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Research and Development in Education

Martha A. York

Research and development (R&D) is a process in which new products are created that will apply current knowledge about education to practical everyday classroom situations. These products can be tangible and can include curricula, classroom materials, assessment instruments, computer hardware and software. Intangible products may include processes used in improving learning, policy recommendations and laws, ways to improve communication among groups and individuals, and methods for implementing change in the school setting.

This paper will look at many aspects of research and development in education. It will examine its importance, history and settings in which this process occurs. It will review the ten step process proposed for educational development by Borg and Gall (1989), highlight some successful products and show how they were developed, and point out some of the challenges associated with R&D.

Definition

In education, research and development is defined as a "process used to develop and validate educational products" (Borg & Gall, 1989, p. 782). Endres (1997) describes the R&D process in this way: It will be helpful to think of research as the process used by an organization to acquire new scientific or technical information and knowledge, and development as the process used to apply technical or scientific information and knowledge for product or process designs required to meet the needs of the organization or its customers. (p. 5)

Hemphill (1969) separates the concepts of research and development, stating that educational research generally produces knowledge and theory. "Educational development is a systematic process of creating new alternatives that contribute to the improvement of educational practice" (p. 1). Development involves the application of pure educational research and can act to translate research into experience.

Bright and Gideonse in Klausmeier (1968) expand the concept of research and development (R&D) to include empirical research, development of new practices, processes and materials, demonstration of the products developed, and dissemination relating to the previous three stages. They closely tie research and development with the change process as it occurs in education. This link could serve to make educational change more grounded in research. Ideally, the adoption process is a joint effort of the developers and the practitioners who will become the customers of the product.

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Importance

Quality research and development has long been neglected in the field of education. Unlike private industry which devotes four or more per cent of its overall budget to R&D, education budgets allow less than one per cent (Borg & Gall, 1989; Klausmeier, 1968). This fact is offered as one of the explanations of the lag of education behind business in current times (Borg& Gall, 1989). Marsh Fisher, the co-founder of Century 21 Real Estate Corporation states that "the real true source of power in any company today is ideas—the rest is housekeeping...Ideas are the DNA of everything that is worthwhile" (Kao, 1996, p. xvi).

History

Much of the formalized research and development that has been done in education has been sponsored by the federal government. Funding was established with the passage of the Cooperative Research Act of 1954. Dollars increased slowly during the late 1950's and early 1960's, but were only directed toward specific curriculum areas. In 1965, a coordinated network was established which consisted of ten regional educational laboratories which were charged with developing new educational products and processes, and with disseminating the information that was obtained (Klausmeier, 1968). In addition to the ten regional centers established by the federal government, many universities and private agencies have established programs to conduct research and development.

Types of Research and Development

Research and development may occur in a number of settings, and contributes to educational improvement at all levels. Some occurs at the level of the individual teacher and classroom as action research. Still other R&D efforts occur at the district level in the form of grants from state, federal and private agencies. These grants usually include requirements for dissemination of information, and some products are created under these conditions. Research conducted at the university level, by nonprofit organizations, and commercial interests are described below:

1. *Grants given at the university level/Centers and Institutes*

Universities have long been charged with the responsibility for research in education and all other areas. Many universities have established institutes or centers which are devoted solely to research efforts, and which share staff and facilities to make the most of the dollars available. An example of a center which is focused on research is the Frank Porter Graham Child Development Center which is part of the University of North Carolina at Chapel Hill. The center describes its mission in the following way:

The Frank Porter Graham Child Development Center was established in 1966 as a multidisciplinary center for the study of children and families, especially children at risk for developmental problems due to biological or environmental factors. The Center's mission has always been dedicated to enhancing the development of young children and supporting their families through research, public service, and teaching. The Center maintains a strong commitment to proving that early experiences have a powerful influence on children's development, developing curriculum materials and teaching strategies, and demonstrating to others the kinds of experiences most likely to enhance child development.

Research projects have included the Abecedarian Project, a longitudinal study of the effect of early intervention on at-risk children which began in 1972 and continues today, and other research which looks at issues concerning child development including child care, health, disability, and family support. Products which have been developed include training material in early intervention, and numerous books and other publications (FPG, 1997).

The Wisconsin Research and Development Center for Cognitive Learning was established in 1964, and is another example of a research and development center. At the time of its creation, it was charged with conducting basic research, translating research findings into materials and procedures that could be used in schools, demonstrating and disseminating the information and products that were created, and providing leadership to the field of education as a whole (Klausmeier, 1968).

Now called the Wisconsin Center for Educational Research, the focus remains on improving education and conditions in the schools. Current and past projects have examined writing skills, the teaching of mathematics and science, educational policy, child care for young children, special education and the education of students from culturally diverse backgrounds. Dissemination efforts include a number of newsletters and publications, as well as training and partnership with schools as outlined in individual grants and projects (WCER, 1997).

2. Regional research and development centers

In 1966, the federal government charted ten regional laboratories to bring about educational improvement. These laboratories are still in existence today and address a number of educational concerns including rural education; assessment and accountability; curriculum, learning and instruction; technology; school change processes; language and cultural diversity; urban education; and early childhood education. The laboratories offer publications and consulting services to educational agencies, and information is disseminated on the Internet as well as through more conventional sources (NWREL, 1997)

The Far West Laboratory was chartered as one of the regional research and development centers in the mid-1960's. Borg and Gall (1989) worked there developing minicourses for teacher inservice. In 1995, the Far West Lab became WestEd, and their work continues in a number of educational areas(WestEd, 1997).

3. Nonprofit organizations

Another source of research and development in education is nonprofit organizations who gather private and public funding to create new educational products. An example of this type of organization is Zero to Three which was founded in 1977 by leading experts in the field of child development and which "disseminates key developmental information, trains providers, promotes model approaches... and works to increase public awareness about the significance of the first three years of life" (Zero to Three, 1997). Products available from Zero to Three include a monthly journal, numerous books and other publications, videotapes and training opportunities which are all provided at a very reasonable cost.

Another example of research and development which was done by a consortium of individuals and nonprofit agencies is the Survival Skills Workshops for Urban Women curriculum which is described at length later in this paper. It was designed by teachers, social workers, home visitors, and graduate students who were working directly with low income women. They came together for the specific purpose of creating the materials which were ultimately produced. Funding came

from federal and state grants, private donations, and through the "sweat equity" of the developers themselves (L. Thurston, personal communication, October 30, 1997).

4. Commercial companies

Perhaps the most successful research and development is that which is done for profit. Educational materials produced by commercial entities include much of the educational software, textbooks, assessment tools, and hands on materials that are used in the classroom. These materials are developed using the same steps that are outlined below, and many are meticulously tested in a school environment. The testing for computer software recommended in Apple (1994) closely parallels the Borg ten step process.

Research and Development Cycle

Borg & Gall outline a ten step research and development cycle which includes:

1. Research and information collecting

Needs assessment is a vital piece of the research and information collecting phase of the cycle. The researcher must determine if the product or process that is being designed will be considered valuable by future users. A need can be defined as "a discrepancy between an existing set of conditions and a desired set of conditions" (Borg & Gall, 1989, p. 761). McKillip (1987) and Fullan (1991) feel that needs assessment involves value judgments on the part of researchers and subjects alike which determine priorities, and which can have a huge impact on the implementation of the finished product.

The first step in a needs assessment is to determine the identity of stakeholders. Johnson, Meiller, Miller and Summers (1989) divide stakeholders into two groups– consumers, those who will be using the product, and providers, those who supervise or assist consumers in its use.

Stakeholders at all levels can be expected to give subjective information that will come from previous experience and values. This may or may not be reliable and helpful to the researcher. Therefore, in addition to simply asking participants about their perceived needs, it is important to examine statistics and artifacts that may give more objective views of the situation. It may also be helpful to observe the behavior of those involved to determine the actual level of need for the product. If the 3M company had interviewed office workers and asked them if they needed little pieces of paper to make notes that could later be removed, they probably would have received little response. However, they tested the marketability of sticky notes by handing out free samples. Once the office workers were able to use the little yellow note pads, their value became apparent, and they shared them with friends and begged for more– which created a market for the product. (Nayak & Ketteringham, 1986).

Next, a literature review should be conducted to determine if the proposed product is already in existence, or perhaps has been tried in another form previously. If no information can be found regarding the topic being explored, that would indicate that either there is a need for information on that topic or that there is virtually no interest in it. A value judgment would need to be made at that time regarding whether or not to continue.

Another aspect of the needs assessment process involves looking at the level of resources of the researchers to determine if it would be feasible and profitable to develop a given product. Borg and Gall (1989, p. 785) suggest that the following four questions be asked

as part of the needs assessment process:

Does the proposed product meet an important educational need?
Is the state of the art sufficiently advanced that there is a
   reasonable probability that a successful product can be built?
Are personnel available who have the skills, knowledge, and
   experience necessary to build this product?
Can the product be developed within a reasonable period
   of time?

2. Planning

Once an ample amount of information has been collected, the researcher should prepare a plan of the product including the its future use, potential audience, and a description of salient features. It should be taken into account that the concept of the product will substantially change over time, but the planning process is still of vital importance (Borg & Gall, 1989). Project goals should be devised and adhered to throughout the development process (Apple, 1994).

3. Develop preliminary form of product

All R&D projects should be designed with specific objectives in mind. Gagne, 1988 urges designers to keep the results of empirical testing at the forefront when creating new products and materials. "Therefore, it is essential that the desired outcomes of the designed instruction be clearly and unambiguously stated. These outcomes are variously referred to as behavioral objectives, learning objectives, or performance objectives" (p.121).

The creation of the prototype addresses the content piece of the R&D puzzle. A prototype of the proposed project should be prepared drawing on research regarding both subject matter, and learning theory. As the preliminary form is produced, the developer will make decisions about what will be taught, and about the format in which the content will be presented.

A designer of computer software recommends that the design of the prototype embody the project's concept, purpose and messages. This applies to other media as well. Factors to consider when creating a prototype should include "simplicity, consistency, engagement, depth, fun, and affordability" (Apple, 1994, p. 128).

Another part of this step is to develop a method for field testing the product. The developer will decide who the testers will be, and what questions will be asked regarding possible uses for the finished product (Borg & Gall, 1989). This test plan should be closely tied to the original objectives of the project. It is important to identify what will be an end point even at this early stage to insure that the project does not take on a life of its own and completely change shape before it is completed (Apple, 1994).

4. Preliminary field testing

Once the first draft of the product is completed, it should be tested on a small sample of potential users in the same type of environment as that in which it will be used. Testers should be closely monitored, and asked for suggestions about improving the product. In addition, the developers should do some type of objective testing to determine if goals are being met. For example, a group of teachers who were a pilot group testing a specific type of inservice training reported that they felt that the training was very valuable, but no improvement in their teaching was noted. Impartial observation is necessary in order to confirm that the true objectives of the R&D project are indeed being met. The Hawthorne Effect can play a big part in the preliminary testing process because testers and subjects need to work so closely together, so safeguards must be put into place to insure that user evaluation is indeed accurate (Borg & Gall, 1989).

5. Main product revision

After the preliminary field test is completed, the product needs to be revised to a nearly completed state. More attention at this point should be given to its form in addition to its substance. Decisions should be made about printing style in the case of a written product. Graphic design, navigation, interface, and debugging should be considered when working with multimedia computer software. Durability issues in the case of a toy or game will need to be taken into account. Content should be edited and proofed for accuracy and grammar. Plans will be finalized for the main field testing during this stage.

6. Main field testing

According to Apple (1994), the main testing process should occur in three phases: user testing, functional testing, and content testing. User testing examines the relationship between the product and the audience for which it was intended. Aspects to consider include the way that the product sustains the interest of the user, its ability to meet specific learning objectives, and whether targeted users like the product and feel that it meets the intended objectives. In addition, there should be some procedure to test to see if students are learning the content that is presented, and if the product has met its original vision.

Functional testing looks at the format of the project. In the case of multimedia computer programs, this phase of testing examines the graphic design, durability, compatibility with various computers, and the way that the program responds under the actual conditions in which it will be used. Corresponding tests with print material would look at features such as binding methods, type of paper, print size and style, and overall format and organization.

Content should be tested by someone who is an expert in an appropriate content area, and who has not been a part of the product development. The product should be checked for accuracy, artwork and photos should be labeled appropriately, and spelling and grammar should be immaculate. Apple (1994) states that finding qualified testers is not as difficult as making sure that they cover all of the material and that they go over it all more than once to insure that the information presented is absolutely correct.

As important as the testing process is, it is vital to know when to stop. There will always be additional features that would be nice to add, and wonderful suggestions for improvement of the product are liable to come from the field testers. Apple (1994) urges developers at this point to return to their original plan and objectives, and to retain the concept envisioned at the beginning of the project.

It is important to draw a line in the sand and say that any feature on one side of the line needs to get finished and tested completely before the product ships. Any feature on the other side gets removed or put into another version. Without this line, the project features continue to grow and the initial purposes and goals get subverted or changed without conscious thought. The later in the schedule that this line is drawn, the more chance the project will fail. Again, the product plan or proposal should be used to set these lines (p. 219).

7. Operational product revision

Operational product revision takes into account all of the collateral

materials and documentation that will be necessary when the product is shipped and sent off to schools in its final form– without the developers present to oversee its dissemination and use. Handbooks, instructions and other supplementary materials are developed at this stage. The product should be packaged in "final form" sent to a school or other intended audience group.

8. Operational field testing

Operational field testing is done by regular school personnel and materials should be used in as natural a manner as possible. The developers of the product should have little or no input at this point because it is time to see how the product is used by people who are not familiar with it. Questionnaires should be distributed to determine if the almost finished product is in a form that is understandable and usable to the consumer.

9. Final product revision

Final product revision is simply a final editing of content, and minor adjustments that are made based on the feedback received during operational field testing. Following this final revision, materials are produced in quantity and marketed to the intended audience.

10. Dissemination and implementation

Research and development must occur in partnership with developers and consumers working together through all phases of the project to create a product that will truly meet the needs of the consumer. This is being recognized in business as well as education. Airplane design is one example. "The 777 was not just designed with the customer in mind– it was designed with the customer in the room" (Black, as cited in Endres, 1997).

In order for the R&D process to work, there must be substantial responsibility placed on the shoulders of the developers in the area of dissemination and implementation. The ideas contained in the product must be sold to those who could benefit from the product's use. The U.S. Office of Education has established the National Diffusion Network to assist in the dissemination of successful R&D products. Commercial companies may assist in the marketing and dissemination for products that they will be handling. Developers need, however, to stay in touch with consumers at every stage of the R&D cycle. (Borg & Gall, 1989).

Examples of R&D

Survival Skills Workshops for Urban Women

The Survival Skills program designed under the leadership of Dr. Linda Thurston of Kansas State University to teach skills necessary for everyday life to low income women is an excellent example of the ten step process outlined by Borg and Gall (1989). The project originally grew out of a need. Home visitors working with parents of young disabled children in Kansas City, Kansas in the late 1970's became concerned because the parents who were participating in the services were often distracted or unable to work with their children because their low income status kept them in a state often of constant crisis. They attempted to find materials to use with these families in teaching them life skills and were unable to locate any programs which fit their needs. Therefore, a team of twelve professionals including teachers, administrators, home visitors and graduate students was put together to create a program that could assist low income women in becoming more independent. After 3 1/2 years of research, the Survival Skills program was developed.

In the next step, members of the team used surveys and focus groups to identify the topics that would need to be covered in a series of workshops that would be presented to the target audience. Professionals in the fields of education, social work, health, nutrition, etc., members of the inner city community, people who had risen out of poverty, and low income mothers themselves were all polled and responses were grouped according to specific categories. In addition, the computer records of a local television station's "Call for Action" hotline were examined to determine community concerns. Once the topics were identified, lists were distributed to experts to prioritize in order to determine which should be covered with the greatest intensity. A task analysis was done to determine the best way to present the information.

The team then broke into committees who were charged with developing modules to address the topics that had been chosen. Prototypes of each session were developed, and the entire team continued to meet to ensure that each segment of the program was true to the original intent and mission of the project. Sample workshops or "mockshops" were created. Field testing was conducted in two phases, the first on each module individually as it was completed, and the second on the series of workshops in a more final form. Initially, facilitators presented individuals modules to a variety of groups including Head Start teachers, women on probation, and community organizations. Data was kept from pre and post testing to see if the content presented was learned, observers attended the sessions to observe the behavior of the presenter and the participants, and interviews were conducted both immediately, and six to eighteen months after the training to see if the information had been useful in the long term. Readability levels were checked to make sure that all written materials would be presented at a fifth grade level. Team members developed and identified research tools during this phase that would be used during the full scale testing process.

The second phase tested the modules as a completed curriculum. Ten 3-hour workshop sessions were presented as a series. Details such as the seating arrangements, and the best procedures for breaks and snacks were reviewed in addition to the content of the lessons. Revisions were made to make the content clearer, to remove material offensive to participants, and to insure that the material was presented in a way that was interesting and motivating to low income women who for the most part had not previously been successful in school or other training situations. Once a final form for the modules had been completed, materials were printed, and operational testing was performed. Trainers who had not been a part of the development process were trained and sent to different areas of the country to test the program. Facilitators are given a script to use when presenting, so at this stage the method of training trainers as well as the content and format of the package was evaluated.

At the present time, the program is in use in thirty states, two countries, and has been translated into Spanish. Additional programs for men and youth have been developed as well. Data continue to be collected, and often the results have been very positive and reinforcing. Most people score near 100% on the post tests of the content presented, and personal experiences for trainers and participants alike have been very gratifying.

Dr. Thurston feels strongly that the program has been successful because of the extensive research which was conducted during the development process (L. Thurston, personal communication, October 30, 1997).

Voices of the 30's

An example of an education product which was created by a commercial enterprise is a multimedia computer program entitled "Voices of the 30's". It was originally conceived by a high school teacher and librarian to teach the *Grapes of Wrath* by John Steinbeck. It was expanded and prepared for mass distribution as a cooperative effort by Apple Computer and WINGS for Learning. Information about needs assessment and information gathering was not available, but the project evidently grew out of a need to present information about the depression to high school students. Planning included decision making around organization of the material, and methods of navigating from one section or topic to another. Pat Hanlon and Bob Campbell, the original designers of the program acted as content experts and editors. A prototype was developed, tested and revised. During this revision, the background of one section was changed which meant that more than 300 images required modification, but the creators felt that the finished product was much more attractive. Testing included proofing all quotes and references included in the content, as well as testing for bugs,or problems in the computer programming. The development team consisted of ten people over the period of one year, and development costs were approximately $80,000 (Apple, 1994).

Challenges/Problems

People who have been experienced in the R&D process have suggested potential pitfalls, and ways in which they can be avoided.

1. *Poorly chosen goals*

The needs assessment process can simply not be understated. Ideas which make total sense to researchers may not have any attraction at all, and may not meet the needs of the consumers of the product. Producing a product simply for its own sake can be disastrous.

2. *Making the prototype too polished*

Borg and Gall (1989) warn that making the prototype too polished can be a waste of resources and time. They urge the developer to put maximum effort into developing a sample of the product which will have integrity and rigor of content, and to focus as well on the the learning theory that will be used in getting the message across. The prototype should be attractive enough to not distract those who will be using it, but numerous changes are likely to be made during the preliminary revision process, so it makes little sense to put much polish into a product at this stage.

3. *Expense*

Some R&D projects fail because the developers underestimate the cost of creating a new product. Borg & Gall (1989) discuss what they call the ratio of 1:10:10 which is used in industry to estimate the expense of research and development. If $1 million is spent to do the basic research required for a project, $10 million will be needed to carry it through the operational field test stage, and $100 million will be spent in manufacturing and dissemination. It is vital, therefore, to accurately estimate the cost of bringing the product to market, and to have funding in place before the project begins.

4. *Size of project*

Having a good project plan in place at the beginning of the project is necessary in order to focus the scope of what is attempted. Particularly in the area of education where it is easy to look around and identify needs everywhere, it is tempting to broaden the range of the enterprise to include more than can actually be addressed with the resources available. The original goals should be kept in mind throughout, which may require tremendous discipline on the part of the developer (Apple, 1994).

5. *Lack of reality check*

Knowledge of the change process in education is another vital component of educational research and development. One of the aspects of this process is that change occurs best when stakeholders have an investment in the development of the project as it goes along. The best research and development occurs when the developer and the stakeholders work together to identify actual need, and to build support for its use from the practitioner level up instead of from the administrator level down.

> It takes a fortunate combination of the right factors– a critical mass–to support and guide the process of re-learning which respects the maintenance needs of individuals and groups and at the same time facilitates, stimulates, and prods people to change through a process of incremental and decremental fits and starts on the way to institutionalizing (or, if appropriate, rejecting) the change in question. (Fullan, 1991, p. 92)

6. *Lack of dissemination*

The relationship between R&D and dissemination has not always been clear, but is vital to the process. "'Development' of an innovation appears to have been interpreted to mean almost everything from eloquent theoretical justifications to careful field testing of standardized procedures; and 'dissemination' has encompassed such varied activities as program visitations, newsletters, journal articles, and systematic replication of total programs" (Paine & Bellamy, 1982, p. 29). These authors advocate the creation of demonstration and model programs that can be replicated in a number of settings. Other research suggests that dissemination is more likely to be successful when the product has been thoroughly tested and found to be effective, when it meets the need of the adopting agency, and when funding has been made available for dissemination (Stoltz, 1981).

The key to the dissemination process is actually in following all of Borg and Gall's (9189) ten step development program. The Survival Skills for Urban Women curriculum was adopted on a wide scale for the following reasons: it met a pressing need, it was thoroughly researched and documented, a model program was developed, it utilized standardized procedures, and it had ongoing support (Thurston, 1990).

Conclusion

Research and development in the field of education has been neglected, and needs to occur on a larger scale today than ever before. However, the benefits of the process are lost without a systematic approach to R&D. All of the steps in the process as outlined by Borg & Gall (1989) are equally important, and if followed, will give a product a far better chance for success. Special attention should be paid to the needs assessment process in order that potential users feel ownership and interest, and to the dissemination process which is often overlooked by developers. With a rigorous research base, a market interested in the final product, and aggressive dissemination, research and development can produce global change in the field of education.

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