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ENGINEERING EDUCATION THROUGH OFFICE HOURS FOR MANUFACTURING (MONODUKURI OFFICE HOUR)

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Abstract

To improve students' skills at manufacturing, introductory manufacturing education has been introduced for all departments at Akita National College of Technology since 2006. Survey results conducted for first and second grade students indicated that more than 50% of students thought that manufacturing education was quite useful for their departments and wanted to manufacture on their own in the future. However, about 50% of second grade students have lost interest in manufacturing. Therefore, we have introduced Monodukuri office hours (office hours for manufacturing) as an after-school activity. Results show that Monodukuri office hours have gradually increased students' interest in manufacturing.

Keywords: *manufacturing skill, introductory manufacturing education, Monodukuri office hours*

Introduction

To improve students' manufacturing skills, introductory manufacturing education was introduced for all departments' first grade students at Akita National College of Technology (Akita NCT) in 2006. Currently, according to syllabi of colleges of technology in the Tohoku region, two college education programs have introduced similar manufacturing programs to those of Akita NCT. Sendai National College of Technology – Natori offers a similar class in its Department of Material and Environmental Engineering. Ichinoseki National College of Technology has manufacturing laboratory practice in all departments. Results of a survey administered to first and second grade students indicated that about 50% of second grade students have lost interest in manufacturing. Therefore, in an attempt to improve student interest in manufacturing, we have introduced Monodukuri office hours (office hours dedicated to manufacturing) as an after-school activity. Results show that student interest in manufacturing has been increasing steadily.

Nationwide, reports have described that manufacturing education consists of different classes of the school year (Honmura et al., 2008) and reports on education have addressed lower grade education and graduation research projects (Yoshida et al., 2008). Nevertheless, no example of education combining manufacturing and office hours has been reported yet in the relevant literature.

This study clarifies the effects of Monodukuri office hours on education, conducted as an attempt to improve student interest in manufacturing.

Manufacturing education in workshops

At Akita NCT, manufacturing education is offered in first grade for all departments. Mechanical engineering, electrical engineering, chemical engineering, and civil and environmental engineering are respectively denoted herein as 1M, 1E, 1C, and 1B.

After safety education and guidance, the contents of education in workshops include manufacturing spinning tops using a lathe (lathe), manufacturing pen holders using milling machines (milling machine), making a picture stand by hand-finishing work (hand-finishing work), and making small boxes using sheet metal work (sheet metal work). Figure 1 presents the appearance of manufacturing processes in a workshop.

Fig. 1 Manufacturing processes in a workshop.

授業科目	必・選	学年	学科(組) 専攻	担当教員	単位数	授業時間	自学自習時間
ものづくり工作実習 Manufacturing Technology Workshop Practice	必修	1年	C	野坂 肇 西野 智路	2	前期週4時間 (合計60時間)	

［教 材］教 科 書：「製図」原田明，足立透，白瀬俊則，竹内正年 共著 実教出版
補助教科書：「機械実習 上，中，下」実教出版
そ の 他：自製プリントの配布

［授業の目標と概要］
もの作りの基本作業，図面の作成，各種工作の実技修得を目的とする。図面を読む能力，規格に従って図面を作成する能力，そして計画された工作物品が完成するまでの手順を把握して安全な作業を行う能力を修得する。

［授業の進め方］
工作実習分野は各テーマを3週間ずつ行う実技実習，製図分野は演習形式で行う。工作実習での実物，演習課題，レポート，工作実習報告書を提出する。試験結果が合格点に達しない場合，再試験を行うことがある。

［授業内容］

授業項目	時間	内容
授業ガイダンス	1	授業の進め方と評価の仕方について説明する。
工作実習		
1．安全衛生教育	2	報告書のまとめ方を理解することができる。
2．工場ガイダンス	2	工場での工作実習の概要および設備見学を行なう。
実 習		
3．旋盤作業 コマの製作（機械と操作方法の説明）	6	外周切削，端面切削，テーパ切削ができる。
4．フライス作業 ペン立ての製作（機械と操作方法）	6	平面切削，ドリルによる穴あけ加工ができる。
5．手仕上げ作業 フォトスタンドの製作	6	ケガキ，ヤスリ，卓上ボール盤による穴あけ作業， ネジの加工，折り曲げ作業ができる。
6．板金作業 小箱の製作	6	ケガキ，ヤスリ，卓上ボール盤による穴あけ作業， 折り曲げ，金属板の接合作業ができる。
製図		
7．製図の基礎 線の種類と用法	1	線の種類と用法がわかる。
8．投影図 投影法と投影図の書き方	4	立体を平面上に表現する投影図の書き方がわかる。
9．立体的な図示法 等角図	2	立体を平面上に表現する等角図の書き方がわかる。
キャビネット図	2	立体を平面上に表現するキャビネット図の書き方がわかる。
10．展開図と断面図	4	展開図と断面図の書き方がわかる。
11．寸法記入法 寸法の表示のしかた	2	寸法が記入してある図面の読み方がわかる。
基本的な寸法記入の方法	4	寸法を含む図面の書き方がわかる。
12．はめあい 寸法の許容限界	2	表面性状の図示方法と寸法の許容限界がわかる
はめあい	4	はめあい方式による寸法の表示方法がわかる。
13．スケッチ図	2	化学装置などのスケッチ図の書き方がわかる。
まとめ	2	本授業のまとめ
前期末試験	あり	上記項目について学習した内容の理解度を確認する。
試験の解説と解答	2	前期末試験の解説と解答，授業アンケート

［到達目標］
各種工作器具，工作機械を用いた基本的な物づくり能力と製図規格に基づいて正確に描き，読み取ることができる能力を身につけることができるようになること。

［評価方法］
合格点は50点である。工作実習分野の成績は50%で，内訳は課題ごとに提出する作業報告書の評点50%，実習の理解度20%，実習態度20%，作品の出来映え10%の比率で評価する。製図分野の成績は50%で，内訳は試験結果40%，小テストと演習課題60%で評価する。とくに，演習課題の未提出者は単位取得が困難となるので注意すること。

［関連科目］すべての実験系科目と基礎研究や卒業研究等の研究科目に関連する。

［学習上の注意］
工作実習分野では，指導者の指示を厳守，安全教育に留意させ必修科目であることに注意すること。また，作業内容を明確にとらえ，加工手順，完成までの状況を報告書に記載すること。また製図分野は，化学装置の製造，改良など化学技術者にとって重要の科目であることを認識して，基本的事項をしっかり身につけること。

秋田高専学習・教育目標	E	JABEE基準

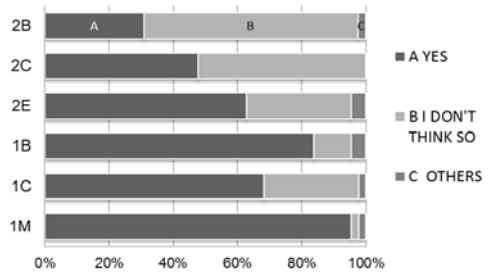
Fig. 2 Syllabus of introductory manufacturing education for the Chemical Engineering Department.

Manufacturing education has been done at the Practice Workshop and the Manufacturing Technology Practice Center. The teaching staff comprises five technical staff members of the Technology Education Support Center and one teaching staff member selected from each department.

Survey results for manufacturing education

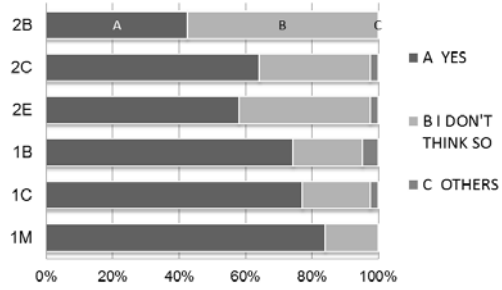
In August 2009, a questionnaire survey related to manufacturing education was administered to first and second grade students who attended manufacturing education when they were first-grade students. Questionnaires were administered respectively to 1M, 1C, 1B, 2E, 2C, and 2B. About 40 respondents' answers were obtained from each class. The obtained results are presented in Figs. 3–7.

Results of surveys are summarized as follows. In Fig. 3, responses to a question about the relation between manufacturing and each department specialty are shown. For each first grade class, about 95% (M Dept.), 70% (C Dept.) and 85% (B Dept.) of students think manufacturing education is useful for their specialty, but these results decrease to about 50% for second grade students. From this figure, for first grade students, we can readily recognize that not only mechanical



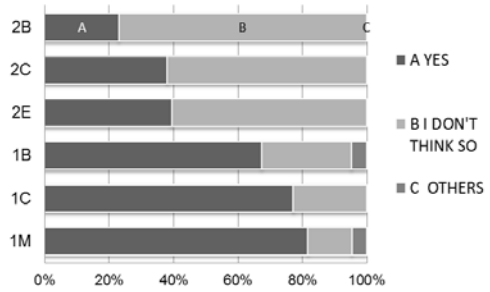
Question 1: Do you think that the contents of manufacturing education are useful for your specialty?

Fig. 3 Relation between manufacturing education and each department specialty.



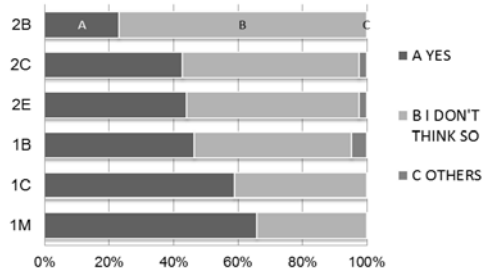
Question 2: Do you want to manufacture in your own in future through the experience gained in class?

Fig. 4 Interest in manufacturing.



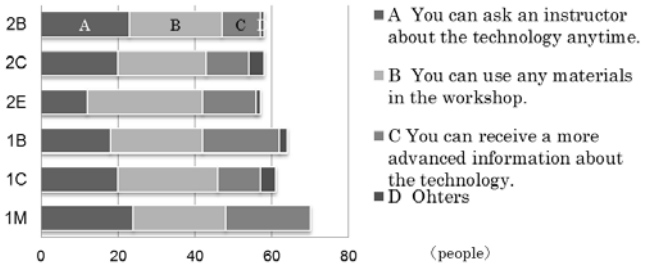
Question 3: Do you hope that there is manufacturing education above second grade?

Fig. 5 Manufacturing education for above second grade.



Question 4: Do you want to use the Workshop and the Manufacturing Technology Practice Center outside of class time, such as during after school activities?

Fig. 6 Use of the Workshop and Manufacturing Technology Practice Center outside of class time.



Question 5:
Fig. 7 Do you want to use the workshop if---?

department students but also other department students regarded manufacturing education as quite useful for their department and for becoming professional engineers. However, that percentage decreased in second grade, probably because students at that stage have mastered basic experiments and practical training in each department, and there are fewer opportunities to demonstrate manufacturing technology.

Particularly, the results of 2C and 2B in Fig. 3 indicate that about 50% and 70% students do not regard manufacturing as useful for their specialization. This is regarded as a serious problem. Figures 4–7 show comments and opinions related to the future of manufacturing after attending manufacturing education. From Figs. 4 and 5, more than 75% of first grade students want to manufacture items on their own, and about 70% of them want to manufacture even more than second grade students do. However, when they become second grade students, the percentage has shrunk, perhaps because the second grade students' interests are directed to subjects in which they have specialized. In addition, because there are fewer specialized subjects, differences in first grade did not arise among departments. Figure 6 shows that about 50% of all first and second grade students want to use the Workshop and the Manufacturing Technology Practice Center outside of class time, as an after school activity. From Fig. 7, we can easily notice that the students desire a so-called support system, judging from a high rate of answer A or B in the questionnaire in Fig. 7. Figure 7 shows the total number of people giving various responses.

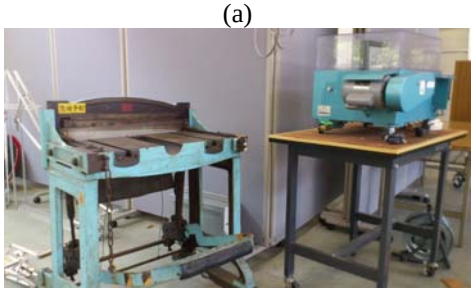
Outline of Monodukuri Office Hours

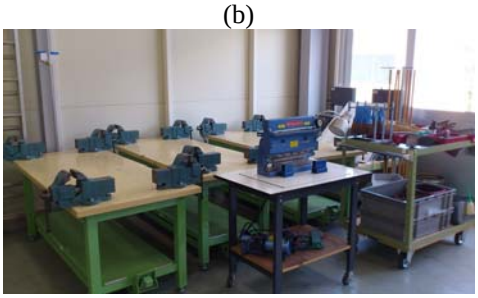
Survey results show that about 65% (M Dept.), 60% (C Dept.), and 50% (B Dept.) of students want to use the Workshop and the Manufacturing Technology Practice Center outside of class time. However, about 50% of second grade students have lost interest in manufacturing by that time. Therefore, we have introduced Monodukuri office hours (office hours for manufacturing) from 5–6 pm every Wednesday as an attempt to improve student interest in manufacturing. This approach designates so-called office hours during which students can receive guidance or actual machine tool manufacturing consultation.

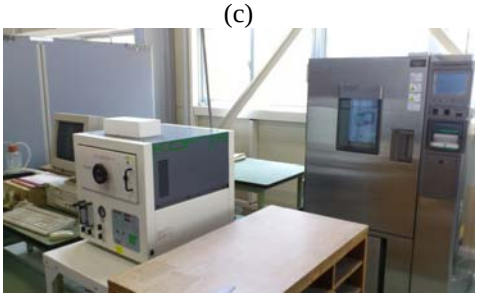
Manufacturing Technology Practice Center

The manufacturing education described above was performed mainly in the workshop during class time. However, Monodukuri office hours are held at the Manufacturing Technology Practice Center outside school hours. The Manufacturing Technology Practice Center has various machine tools as presented in Fig. 8, for instance, two manual-type small lathes, three bench drilling machines and a manual-type small


(a)


(b)


(c)


(d)

(a) Band saw, manual small lathe, bench drilling machine and manual type small milling machine (b) Shirring machine and high-speed precision cutting machine
(c) Work table and bending machine for sheet metal
(d) Vacuum experimental apparatus and constant temperature laboratory equipment

Fig. 8 Main facilities of the Manufacturing Technology Practice Center.

Fig. 9 Poster of Monodukuri office hours.

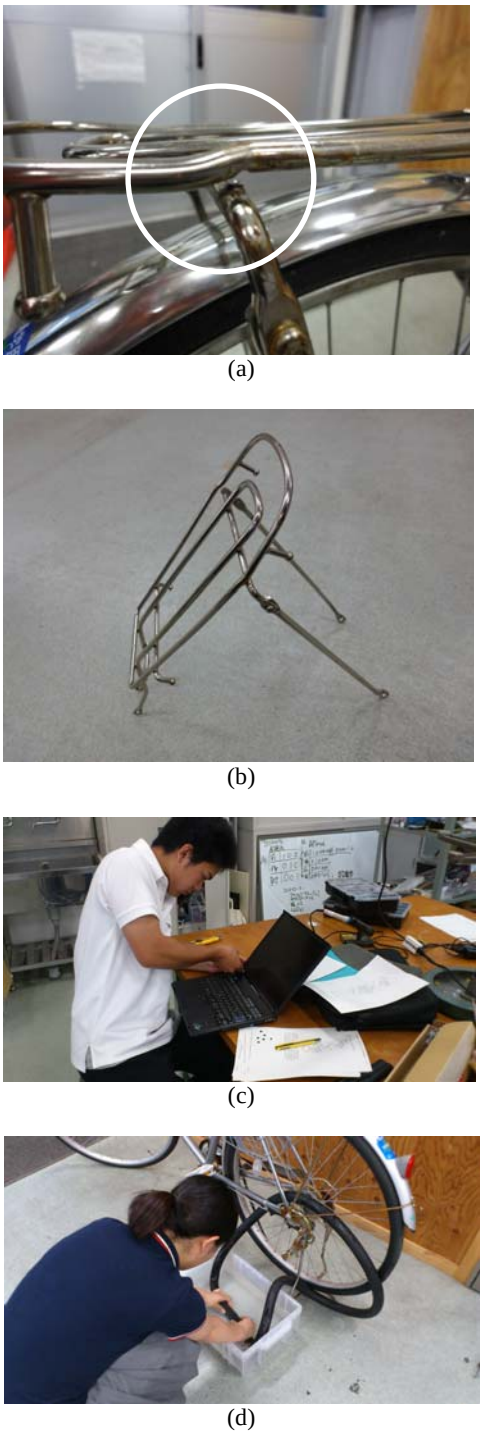
milling machine. As cutting tools, there are three bench-type band saws, a middle-type band saw, a shirring machine, and a high-speed precision cutting machine. Furthermore, there are a work table for finishing work, a bending machine for sheet metal, a vacuum experimental apparatus, and constant temperature laboratory equipment. Using these machine tools, students can attempt more varied machining and manufacturing work than ever before.

Details of Monodukuri Office Hours

The Monodukuri office hours were performed at the Manufacturing Technology Practice Center. Teaching staff include four robocon supervisors (teacher) selected from each department. Not only teachers of M Dept. and E Dept., but also the teachers of C Dept. and B Dept. have joined as instructors for Monodukuri office hours, and students of each department are familiar with using the Manufacturing Technology Practice Center. Moreover, we are able to correspond not only with manufacturing by machine tools and electronics workshops, but also with pottery using an electric

Table 1 Actual use result of Monodukuri office hours (Apr. 2010–Mar. 2012)

Contents of consultation	number
Repair of a personal computer	4
Repair of a bicycle	13
Puncture repair of a bicycle	13
Others	4
Total	34



(a) Broken carrier of bicycle (inside white circle)
(b) After repairing the carrier by welding work
(c) Repairing the back-light of a notebook PC
(d) Puncture repair of a bicycle

Fig. 10 Appearance of office hours for manufacturing.

furnace, and so on. To have use of the Manufacturing Technology Practice Center during Monodukuri office hours, we have been dealing with machining work by lathe and milling machine as well as puncture repair of bicycles and consultations about the repair of personal computers, which are not treated in the manufacturing education in the workshop. As public relations activities,

we put up a poster of Monodukuri office hours in each classroom (Fig. 9).

Table 1 shows actual use results of Monodukuri office hours. As shown in this table, many students use Monodukuri office hours for repairing bicycles (used for commuting to school). To date, the actual use of Monodukuri office hours has amounted to more than 30 instances, even though opening hours are late for many students.

During Monodukuri office hours, teaching staff only give advice and help students. Students must fundamentally prepare the materials in advance. Repair and maintenance work must be done on their own.

As an example of Monodukuri office hours, a student came to the Manufacturing Technology Practice Center to repair a broken carrier of the bicycle. Figure 10(a) shows the bicycle carrier with the break. The teaching staff member (teacher) consulted about it with technical staff of Technology Education Support Center. According to the advice of the teaching staff, it was to be repaired completely with welding work. Initially, the student thought of repairing it on his own. However, because he joined the 1C class, he was not taught how to do welding work. Therefore, the welding work was done by technical staff (Fig. 10(b)). As in this case, work and technical guidance for students are done by professional technical staff instead of teaching staff. Figures 10(c) and 10(d) portray students repairing the back-light of a notebook PC and repairing a bicycle puncture independently.

Although the actual instances of Monodukuri office hour use are not many (34 times in two years), this effort is an attempt to improve student interest in manufacturing, especially for students who have difficulty operate machines, students who are not interested in making things themselves, etc. Based on these results, we inferred that students' interests in manufacturing have increased gradually.

Recently, student members of the robot contest club, who designed and manufactured robots for competition, and the motor vehicle club, who designed and manufactured solar cell vehicles and fuel cell vehicles, have come not only from M Dept. and E Dept., but also from C Dept and even B Dept. Moreover, in open lectures teaching students how to design and make model airplanes and trying to fly them held at the Mechanical Engineering Dept. of Akita NCT. In Aug. 2009, there were some C Dept. and B Dept. students serving as teaching assistant students. Until that time, such students were almost all M and E Dept. students. These results clarify that the effect of introductory manufacturing education and Monodukuri office hours on the students' interest in manufacturing has increased.

Conclusion

Examples of applications of current cases of Monodukuri office hours were introduced in this paper, and the outline and details of Monodukuri office hours were explained.

Initially, to improve student interest in manufacturing, we introduced Monodukuri office hours (office hours for manufacturing education) in after-school activities. Results show that student awareness was improved, and that student interest in manufacturing has been increasing steadily.

Not only for M Dept. students, but for all students, manufacturing education using machine tools has become the foundation of basic manufacturing. Students can experience difficulties and enjoy their time through manufacturing education. They can become engineers with multifaceted ideas related to their department specialties.

We hope that, through manufacturing education and Monodukuri office hours, many students will become familiar with manufacturing, and will take advantage of that knowledge graduate research projects and their work after graduating from our school.

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