespondents yielded no significant differences between them and respondents on selected items (Yrs. taught, $t=-1.2$; yrs. known about aquaculture, $t=-.473$; aquaculture meets needs to teach science, $t=-.234$; aquaculture helps learn science, $t=.247$).

Interviews and Focus Groups

Maximum variation sampling was used to select study sites and participants to ensure diverse variations in outlier cases, and to discern whether patterns uncovered in the quantitative analysis would hold (Patton, 1990; Seidman, 1991). A total of 28 persons were individually interviewed using open-ended questions about their experiences in and perceptions of aquaculture integration into their overall programs. They also were asked to describe their feelings and beliefs about barriers to initial implementation of the aquaculture curriculum as well as ongoing problems that may exist as they try to maintain their programs.

Three focus groups (Total $N=19$) were conducted. Two were held during the AAEE/NAAE Eastern Region Conference and had a combined total of 15 participants from five states including 11 teachers, two college faculty, one industry representative, and one state education department employee. While it is recognized that

there are limitations to conducting focus group discussions in only one region of the country, it is assumed that the participating individuals are representative of teachers and others throughout the country. Individual in-depth interviews conducted in other regions of the country did not reveal any major differences and, in fact, served to confirm information provided by participants of the focus group discussions. The final focus group consisted of four RALC directors (two from the central region, one from the southern region, and one from the western region) and was held at the 1997 National Aquaculture Inservice. Trustworthiness of the data was ascertained through comparing evidence between multiple sources from each investigator. A detailed audit trail, cross-member checks, and juxtaposition with the quantitative data through use of a matrix were also utilized.

Results

Objectives 1 and 2 were addressed through the survey data analysis. Of the 406 individuals who responded to the survey, a total of 96 (23.6%) teach aquaculture, 15 (3.7%) stated they had taught it in the past, and 189 (46.6%) indicated an interest in teaching aquaculture. The remaining 106 individuals (26.1%) indicated they were not interested in teaching aquaculture. Participants were asked to identify perceived barriers to the implementation of an aquaculture education program. They responded to a 4-point Likert scale with responses of "1" (Not a Barrier), "2" (Somewhat of a Barrier), "3" (A Barrier), and "4" (A Serious Barrier). Individuals were also given the option to select "5" (Don't Know); those responses were eliminated from the calculation of the mean for all items (Table 1).

An analysis of Table 1 reveals that persons teaching aquaculture and those who do not rated the same three items as the most serious barriers: 1) high cost of remodeling facilities for aquaculture, 2) high cost of equipment to teach aquaculture, and 3) limited facilities to house the

program. Based on t-test analyses, persons not teaching aquaculture considered those items, in all cases, to be more significant barriers than did those teaching aquaculture. In fact, the respondents teaching aquaculture rated those items as between "Somewhat of a Barrier" and "A Barrier" as evidenced by mean scores of < 3.0 for each of the items, while the same items for persons not teaching aquaculture had mean scores of > 3.0 . The two groups also agreed on the two items that were not considered barriers: inflexible state curriculum requirements and restrictive environmental regulations. Again, individuals teaching aquaculture perceived these items to be less of a barrier than those not teaching aquaculture. The mean scores for one of the items - restrictive environmental regulations - were significantly different ($p \leq 0.05$) (Table 1).

Persons not teaching aquaculture also rated each of the following items as significantly more of a barrier than did those persons teaching aquaculture: limited student interest, limited administrative support, possibility of odor in the school, limited quality teaching materials, limited technical assistance, low teacher knowledge about aquaculture, high cost of facilities, and limited local aquaculture industry. However, it is important to note the means of these items place them between "Somewhat of a Barrier" and "A Barrier" based on means of > 2.0 to < 3.0 .

Themes From the Qualitative Data

To reach a deeper understanding of how teachers have overcome barriers to offering instruction in aquaculture, interviews and focus group discussions were held with 51 individuals. Three themes emerged from the interviews and discussions - all of which occurred with individuals involved in aquaculture education: 1) availability of instructional materials is not an issue at the present time, 2) aquaculture education can be implemented with varying degrees of cost, and 3) time to effectively manage the system is the most

Table 1. Perceived Barriers to Implementation of Aquaculture Education as Perceived by Teachers of Aquaculture vs. Non-Teachers

Perceived barriers	n _a	M _b	Persons teaching aquaculture		Persons not teaching aquaculture		t
			M _b	SD	M _b	SD	
Inflexible state curriculum requirements	359	1.59	1.54	0.92	1.62	0.70	0.70
Restrictive environmental regulations	313	1.86	1.69	0.80	1.95	0.96	2.33"
Limited student interest	342	2.06	1.83	0.83	2.17	1.01	3.04"
Limited administrative support	346	2.10	1.89	1.06	2.19	1.10	2.49"
Possibility of fish die-off	361	2.30	2.41	0.97	2.55	1.02	1.15
Possibility of odor in school	361	2.31	1.94	0.96	2.46	1.08	4.22*
Limited high quality materials	367	2.32	2.06	0.93	2.42	1.01	3.20"
Limited technical assistance	352	2.32	2.07	0.87	2.42	0.97	3.16"
Low teacher knowledge	382	2.54	2.22	0.83	2.66	0.91	4.36*
High cost of utilities	373	2.58	2.16	1.02	2.75	1.07	4.96"
Limited local aquaculture industry	369	2.59	2.32	1.07	2.71	1.09	3.12"
Limited job opportunities in aquaculture for graduates	359	2.67	2.51	0.99	2.73	1.05	1.81
Need to take care of fish on weekends and holidays	371	2.83	2.70	0.96	2.88	1.03	1.53
Limited facilities	381	3.09	2.83	1.07	3.19	0.95	3.18"
High cost of equipment	373	3.12	2.80	0.94	3.24	0.88	4.22"
High cost of remodeling facility	371	3.13	2.82	1.03	3.2	0.91	3.93"

Note. Test for equality of variances yielded no significant differences.

^aReflects 406 respondents less those indicating "Don't Know" as a response to that statement.

^bBased on responses ranging from "1" (Not a Barrier) to "4" (A Serious Barrier)

* $p \leq 0.05$

critical barrier to expansion.

Availability of Instructional Materials

Most interviewees agreed there is a lot of information available for instruction in aquaculture at this time compared to a few years ago. In fact, most believe that there are more materials available for aquaculture than in some other, more traditional, areas of agricultural education. Teachers shared that the change in the past 10 years has been phenomenal:

Quote 1: When I started infusing

aquaculture into my classes in the late 1980s, there were no textbooks. I drove to three universities that first summer. . I went to their libraries, their bookstores, to find textbooks or anything that they taught.

Quote 2: Everything was highly scientific and nothing that you could really adapt to the high school student's level. . it was a real hunt and search.

Quote 3 : I tell teachers that I talk to, man, there is now a lot of information out there. If you were trying to do aquaculture in 1988 like I was, it would literally blow your mind what is out there today.

To clarify the importance of the presence of high quality instructional materials, I examined a section of the survey data not specifically related to identification of barriers to teaching aquaculture. The 300 individuals who teach or are interested in teaching aquaculture were asked to identify what factors have influenced the decision to teach or interest in teaching it. An analysis of this section revealed that having the "Availability of high quality materials to teach aquaculture" was ranked as the most important factor by persons teaching aquaculture (Mean=3.2/4.0) and those interested in teaching aquaculture (Mean=3.3/4.0). This data contradict data in Table 1 which indicates that a lack of quality teaching materials is perceived by all 406 study participants-the 300 who teach or are interested in teaching aquaculture plus 106 who are not interested-to be a barrier for individuals in considering the adoption of aquaculture (Table 1). A possible answer to this contradiction might be that those who have no interest in teaching aquaculture are not aware of what materials are available to them. Based on the interview data, those who teach aquaculture are aware of the amount and quality of materials available to them and this is rated as the most important factor in their decisions related to adoption of aquaculture as a component of their secondary programs.

Implementation Can Occur with Varying Levels of cost.

An analysis of the interview data revealed that individuals actively engaged in teaching aquaculture all believe that cost should not be a factor in beginning to teach it. Of course, some programs have more resources available to them and the extent to which resources are available

usually drives the level of adoption of most curriculum innovations (Lionberger, 1960). This adoption has occurred at very high levels in some instances such as one school where nearly \$1 million has been invested in a program that serves as the thematic "hub" around which nearly all school curriculum was originally intended to evolve. The facility has roughly 2,000 square feet devoted to "tours for elementary and other students in the area" and roughly the same amount of space devoted to production aquaculture. At the other end of the spectrum are sites at which aquaculture may be offered as one unit of instruction in the animal or environmental science courses, utilizing small tanks that are not kept in operation over the summer. All teachers interviewed, however, agreed with one teacher's strong belief that "thinking that you have to start out with a lot of money is bull." They shared that success is possible with a wide range of available resources as reflected in the statements below:

Quote 1: Initial start-up for our system was between \$25 and \$27 thousand. We think that is a bargain price for what we get. . . Other programs have a quarter of a million dollars invested in their facilities. . . we can match them in production right now.

Quote 2: I know from just experience that the most valuable place you can go is the junk pile. Junkyards are a gold mine old tanks, pieces of PCV pipe, Plexiglas, and everything. . . enough to design and build a recirculating system.

One teacher made an investment of \$1,500 to put in a 400-gallon recirculating tank that will serve as the focus for instruction; he is already constructing a companion aquaponics system out of donated PVC pipe and a few inexpensive materials.

It is interesting that the interview data is contradictory to the survey data (Table 1) in regards to the importance of cost as a barrier. This illustrates what can be an important advantage to the type of mixed methods approach utilized in this study-discovering areas of discrepancy between the quantitative and qualitative data which gives rise to reflection on the nature of and possible reasons for the discrepancy. I surmise that teachers of aquaculture are very aware of cost as a barrier to deciding to teach aquaculture. I suggest that, based on the interview data, individuals who have made the decision to teach aquaculture either have done so because some external forces are involved in the decision-and perhaps have provided the resources-or the desire to teach aquaculture is strong enough that ways to overcome the barriers are sought and obtained. To illustrate, a review of additional interview data related to how teachers became involved in aquaculture education to begin with revealed that they chose to teach it because they believed aquaculture could help their students learn science and mathematics concepts, would generate interest in their programs, and would be an effective public relations vehicle for them (Conroy & Walker, 1998).

Time to Effectively Manage the System

An examination of Table 1 reveals that the need to take care of fish on weekends and holidays was identified as the fourth most serious barrier by participants. Analysis of the interview data supports this, but also reveals that time is an even more serious barrier than might be thought based on the survey data alone. Teachers indicated that they just do not have enough "hours in the day" to do all that they must do; many put in 12-13 hour days. One teacher stated that he receives a lot of phone calls from other agriculture teachers seeking information about his aquaculture program. He indicated that the phone "rings a lot.. . so, right in the middle of a lecture or something you have to answer the phone." Because of this, he indicated that he cannot add any more tanks without a

teacher's aide, even though he would like to. He also agreed with comments of his colleagues that he spends too much time taking care of the fish and the facility:

Quote 1. It (taking care of the fish) requires a lot of vigilance. You have to be prepared to come here on weekends and you just can't go away on vacation and forget about it.. I'm here at the school essentially everyday except Christmas.

Quote 2: I have to have a telephone alarm system connected to my home phone. It sometimes goes off at odd hours.. . this is a drawback.

Quote 3 : This is just like having a dairy farm.. . cows, fish, whatever, they have to eat. My wife has to come take care of the tanks when I am not around. Sometimes we can't go away together because someone has to take care of the fish. Some teachers don't keep their fish year-round like we do.

In summary, qualitative data, for the most part, strongly supported the quantitative data results that revealed that teachers already teaching aquaculture perceive most things to be less of a barrier than those who have never taught aquaculture. This is most evident regarding perceived barriers such as limited high quality teaching materials and high cost of facilities. Most interestingly, qualitative data showed that the greatest barrier to teaching aquaculture, as perceived by teachers already involved in aquaculture, was time.

Conclusions and Recommendations

Both the quantitative and qualitative data

revealed important information about barriers to teaching aquaculture as perceived by teachers. Perceived barriers parallel those cited in the literature as reasons why teachers might not modify curriculum or change courses, specifically, perceptions that there may be no cost benefit (Lionberger, 1960), or that the teacher's workload may be increased (Dar-row & Henderson, 1987). The data certainly support that there is much potential for workload to be increased. Knowledge level and understanding about an innovation-beyond awareness-are also both important factors in adoption of a curriculum innovation (Fullan, 1987). Many agriculture teachers are aware of aquaculture as a potential area for enhancing their course offerings. Beyond awareness, however, few teachers have had the opportunity to gain significant first-hand knowledge about teaching aquaculture and the commitments required to start-up and maintain a program (Conroy & Walker, 1998).

Survey participants perceived the cost of purchasing equipment and facilities issues-costs of remodeling/building and limitations to existing facilities-to be the greatest barriers to teaching aquaculture. However, this is not reflected in the interview data. Beyond the obvious question of, "Why?" we should examine whether this discrepancy has implications for our future research using, exclusively, surveys to identify perceptions held by subjects under investigation. I am primarily thinking of the questions related to whether the perceptions quantified as means for the group relate to actual practice when examined on the micro-level. If individuals teaching aquaculture have a perception about a specific barrier such as cost, why has that barrier not influenced adoption of the innovation for those individuals? Since it is not possible to anticipate where these discrepancies will surface prior to the administration of the survey, more attention should be given to the value of mixed methods design for research to identify and investigate these areas of disagreement. Such information could be extremely useful in the planning and delivery of

inservice and other professional development activities, to name one application.

While "time" was ranked fairly high as a barrier by survey participants, the qualitative data revealed that it is, by far, the major concern for those individuals presently teaching aquaculture. Perhaps the issue of cost, once resolved during start-up, is not a lingering issue, but time to manage the facilities and provide quality instruction are ongoing concerns. There may be little costs associated with expansion of the operation, and the costs might easily be absorbed within the normal operating budget of the program or the school. However, if time limitations are already reached or exceeded, expansion might prove difficult if it would result in additional time commitments.

It is also interesting to note that those individuals teaching aquaculture perceived all items on the survey to be of less concern as barriers than did those individuals not teaching aquaculture. Since many individuals stated an interest in adding aquaculture to their programs of study, the potential for anxiety over some of these concerns to diminish is high.

Implications for Education

Rosati and Henry (1992) argued that "aquaculture appears to be following the historical trend of most forms of animal agriculture, evolving from extensive, outdoor production to intensive, indoor controlled production environments" (p. 16- 17). There is immense potential for the role that aquaculture can play in the agriculture of the United States in the future. It can also play a role in the integration of mathematics and science into the agriculture classroom by providing hands-on experiences to complement theory (Conroy & Peasley, 1997). However, adoption of an aquaculture curriculum-or any curriculum innovation, as a matter of fact-will require teachers to perceive a true need for it as well as to have a sustained commitment for successful

implementation.

The attitudes of the adopters affect ways that they internalize their commitment to the specific curriculum elements themselves (Fullan, 1991). However, it is clear that having particular attitudes about barriers to adoption does not necessarily result in non-adoption. It is also not enough to identify perceptions and barriers, and to deal with those through short-term workshops or other dissemination mechanisms, as the means to promote curricular innovation.

The most significant implication from this study may be that participating teachers adopted a curriculum innovation in spite of the presence of serious obstacles such as lack of curriculum materials (for early adopters), cost, and overwhelming time commitments. They adopted the innovation because, in spite of the barriers, aquaculture was something they believed would better help their students learn animal aquaculture principles along with science and mathematics concepts, would generate interest in their programs, and would permit greater outreach to their communities (Conroy & Walker, 1998). Helping teachers to identify program needs and thoughtfully pursue the means to meet those needs-fully addressing barriers in the process and how those have been managed by their peers-would be a significant step in moving agricultural education programs into the next century.

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